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THE MARGINAL COSTS OF TAXATION IN NEW ZEALAND

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compliance costs were found to be highly regressive in their impact. Amongst smaller businesses, the equivalent of 13.4 per cent of the firm's turnover was taken up in compliance costs as against only 0.03 per cent for the largest businesses.

The costs of compliance are clearly large. There are also significant costs of administering the tax system, and of policing avoidance and evasion. But raising government revenue through taxes also imposes costs in a much more important but less visible way. It's not feasible to tax everything and the tax system makes those activities that are taxed relatively more expensive than those activities that aren't. Taxes thus change relative prices and thereby people's behaviour. Such tax-induced changes in behaviour impose an additional type of cost known as the deadweight cost of taxation. Taxes on income, for example, affect people's willingness to work, save, invest and take risks — in a multiplicity of ways.

An example will help illustrate the concept. A tax on cars may mean that some people choose not to buy a car. They would have bought a car in the absence of the tax, but the tax increased the price too much, and so they go without. Because the would-be car buyers don't make their purchases, no tax is paid. But that doesn't mean that the tax hasn't imposed a cost, because in the absence of the tax they would have bought cars. It follows that a tax has a deadweight cost over and above the actual money that it raises. It changes people's behaviour and causes them to make decisions that they wouldn't otherwise make. From the taxpayers' viewpoint, those decisions are less preferred ones.

The total cost of a tax is thus not just what the tax raises and the costs of tax collection (administration and compliance costs). It is instead what a taxpayer would need to be paid in order to be made just as well off with the tax as without it. The difference between the amount of tax raised plus collection costs and the total cost of the tax is known as the deadweight cost of the tax. The cost is 'deadweight' because it represents a loss of potential economic welfare. Compulsory levies incur similar costs if they alter people's behaviour.

The deadweight costs of taxation are typically ignored. This is because their estimation is technically very difficult and complicated. Government expenditure is, at best, treated as costing no more than the dollar amount spent. The deadweight cost of tax is effectively assumed to be zero. However, economists have long understood that taxation imposes economic costs and a number of studies overseas have suggested that the magnitude of these costs can be large. No such studies, however, have previously been undertaken in New Zealand.

To fill that gap, the New Zealand Business Roundtable commissioned Swan Consultants (Canberra) Pty Ltd in 1992 to undertake the present study. The Swan Consultants team consisted of Professor Erwin Diewert and Dr Denis Lawrence. Professor Diewert of the University of British Columbia has been a pioneer in the application of mathematics to economics. Dr Lawrence has worked for the Industry Commission and the Bureau of Industry Economics in Australia and has considerable experience in applied quantitative economics. We were indeed fortunate to attract the services of such an eminent team.

The results of their work are outlined in the executive summary of this report. In essence, they find that the deadweight costs associated with labour taxation (primarily taxation on the income of wage earners and the self-employed) in New Zealand are around 18 per cent (18 cents) for the last or marginal dollar of revenue and around 14 per cent (14 cents) for the marginal dollar raised through consumption tax (primarily GST). These costs (which are additional to collection costs) are very significant, and represent an important part of the costs of maintaining present levels of government spending.

The implication of the study's finding that the economic cost of labour taxation at the margin is around 18 per cent is that, to justify a claim on that dollar, a government project would need to return $1.18 net of collection costs for each dollar spent on it just to cover the opportunity costs to the community of the dollar and the deadweight loss. If it doesn't earn that return, then society is better off not undertaking the project. Of course, some of the returns to government expenditure are difficult to measure. However, we now have a professionally-researched estimate of what we are having to give up. That last dollar spent on defence, administration, income support, health or education means forgoing $1.18 of benefit that would otherwise accrue to taxpayers. If the dollar of government spending were only worth a dollar to the taxpayer, the gain from reducing government spending would be 18 cents — effectively an 18 per cent return.

Looking at the finding in that way, the study shows that there is a very attractive project available to the government. However, the project is no ordinary one involving increased government spending. Quite the reverse. The project involves reducing government spending and hence taxes on wages. The study finds that reducing taxes on labour would yield a return to New Zealand of around 18 cents for every dollar of tax reduction. Given that generally a dollar spent at the margin, whether by a government on behalf of individuals or by individuals themselves, produces at most only a dollar of benefits (and some individuals may value the dollar of government spending less), a benefit of $1.18 per dollar of tax reduction represents a very large gain.

The only justification for not reducing government spending and realising that gain would be if the marginal dollar of government expenditure financed by labour taxation yields a return to the community of 18 per cent or more. This is highly unlikely. The present study thus provides a very powerful argument for reducing government expenditure from present levels. Cutting expenditure that yields a benefit which is less than the sum of the amount spent plus the marginal costs of taxation would make New Zealanders better off in aggregate.

Such a finding has obvious policy implications. For example, a major economic and social problem is the high rate of unemployment. An overriding concern for the government is accordingly what it can do to improve people's job prospects and ensure rising incomes for all New Zealanders. The so-called tax wedge — the difference between pre- and post-tax returns from working — itself discourages people from taking employment. Despite this, various schemes are frequently suggested involving higher government expenditure and, therefore, taxation. Furthermore, a major argument put forward for not reducing government expenditure is that it would involve job losses. But always ignored in the discussion is the drag on the economy that government expenditure imposes. If the drag is large, the very best thing the government can do for jobs and growth is to reduce government spending and hence taxes. As government spending falls, the deadweight costs fall more than in proportion to the associated fall in tax rates. To increase government spending and taxes risks making matters worse.

It is important to note that the study is not saying that less government spending is always better. The optimal level of government spending is not zero. The government has an important role to play, for example in providing public goods and physical and legal infrastructure that would not be supplied — at least in desirable quantities — through private transactions. It is worth incurring the deadweight costs of taxation up to the point justified by the returns to such expenditure.

Nor is the study saying that no sacrifices of economic output should be made in the interests of greater equity (e.g. through income redistribution). It does not deny the case for a social welfare safety net, for example. We may well wish to accept such trade-offs. What the study highlights, however, is that transferring a dollar from Peter to Paul is costly. Deadweight costs are associated with the taxation needed to finance government spending on transfers as well as spending on goods and services. Indeed they are higher for redistributional programmes to the degree that individuals derive less benefit from a dollar of government consumption than they do from a dollar of transfer payments. Because of these costs, the tax and transfer system has been likened to a leaky bucket, which 'spills' potential income in the process. Much government expenditure, for example on education, health and superannuation, benefits people with substantial levels of income or assets. The costs of taking money from them to buy such services on their behalf may be much higher than is commonly realised. If spending decisions were left to a greater extent to individuals, with support for those who needed assistance, the deadweight costs that taxation imposes could be reduced.

It also needs to be borne in mind that a less wealthy society has more difficulty catering for those who are less well off. Much evidence suggests that the most powerful force for poverty alleviation is sound economic growth. It is apparent that high spending and taxing countries, such as many of those in Western Europe, are finding it increasingly difficult to achieve economic growth and compete successfully with low tax countries such as those in the Asian region. Given open borders for trade and investment and intensifying competition from emerging economies, New Zealand must be conscious of the impact of tax burdens on its economic performance.

The study is a pathbreaking one for New Zealand which we hope will stimulate investigations into other aspects of the costs of the tax system. New Zealand researchers will no doubt focus on the study's methodology and the data sets that Professor Diewert and Dr Lawrence have generated. But the study is also important in terms of policy direction in New Zealand. It provides for the first time an estimate of the deadweight cost of taxation in New Zealand. There is now no excuse for not including deadweight cost in any serious debate about whether government spending should be increased or decreased. We also now know that we have a government project offering a very attractive potential return — that project is called reducing government expenditure.

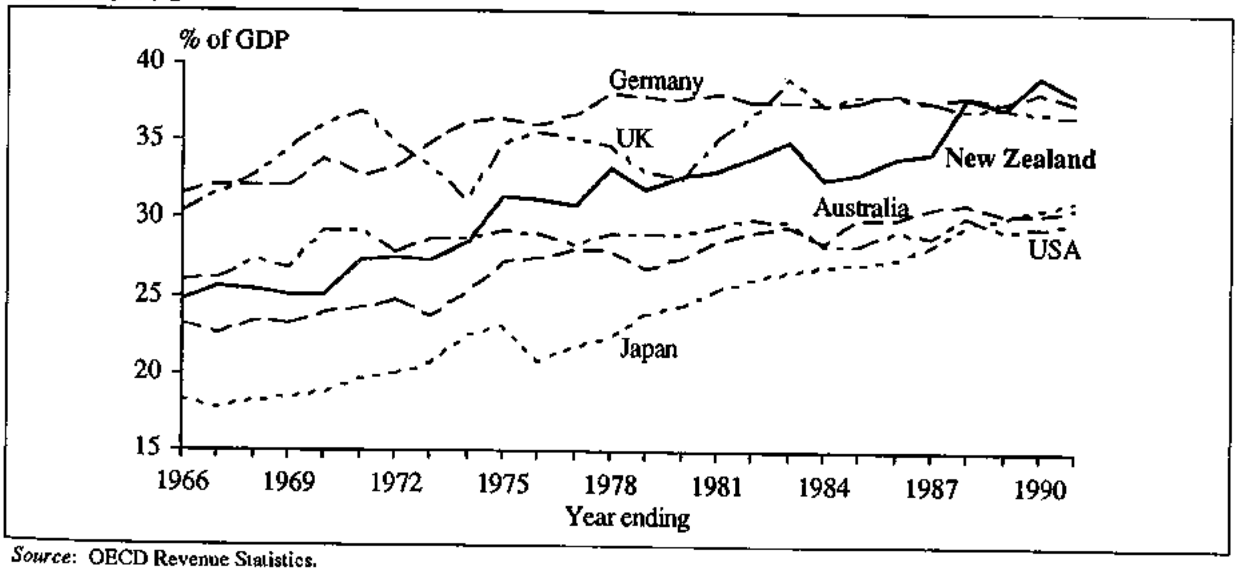
R L Kerr
EXECUTIVE DIRECTOR

EXECUTIVE SUMMARY

The New Zealand economy has undergone considerable reform in the last decade. Reform of the tax system has been an integral part of this process. More reliance has been placed on indirect taxes with the introduction of what is regarded as one of the most comprehensive and 'pure' goods and services taxes in the world, the income tax has been made broader-based but with a flatter rate structure and import tariffs have been scaled down.

However, tax revenue as a proportion of gross domestic product (GDP) has continued to increase and is very high relative to comparable countries. In 1991 New Zealand's share of taxation in GDP was 38.2 per cent compared with 29.9 per cent in the United States and 30.8 per cent in Australia. New Zealand's tax share in 1991 was also higher than that of Germany, the United Kingdom and Japan (see Figure 1). While all these countries' tax shares have increased over the last 25 years, New Zealand's tax share has increased far more rapidly. Although New Zealand's tax share has fallen somewhat since its peak in 1990-91 and is projected to fall further, it remains high by OECD standards. Furthermore, the tax shares of OECD countries tend to be very high compared to the dynamic Asian economies. For instance, South Korea, Singapore, Thailand and Indonesia all had tax shares of less than 17 per cent in 1991. In a world of increasing globalisation and capital mobility, high tax countries will find it increasingly difficult to compete.

Figure 1: **Tax Revenue as a Percentage of GDP — Selected OECD Countries**



Source: OECD Revenue Statistics.

New Zealand's situation is even more perilous when it is realised that its government expenditure has consistently exceeded taxation revenue by a large margin for all but one of the last 12 years, leading to increasing levels of public indebtedness. In 1992-93 net public debt stood at 55 per cent of GDP (Richardson 1992). High levels of government spending and consequent increases in public debt imply the need for higher taxation levels in the future to cover interest and repayments on borrowings.

Far from being free, government expenditure has to be financed sooner or later by increased taxation and that taxation imposes a number of costs on the economy. Sandford and Hasseldine (1992) found that the compliance costs alone of business taxation in New Zealand are quite significant. For instance, the compliance costs of pay-as-you-earn, fringe benefit and related taxes range up to 2 per cent of the revenue collected while the compliance costs of the Goods and Services Tax exceed 7 per cent of the revenue collected. However, apart from the direct cost of the extra revenue and associated administration and compliance costs, an important additional cost arises from the changes in behaviour induced by taxation. These incentive costs are generated when people turn to less preferred substitutes as a result of taxation, or employ less satisfactory methods of production. The losses created are known as *deadweight costs* or the *excess burden* of taxation.

Taxes distort the incentives to work, save and invest and the pattern of input use and production in the economy. These distortions impose costs on the economy by reallocating resources from their most productive uses to less productive ones. Consider the taxation of labour income. Because taxation adversely affects the incentives people face, as taxes increase people will tend to substitute towards leisure, work less intensively, undertake more do-it-yourself work and shift into occupations with relatively large non-pecuniary benefits. In New Zealand's case, the way many social security benefits are provided also has a major negative impact on the incentive to work.

The deadweight cost of taxation is a measure of the value of the opportunities that are effectively lost when taxation diverts labour, land and capital from their best uses. By calculating the deadweight costs of taxation we can gauge the potential effects of taxation on the economy and society.

The size of deadweight costs is influenced by a range of factors but they are likely to be largest when the actions of producers and consumers are highly responsive to after-tax prices, when existing marginal tax rates are high and when savings are highly responsive to after-tax returns. Overseas studies have typically found that the deadweight costs associated with raising taxation revenue range from a minimum of 10 cents to well in excess of $1 for each additional dollar of revenue raised. In percentage terms this corresponds to a range of 10 per cent to over 100 per cent of the additional revenue. For instance, the only study of deadweight costs in Australia found a range of 23 per cent to 65 per cent while key studies of the United States have found ranges of 17 per cent to 56 per cent depending on the assumptions made.

Against this background, the New Zealand Business Roundtable commissioned Swan Consultants (Canberra) to estimate the marginal deadweight costs of taxation in New Zealand.

The key findings of the study are that the marginal excess burdens or deadweight costs associated with labour taxation have increased from 5 per cent to over 18 per cent in the last 20 years (Figure 2). This more than tripling of the size of the deadweight cost of labour taxation is not accounted for solely by increases in labour tax rates as they increased by only around a half from 20 per cent to 32 per cent over the same period.

Figure 2: **Labour Tax Rates and Deadweight Costs**

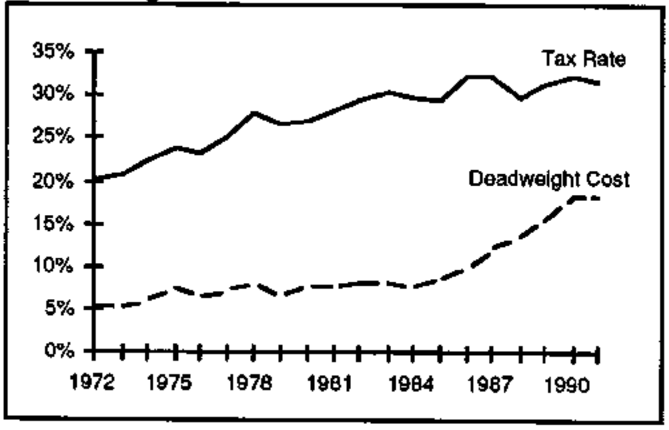
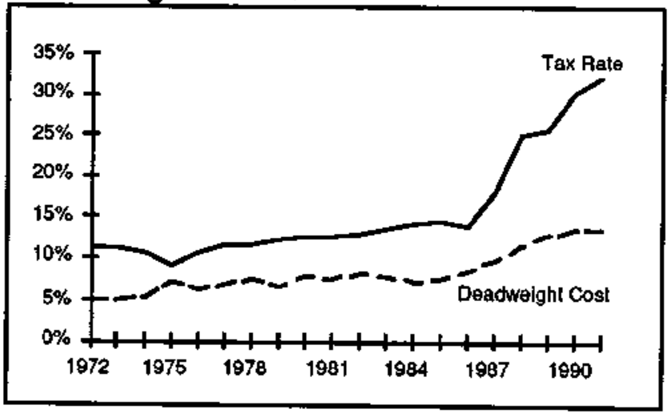


Figure 3: **Consumption Tax Rates and Deadweight Costs**



Even though deadweight costs tend to increase more rapidly than the increase in the tax rate (all else equal), much of the increase in the size of the deadweight cost is accounted for by the increased flexibility and responsiveness of the New Zealand economy in recent years and increasing international capital mobility. This can be seen from Figure 2 where the rate of increase in the labour tax rate eased off after 1983 while the deadweight cost of labour taxation increased rapidly after 1984.

Over the last 20 years the marginal excess burden of consumption taxation (all indirect taxes other than property taxes and import duties) has increased from 5 per cent to around 14 per cent (Figure 3). The almost tripling of the consumption taxation deadweight cost coincided with an almost tripling of the total consumption tax rate from around 11 per cent to 32 per cent. Most of this increase in the consumption tax rate occurred after 1986 coinciding with the introduction of the goods and services tax. The average marginal excess burdens for labour and consumption taxation were 9.5 per cent and 8.3 per cent, respectively.

While at the lower end of the range of previous estimates of deadweight costs for other countries, both of these excess burdens are quite significant. Importantly, our estimates are the first to use key parameters calculated from consistently specified statistical models of the economy being examined whereas previous studies have typically assumed a range of values for these parameters. Also, our estimates are based on a rigorously specified general equilibrium model which takes account of interactions between different parts of the economy. Because we use this framework, our deadweight cost estimates apply year after year once a change in taxation has occurred. Consequently, if a government project is to be justified taking deadweight losses into account, it must provide a return each year which exceeds its direct cost (including a normal return) by at least the amount of the deadweight cost. This is equivalent to earning an ongoing real rate of return over and above the normal rate of return by at least the estimated percentage of deadweight costs.

For example, a government project financed by additional labour taxation should have, on average, earned a real rate of return 9.5 per cent above the normal real rate of return in order to overcome the adverse effects of increased taxation. Since the average real rate of return for the private sector of the New Zealand economy was only 0.6 per cent for the 20 years of our study, this represents a very large penalty which government spending has to overcome to be justified.

These findings point to the urgent need to review taxation levels in New Zealand as the costs of allowing the average tax take to continue to increase are becoming increasingly and prohibitively high. Conversely, the New Zealand economy would reap large benefits from reduced government spending and taxation.

The growth in the tax take in New Zealand has been driven by high levels of government expenditure, particularly on social services, and increasing government debt levels. In 1991 the high cost of taxation can be alternatively illustrated by considering that a reduction in government spending financed by reduced labour taxes would have led to a real rate of return on this 'investment' of 18.3 per cent. There are very few, if any, government projects which can boast such a high real rate of return. A more urgent priority, however, is likely to be a reduction in government spending accompanied by a period of unchanged taxation levels to facilitate the reduction of government debt. This would pave the way for a sustainable long-run reduction in taxation levels and associated gains to the New Zealand economy.

The importance of these issues is further highlighted by the fact that our deadweight loss estimates are likely to be relatively conservative as we have not calculated the marginal excess burden of capital taxation. Other studies which have attempted to introduce dynamics and model capital accumulation decisions have shown that the marginal excess burden of capital taxation is generally higher than that for labour. This is particularly likely to be the case for a small economy such as New Zealand trading in a world of ever-increasing capital mobility.

The priority for future work should be to extend the model to include explicit modelling of the capital accumulation process. This will enable marginal excess burdens associated with capital taxation to be calculated.

To summarise, the main policy conclusions from the study are:

- New Zealand's tax share of GDP has increased rapidly, is high by OECD standards and over double those found in the dynamic Asian economies;
- the costs that this high level of taxation have imposed on the New Zealand economy have increased rapidly as the economy has become more flexible and integrated with the rest of the world;
- continuing reforms in New Zealand and overseas, and ever-increasing international capital mobility will further increase the costs of high levels of taxation;
- increasing levels of public indebtedness are bequesting high levels of taxation and poverty to New Zealand's future generations;
- far from being free, government expenditure comes with a high price tag and must correspondingly be spent wisely on high yielding projects or not at all;
- the over-riding priority should be to reduce government expenditure and public debt levels, and to pave the way for sustainable reductions in taxation levels; and,
- priority should be given to reducing income taxes ahead of consumption taxes.

1. INTRODUCTION

When revenue is raised through taxation, a number of costs are imposed on the community. The most obvious of these is the cost accounted for by the amount of the revenue, a cost which is borne by consumers and producers in the particular market in which the tax is imposed. Looking at the community as a whole, this cost is offset, to some extent, by gains to those who benefit from the expenditure financed by the revenue.

However, an important cost arises from the changes in behaviour induced by taxation. These incentive costs are generated when people turn to less preferred substitutes as a result of taxation, or employ less satisfactory methods of production. The losses created are known as *deadweight costs* or are sometimes referred to as the *excess burden* of taxation.

1.1 How do deadweight costs arise?

Taxes distort the incentives to work, save and invest and the pattern of input use and production in the economy. These distortions impose costs on the economy by reallocating resources from their most productive uses to less productive ones. The deadweight cost of taxation is a measure of the value of the opportunities that are effectively lost when taxation diverts labour, land and capital from their best uses. By calculating the deadweight costs of taxation we can gauge the potential effects of taxation on the economy and society.

Consider the taxation of labour income. Because taxation adversely affects the incentives people face, as taxes increase people will tend to substitute towards leisure, work less intensively, undertake more do-it-yourself work and shift into occupations with relatively large non-pecuniary benefits. Individuals lose because their purchasing power is reduced and society gains because tax revenue is collected to provide government services. It is possible that these effects could offset each other so that there is no deadweight cost. But this is unlikely because in the absence of taxation people would have chosen to do things differently, implying that they valued the choice of more work (and all it could buy) more than they valued more leisure.

Deadweight losses measure the extent to which the actual tax system deviates from a 'neutral' tax system. A neutral tax system is one which leaves individuals' decisions unchanged relative to what they would be if no tax system existed but their incomes were reduced by the amount of the revenue collected. A poll or head tax is the classic example of a neutral tax where people's incomes are reduced by a given amount irrespective of what actions they may take. However, for most forms of taxation the amount paid will be influenced by the responses people take to the tax, inducing them to adopt less preferred actions and imposing additional costs on them. One way of thinking about deadweight losses is as the amount that consumers and producers would pay to avoid taxation, less the revenue raised from them. This amount is almost always positive, indicating that taxation generally imposes a net cost on society.

The size of deadweight losses is influenced by a range of factors but they are likely to be largest when the actions of producers and consumers are highly responsive to after-tax prices, when existing marginal tax rates are high and when savings are highly responsive to after-tax returns. Overseas studies have typically found that the deadweight losses associated with raising taxation revenue range from a minimum of 10 cents for each additional dollar of revenue raised to well in excess of $1 for each additional dollar of revenue raised. Deadweight losses thus have the potential to be very significant and should be taken into account in discussions of the role and size of government.

In addition to the direct costs and deadweight losses associated with taxation there are a number of additional resource costs. These relate mainly to avoidance, evasion, compliance and administration. In a free society individuals will arrange their affairs so as to minimise the amount of tax paid. This can be done legally by means of tax avoidance as less preferred mechanisms are adopted to split income and substitute less heavily taxed goods for more highly taxed ones or illegally by means of tax evasion as income is hidden from authorities. In both cases significant resources of individuals, firms and specialist advisers are tied up in socially "unproductive" activities. Similarly, compliance with taxation laws usually requires firms to keep additional records that they would not otherwise require. Enforcement and administration of the tax system also tie up significant amounts of society's resources, increasing the costs of raising revenue.

1.2 Why are deadweight costs important?

The calculation of deadweight losses is central to a number of policy questions including:

- how valuable do public projects have to be to cover the full costs of the revenue needed to finance them?;
- which tax measures impose least costs in financing a given expenditure burden?; and
- how much redistribution from rich to poor can society afford?

The value of public projects

The total cost to society of financing a marginal dollar of public expenditure is the sum of that dollar (since it is diverted from another use) plus the deadweight costs of raising that dollar. A study of the deadweight cost of taxing labour income for Australia estimated the marginal deadweight cost to vary from 23 cents to as much as 65 cents (Findlay and Jones 1981). This means that an extra $1 of public expenditure costs $1.23 to $1.65. The implication from this analysis is that, in undertaking a cost-benefit assessment of a publicly-funded project, benefits should be at least 23 to 65 per cent more than the value of the funds provided, if taxes are raised from labour income. The costs could be higher for other forms of taxes since deadweight costs are highest where behavioural responses to taxes are highest and the behavioural response of labour is normally relatively low on average.

Cost-benefit calculations often neglect the cost of raising revenue and the true economic penalty — in terms of deadweight costs — is usually not even contemplated. A better understanding of the marginal deadweight cost of raising revenue and its careful application in cost-benefit assessments would help ensure value for money when spending the taxpayer's dollar.

The choice of the tax base

Different methods of taxation have different deadweight costs. These costs can be central in choosing among methods of raising revenue. Thus one tax base may generate a deadweight cost of 20 cents for each additional dollar raised, while another may involve costs of 40 cents. In fact, these principles are often implicit in conventional views about public finance. The idea that a tax base should be as broad as possible has its origins in the observation that deadweight costs increase with higher tax rates, *at an increasing rate*. Thus the broader the base, the lower the tax rate and the lower the deadweight losses in aggregate. An optimal tax system would be one that equates the marginal deadweight losses across revenue sources.

The benefits from redistribution

Raising revenue for transfer to the less well-off also involves deadweight costs. Even now the level of such transfers implicitly involves consideration of the cost to those from whom revenue is being taken. Because the costs of transfers also involve deadweight losses, these should be included.

Given that the taxation required to finance public expenditure is costly to raise, governments should leave money in the hands of taxpayers unless it is abundantly clear that they can do a better job of spending it. If the deadweight loss figure for New Zealand was 50 cents in the dollar, then reducing tax collections by a billion dollars would lead to national income being higher by up to half a billion dollars.

1.3 Is taxation a problem in New Zealand?

The New Zealand economy has undergone considerable reform in the last decade. Reform of the tax system has been an integral part of this process. More reliance has been placed on indirect taxes with the introduction of what is regarded as one of the most comprehensive and 'pure' goods and services taxes in the world, the income tax has been made broader-based but with a flatter rate structure and import tariffs have been scaled down. However, tax revenue as a proportion of gross domestic product has continued to increase and remains high relative to comparable countries. In 1991 New Zealand's share of taxation in GDP was 38.2 per cent compared with 29.9 per cent in the United States and 30.8 per cent in Australia (OECD 1991).

Government expenditure has consistently exceeded taxation revenue by a large margin for all but one of the last 12 years leading to increasing levels of public indebtedness. In 1992-93 net public debt stood at 55 per cent of GDP (Richardson 1992). In addition, the way many social security benefits are provided has a major negative impact on the incentive to work.

The time is now ripe to review and calculate the deadweight costs of taxation in New Zealand. This will be an important input to reviewing the role of taxation and government expenditure in the economy and assessing the taxation reforms introduced to date.

1.4 The approach adopted in this study

The responsiveness of economic activity to changes in after-tax prices is the critical determinant of the size of deadweight costs. Consequently, a major part of this study has been concerned with obtaining accurate estimates of the key price elasticities for both consumers and producers. These elasticity estimates are then a key input to a small scale general equilibrium model from which deadweight cost estimates are derived making use of duality theory.

In the case of New Zealand there is little consistent time-series data available and few econometric studies from which to obtain elasticity estimates. Since a consistent database of prices and quantities of goods and services consumed and of outputs produced and inputs used by producers for at least a 20 year period is a pre-requisite for obtaining credible elasticity estimates, the construction of such a database has also been a major undertaking. The database covers the years 1971-72 to 1990-91.

The producer model estimated contains 3 outputs — motor vehicles, general consumption (excluding housing and transport) and investment, and exports — and 2 variable inputs — imports and labour — along with two fixed inputs — capital and land. A normalised quadratic profit function was estimated for the aggregate private production sector. This provides for fully flexible modelling of production relationships between all outputs and inputs. By placing a minimum of restrictions on the production technology this technique enables accurate elasticity estimates to be derived.

The consumer model estimated contains 4 consumption goods — motor vehicles, general consumption (excluding housing and transport), housing and leisure. A normalised quadratic expenditure function model was estimated for the representative consumer incorporating a linear spline on utility levels. This methodology again places a minimum of restrictions on the consumer's preferences and enables accurate elasticity estimates to be derived. At this stage the consumer model is static. Intertemporal considerations have not been included.

The small scale general equilibrium model equates supplies of goods from producers with the demand for them from consumers and the government. Consumer and government budget constraints are included and the balance of payments on current account and the budget deficit are specified exogenously. Producers' supplies are specified as price derivatives of the profit function in terms of producer prices while consumer demands are specified as price derivatives of the expenditure function in terms of consumer prices.

The difference between producer prices and consumer prices represents the price wedges or distortions introduced by taxation and government subsidies. The marginal excess burden associated with changing a given tax rate is calculated as follows. Consumer's utility levels are held constant by means of transfers following a change to the tax rate. The change in overall welfare resulting from the change to the tax rate is then equal to the change in the value of the government's consumption of goods and services (what the government can purchase after it has compensated consumers to return them to their original utility level). The marginal excess burden or marginal deadweight cost is defined as minus the rate of change in welfare divided by the rate of change in revenue with respect to the given tax rate.

Marginal deadweight cost estimates are derived for four major tax categories: labour taxes, general consumption taxes, motor vehicle consumption taxes and import duties. Because the model is not dynamic (it does not have an intertemporal dimension) deadweight costs resulting from the taxation of capital cannot be calculated. Capital is instead assumed to be in fixed supply each period and investment is treated as being exogenous.

1.5 Results of the study

The key findings of the study are that the marginal excess burdens or deadweight costs associated with labour taxation have increased from 5 per cent to over 18 per cent in the last 20 years. Over the same period the marginal excess burden of consumption taxation has increased from 5 per cent to around 14 per cent. The average marginal excess burdens for labour and consumption taxation were 9.5 per cent and 8.3 per cent, respectively. Both of these excess burdens are quite significant. For example, a government project financed by additional labour taxation should have, on average, earned a real rate of return 9.5 per cent above the normal real rate of return in order to overcome the adverse effects of increased taxation. Since the average real rate of return for the private sector of the New Zealand economy was only 0.7 per cent for the 20 years of our study, this represents a very large penalty which government spending has to overcome to be justified.

Over the 20 year period the average tax rate on labour income less than doubled while the marginal excess burden associated with labour taxation more than tripled. The more than proportional growth in the marginal excess burden can be attributed in part to the increasing flexibility of the New Zealand economy and points to the urgent need to review taxation levels.

The growth in the tax take in New Zealand has been driven by high levels of government expenditure, particularly on social services, and increasing government debt levels. Many countries have experienced rapidly increasing per capita government debt levels and are also discovering the substantial costs associated with this policy as tax rates increase to cover interest costs. In the case of New Zealand, in 1991 the high cost of taxation can be alternatively illustrated by considering that a reduction in government spending financed by reduced labour taxes would have led to a real rate of return on this "investment" of 18.3 per cent. A more urgent priority, however, is likely to be a reduction in government spending accompanied by a period of unchanged taxation levels to facilitate the reduction of government debt. This would pave the way for a sustainable long-run reduction in taxation levels and associated gains to the New Zealand economy.

The importance of these issues is further highlighted by the fact that our deadweight loss estimates are likely to be relatively conservative. By estimating a static model which treats investment as exogenous and capital as fixed each period we have not been able to calculate the marginal excess burden of capital taxation. Other studies which have attempted to introduce dynamics and model capital accumulation decisions have shown that the marginal excess burden of capital taxation is generally higher than that for labour. This is particularly likely to be the case for a small economy such as New Zealand trading in a world of ever-increasing capital mobility.

1.6 Structure of the report

In the following section of the report the costs of taxation are examined in more detail. After illustrating the concepts involved in deadweight costs and discussing the adverse incentive effects of taxation, the impacts of taxation on economic growth are briefly examined. The results of previous attempts to calculate deadweight costs are then reviewed.

In Chapter 3 we examine the empirical highlights of the New Zealand economy over the last two decades. After reviewing key price and quantity movements, the performance of the private production sector is assessed using the summary measures of total factor productivity and the real rate of return. The New Zealand taxation system is then reviewed along with trends in government expenditure.

Two models of the marginal excess burden arising from taxation are developed in Chapter 4 to illustrate the concepts involved and the importance of having accurate price elasticity estimates for the production and consumption sectors. The econometric producer and consumer models estimated are then described in detail in Chapters 5 and 6, respectively.

The more detailed model from which deadweight costs estimates are derived is presented in Chapter 7. The policy implications of the resulting deadweight cost estimates are briefly discussed in Chapter 8.

The database which has been constructed for this study is described in detail in Appendix A and the data inputs to the general equilibrium model are listed in Appendix B.

2. THE COSTS OF TAXATION

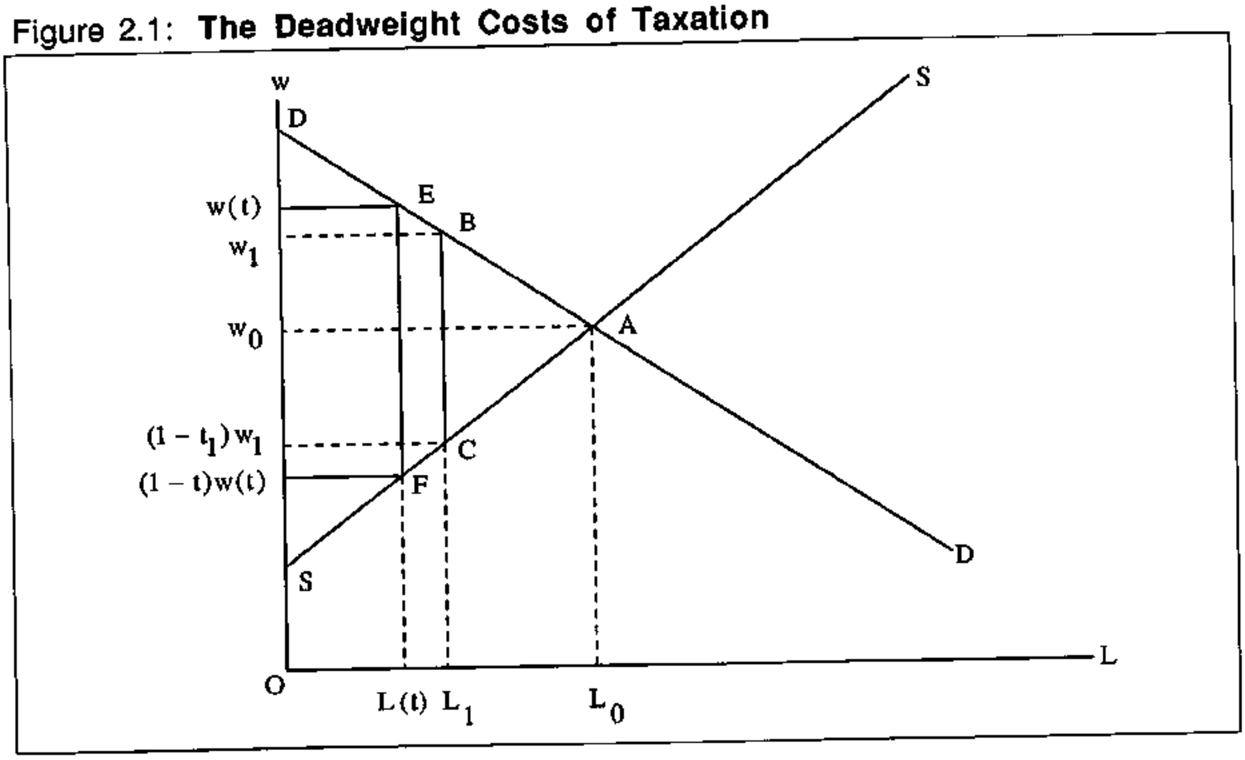
2.1 Analysis of deadweight costs

The behavioural changes which are caused by taxation can occur at a number of margins. Some of the most important are:

- willingness to work;
- choices among consumption goods;
- willingness to save;
- the pattern of savings;
- the production pattern in society;
- the use of inputs by particular industries; and
- the pattern of investment.

The measurement of the impact of taxation in all these areas has received research attention, although success in putting a money value on the costs of behavioural changes has been patchy. Most work has been devoted to the question of labour supply and this will serve as a convenient example for a diagrammatic exposition of how deadweight costs arise.

Figure 2.1: **The Deadweight Costs of Taxation**



The measurement of the deadweight loss arising from the taxation of labour is illustrated in Figure 2.1. The willingness of workers to supply labour (say hours per week) at various hourly wage rates is indicated by *SS*, the compensated labour supply schedule. The demand for labour is denoted by *DD*. In Browning's (1976) formulation of the excess burden concept (which followed up on Harberger's (1964) analysis of total excess burden), the demand curve was taken to be perfectly flat, which corresponds to a perfectly elastic demand for labour. In Figure 2.1, we extend Browning's analysis to allow for a general demand curve for labour. In the absence of labour taxation, the equilibrium wage rate is w_0 and the equilibrium supply of labour is L_0. A tax at the rate of t_1 causes the wage received by workers to fall to $w_1(1-t_1)$ and, at the lower wage, they are less willing to offer work. Labour supply consequently falls to L_1.

The total loss of welfare to workers due to the imposition of the labour tax t_1 is the familiar deadweight loss triangle, *ABC*. A more relevant concept than the total deadweight cost of taxation, however, is the marginal deadweight cost of taxation, since the interesting policy issue is not whether public spending should be abolished altogether, but whether public expenditure and related taxes should be raised, lowered or kept constant. Suppose we are considering adding an additional public sector spending program which will require an increase in the tax rate from t_1 to t to be funded. This increase in taxation will lead to a further reduction in labour supply to $L(t)$ and the deadweight cost increases by the trapezoidal area *BCFE*. If the additional public sector program is to be justified on efficiency grounds, then the benefits of the project should exceed the costs by at least *BCFE*.

Denote the incremental welfare loss *BCFE* as a function of the tax rate t by $W(t)$. With linear supply and demand curves, it can be seen that the area defined by *BCFE* has the following analytic form:

(1) $$W(t) \equiv \left({}^1\!/_2\right)\left[t_1 w_1 + t\,w(t)\right]\left[L_1 - L(t)\right].$$

Denote the revenue raised by taxing labour income at the rate t by $R(t)$. In Figure 2.1, $R(t)$ is equal to the area of the rectangle joining the line segment *EF* to the w axis. Analytically, $R(t)$ is defined as follows:

(2) $$R(t) \equiv t\,w(t)L(t).$$

The marginal excess burden associated with increasing the tax rate t, $MEB(t)$, in order to finance a government project, evaluated at $t = t_1$, can be defined as the rate of change of the incremental excess burden defined by (1) divided by the rate of change of the revenue defined by (2); i.e., we have the following definition:

(3) $$MEB(t_1) \equiv W'(t_1) / R'(t_1)$$

where $W'(t_1)$ denotes the rate of change of $W(t)$ with respect to t evaluated at t_1 and $R'(t_1)$ denotes the rate of change of $R(t)$ with respect to t evaluated at t_1.

An explicit formula for $MEB(t_1)$ in terms of demand and supply elasticities and the rate of labour taxation t_1 can be obtained if we approximate the inverse demand curve DD by the following linear approximation:

(4) $$w = w_1 - b(L - L_1)$$

where b is the slope of DD at the point B. Similarly, we approximate the consumer's inverse compensated labour supply curve SS by the following linear approximation:

(5) $$(1-t)w = (1-t_1)w_1 + c(L - L_1)$$

where c is the slope of DD at the point C. Now regard (4) and (5) as two simultaneous equations and solve for w and L in terms of t, obtaining the solution functions $w(t)$ and $L(t)$. Substituting these functions into (1) and (2) and evaluating the derivatives in (3) yields the following expression for the marginal excess burden evaluated at $t = t_1$:

(6) $$MEB(t_1) = t_1 w_1 / \left[L_1(b+c) - t_1 w_1\right].$$

Define the negative of the elasticity of demand evaluated at the point B as σ. The elasticity σ and the slope b are related as follows:

(7) $$b = w_1 / \sigma L_1.$$

Define the compensated elasticity of supply evaluated at the point C as η. The elasticity η and the slope c are related as follows:

(8) $$c = (1-t_1)w_1 / \eta L_1.$$

Substitution of (7) and (8) into (6) yields the following expression for the marginal excess burden:

(9) $$MEB(t_1) = t_1 / \left[(1-t_1)(1/\eta) + (1/\sigma) - t_1\right]$$

(10) $$= \sigma \eta t_1 / \left[\eta + (1-t_1)\sigma - \sigma \eta t_1\right]$$

where (10) follows from (9) if η and σ are both non-zero and finite.

The case considered by Browning (1976) (and corrected by Findlay and Jones (1982; 556)) is a special case of (9) when $1 / \sigma = 0$. In this case, (9) reduces to:

$$(11) \qquad MEB_{FJ}(t_1) = \eta t_1 / [1 - t_1 - \eta t_1]$$

which in turn is approximately equal to Browning's (1987; 13) amended formula for the marginal excess burden:

$$(12) \qquad MEB_B(t_1) = \eta t_1 / [1 - t_1].$$

The above diagram and analysis illustrates the Harberger-Browning partial equilibrium approach to measuring the incremental excess burden that can be associated with increasing taxes to finance a government project. Note that this approach leads to the rather complex formulae (9) or (10) when the demand for labour function is not perfectly elastic. Note that if either η (the supply elasticity) or σ (the negative of the demand elasticity) are zero, then the marginal excess burden will also be zero.

By differentiating the right hand side of (10) with respect to t_1, η and σ, it can be shown that the marginal excess burden increases as t_1 (the tax rate on labour income), η (the supply elasticity) and σ (the negative of the demand elasticity) increase. This means that if $\sigma > 0$, $\eta > 0$ and $0 < t_1 < 1$, we have the following relationships between our general measure of marginal excess burden $MEB(t_1)$, the Findlay and Jones special case $MEB_{FJ}(t_1)$ and Browning's approximate measure of marginal excess burden $MEB_B(t_1)$:

$$(13) \qquad MEB(t_1) < MEB_{FJ}(t_1)$$

$$(14) \qquad MEB_B(t_1) < MEB_{FJ}(t_1).$$

We also require positive denominators in (10), (11) and (12) to establish the inequalities in (13) and (14).

The above partial equilibrium approach to defining marginal excess burdens has a number of important limitations: (i) the approach is limited to changes in labour tax rates and it is not clear how to extend the approach to changes in other tax rates; (ii) the change in t may induce changes in other prices and quantities which may affect welfare; (iii) the partial equilibrium approach does not specify precisely what the government will do with any extra tax revenue; and, (iv) it is not clear whether consumers receive transfer payments from the government to keep them at a constant utility level as tax rates are varied. The above difficulties (and additional ones) were raised by Stuart (1984), Ballard, Shoven and Whalley (1985), Hansson and Stuart (1985), Ballard (1990) and Fullerton (1991). The general approach of the above authors to dealing with the problems raised by the partial equilibrium approach has been to specify a small general equilibrium model of the economy under consideration with explicit consumer, producer and government budget constraints. The incremental disincentive effects of raising any government tax rate can then be evaluated in the context of their specific general equilibrium model. We shall take up this general equilibrium approach in later chapters. However, instead of using restrictive functional forms to model consumer and producer behaviour or relying on guesstimates for the relevant elasticities, we shall attempt to estimate statistically these elasticities using flexible functional form techniques. Our econometric model of producer and consumer behaviour will be explained in detail in Chapters 5 and 6 below.

Taxes place a 'wedge' between social and private returns. The effects of tax wedges can be illustrated by considering an individual who allocates his labour and capital endowments to maximise returns (both monetary and non-monetary). To do this he will allocate his endowments so as to equalise the after-tax return from uses in both high tax and low tax sectors. Low tax sectors include leisure, do-it-yourself work and the 'shadow' economy. Tax wedges induce people to allocate too much of their resources to low tax sectors where the marginal social returns (as measured by the pre-tax return) are lower. The tax wedges thus divert resources from high tax to low tax sectors and act as barrier to raising total output (goods and leisure) that could result from reallocating resources.

Tax wedges pervade the economy and it is their total impact which is important rather than just looking at one particular market or activity in isolation. Lindbeck (1986) argues the most obvious disincentive effects of marginal tax wedges can be summarised as substitution in favour of:

- leisure or recreation;
- lower intensity of work ('on-the-job' leisure if wages are tied to productive effort);
- the pursuit of do-it-yourself work;
- production for barter;
- occupations with large non-pecuniary benefits; and
- the search for tax loopholes.

There may also be many less obvious effects of tax wedges. For instance, if the income tax system is progressive and the after-tax discount rate is relatively insensitive to tax increases, there will be an incentive to substitute away from investment in human capital although in practice this may be offset to some extent by the tendency of governments to provide highly subsidised education. Labour mobility will also be adversely affected by progressive taxes as wage differentials between regions or industries provide less incentive for people to incur the adjustment costs associated with changing locality or occupation.

The structure of the tax system is also very important. To the extent that the government relies on income rather than consumption taxes there will be a substitution effect away from savings due to the double taxation of savings inherent in most income tax systems. Asset choice can also be distorted by effective tax rates which differ widely between assets. Investment in shares, bank deposits and physical production assets are usually discriminated against relative to consumption-related investment in housing, consumer durables and collector's items which all receive favourable tax treatment, often not being taxed at all. Inflation often aggravates this situation in tax systems which are not indexed.

Given the highly mobile nature of capital today, taxes which penalise investment in physical production assets or make a country a less attractive place to invest relative to its competitors are likely to be particularly damaging. By reducing the rate of capital accumulation, economic growth will be adversely affected and living standards will suffer in the long-run.

Depending on the institutional and cultural characteristics on an economy, there may also be significant lags in the disincentive effects of taxation becoming fully apparent. Consider an economy which has centralised wage fixing and a standard award structure. The long-run impact of higher taxation will be for employees to seek changes to awards to allow for shorter working hours and more liberal special-purpose leave conditions. In other words, there will be pressure for more tax-free benefits to be built into awards.

Disincentive effects are not the only form of deadweight costs which need to be allowed for. As noted in Chapter 1, avoidance, evasion, compliance and administration costs are all likely to be significant and need to be taken into account when assessing the worth of public sector projects. This is best summarised by Slemrod (1990) who notes:

> "Taxation is a system of coercively collecting revenues from individuals who will tend to resist. The coercive nature of collecting taxes implies that the resource cost of implementing a tax system is large."

The focus of the current study, however, is on the deadweight costs arising from the disincentive effects of the New Zealand tax system. The disincentive effects of the tax system are likely to be the empirically most significant source of deadweight cost.

2.2 The Effects of Taxation on Economic Growth

Many factors determine a country's rate of economic growth. The interactions between these factors are often complex. Typically, higher rates of investment lead to higher economic growth as current consumption is forgone to make way for higher production levels in the future. However, innovation and the development of new products are also vital to the process.

Government expenditure and, hence, taxation plays a crucial role in providing law and order and the enforcement of property rights necessary for a stable economic environment which will be conducive to investment and risk-taking necessary for economic growth. Public provision of key economic infrastructure such as transport systems can also play an important role.

However, increasing intervention by governments and higher levels of taxation will affect growth prospects as individuals' incentives to undertake investment, innovation and improvements in their human capital are reduced. By stifling these incentives, high levels of taxation will encourage people to substitute in favour of current consumption, including leisure consumption.

A number of studies have attempted to examine the relationship between taxation levels and achieved economic growth rates. While these studies typically lack any underlying analytical framework and rely instead on *ad hoc* regression analysis, a number of interesting conclusions have emerged. For instance, in a combined cross-section, time-series study of 103 countries between 1960 and 1980, Scully (1991) found that, on average, countries reached their maximum economic growth rates when they took less than 20 per cent of GDP in taxes. Economic growth rates tended to reach zero and then become negative once taxes consumed more than 45 per cent of GDP.

Scully also found that governments maximised the dollar value of their revenue collections when around 43 per cent of GDP was taken in taxes. Attempts to take a larger share of private sector income actually led to the tax base shrinking to the extent that the dollar value of revenue collected declined.

To illustrate the interaction of taxes and growth rates in his study, Scully compares two identical countries. If one chooses its tax rate to maximise current revenue (43.2 per cent of GDP) while the other chooses the tax rate to maximise economic growth (19.3 per cent of GDP), then after 40 years the country that maximises growth will have nearly the same government revenues as the high taxing country but its citizens will have more than three times as much after-tax income as the high tax country.

Studies by Littman (1990, 1991) have found a similar pattern within the United States where states with the highest tax effort (state taxes as a per cent of the tax base) have been losing population to the states with the lowest tax efforts. The ten states with the highest population growth between 1970 and 1990 had an average tax effort 12 per cent below the national average. For the same period, the ten states with the lowest tax effort had an average employment growth of 18 per cent while the ten states with the worst employment growth records all had tax efforts above the national average.

The results of these studies provide important circumstantial evidence on the likely adverse effects of high levels of taxation on economic growth prospects. They point to the need to reassess whether the community is getting value for money from the taxes it pays.

2.3 Key studies of the magnitude of deadweight costs

As noted at the start of this Chapter, a seminal paper in the literature on deadweight costs is that of Browning (1976) who formalised the notion of the marginal cost of public funds. He was motivated by the observation that the cost of financing public expenditure is the value of the expenditure itself plus the welfare or deadweight cost of that expenditure. He applied his methodology to calculate the deadweight cost for taxes that affect labour in the United States.

Browning used the standard formula developed by Harberger (1964). The formula shows that the total deadweight cost aggregated over all workers is:

(1) $$W = \frac{1}{2}\eta t^2 Y$$

where W is the deadweight cost, η is the elasticity of labour supply (compensated for income effects) with respect to a change in disposable income, t is the tax rate and Y is total labour income.

Browning's measure requires an estimate of the elasticity of labour supply compensated for income effects. The intuition of this is as follows. The imposition or raising of a tax on labour income reduces the incentive to work relative to consuming leisure. However, there is also a reduction in disposable income and this has a separate general affect on the amount of consumption of goods and leisure that an individual chooses. This income effect does not normally affect allocative choices and it is, therefore, separated out when measuring deadweight costs. Another reason for separating out income effects is that it is normally assumed that the alternative means of raising the revenue would be a lump sum tax that would only have income effects.

Browning examined the effect of a change in the tax rate by taking the derivative as follows:

(2) $dW = \eta t Y dt$

where dW is the change in the deadweight cost and dt is the change in the tax rate. Assuming a proportional income tax, revenue (R) is given by:

(3) $R = tY$

and additional revenue for a change in the tax rate (for an unchanged tax base) is given by:

(4) $dR = Y \ dt.$

The marginal welfare or deadweight cost per dollar of revenue raised is therefore:

(5) $dW / dR = \eta t.$

The marginal cost of one dollar of public funds is the marginal welfare cost of taxation plus the direct cost or $(\eta t + 1)$.

The above formulae were derived for the case of a proportional tax. Browning also considered the case of a flat rate tax with an exemption up to a certain limit (known as a degressive tax) and of a tax with graduated rates that rise as incomes rise (known as a progressive tax).

The deadweight cost for a degressive tax is given by:

(6) $dW / dR_D = \eta t \ \ Y / B$

where B is the tax base. Since Y is greater than the tax base, the deadweight cost for a degressive tax will be greater than for a proportional tax. Browning shows that with an exemption of 40 per cent of average income, Y / B would be 1.6. In order to raise the same revenue as a proportional tax m would have to rise from 35 to 56 per cent. This implies the marginal deadweight cost for a degressive tax would be 2.5 times larger than for a proportional tax yielding the same revenue.

The deadweight cost for a progressive tax varies depending on how the different rates in each tax bracket are varied. The general formula is as follows:

(7) $dW / dR_p = \sum_i \ \eta t_i Y_i + B_i * change \ in \ t_i + change \ in \ t$

where t is the average tax rate for all brackets and there are i brackets. Browning used formulae 5, 6 and 7 to calculate the deadweight costs of raising an additional dollar in taxation after taking account of the existing marginal tax rates implied by the US federal, state and local income and sales taxes, payroll taxes and social security taxes. He thus assumed that all these

Table 2.1: The Marginal Cost of Public Funds Estimated by Browning

	Proportional Tax	*Degressive Tax*	*Progressive Tax*
Marginal deadweight cost as a per cent of tax revenue	8	13	16
Marginal cost of one dollar of public expenditure	1.08	1.13	1.16

Source: Browning (1976)

taxes affect the decision to work and are effectively borne fully by labour. For example, sales taxes reduce the purchasing power value of earnings and this induces a substitution from taxed goods to untaxed goods including leisure.

Browning's results are shown in Table 2.1. They show that the marginal deadweight cost of raising additional tax revenue varies from 8 per cent to 16 per cent of the additional revenue depending on whether a proportional or a progressive tax structure is used. Although Browning's work was pathbreaking, his estimates of the magnitude of marginal deadweight costs are low compared to subsequent, more sophisticated studies.

As noted in Section 2.1, Browning (1987) modified the approach to adjust for an error arising from the fact that data relating to a situation in the presence of a tax were used, whereas the formula applied to the situation in the absence of a tax. This understated the welfare cost by a factor of $1/(1-t)$. The revised estimates of the marginal deadweight costs as a per cent of tax revenue varied from 8 to well over 100 per cent.

Findlay and Jones (1982) identified the error in Browning's original paper. They also allowed the tax base to vary in their methodology which they applied to Australian data for income, excise and sales taxes. For a compensated elasticity of supply of 0.2 they found the deadweight cost varied from 23 to 65 per cent of tax revenue, depending on whether the rate structure change was proportional, degressive or progressive. For an elasticity range of 0.1 to 0. 4, they found a deadweight cost of 11 to 160 per cent of tax revenue.

A number of other approaches to measuring the deadweight costs of taxation have been developed in the literature. Differences can often be traced to the definition of consumer utility and the specification of labour supply, and whether partial or general equilibrium approaches are used.

The measures of Stuart (1984) and Ballard, Shoven and Whalley (1985) were derived from the computation of a two sector and a multisector general equilibrium model, respectively. They can be used to illustrate some general equilibrium implications.

As noted by Stuart (1984), Browning's approach is strictly only valid for small changes and, more importantly, it compares an undistorted equilibrium to a fully compensated situation. However, most tax changes start with a distorted equilibrium and lead to a new distorted equilibrium. Another problem is that the equilibrium level of welfare and tax revenue depends on the way the government spends the revenue. Stuart overcomes these problems and also relaxes Browning's assumption of a fixed tax base by using a simple general equilibrium framework.

The model assumes two sectors, corresponding to a taxed market sector and a non-taxed household (and leisure) sector. Capital stocks in each sector are assumed fixed and immobile between sectors. Simple, explicit production and utility functions are assumed. Government expenditure takes two forms; consumption which does not affect utility, and transfers that increase household income. The model yields a general equilibrium computation for the deadweight cost of taxation. Calculations are undertaken for United States data on personal income, payroll and excise taxes since all these can be avoided if labour shifts from taxed to untaxed uses.

The deadweight cost as a per cent of tax revenue varied from 21 to 100 per cent for compensated elasticities of supply from 0.2 to 0.84 and a marginal tax rate of 42.7 per cent. The range was 24 to 133 per cent for a marginal tax rate of 46 per cent.

The foregoing estimates relate to an assumption that all marginal tax revenue is distributed on a lump sum basis. When an alternative assumption is made that all tax revenue is used to finance government consumption the benchmark deadweight cost falls from 21 to 7 per cent. The intuition of this result is that when revenue is directed to government consumption, individuals receive no income (or consumption) benefits and they do not consume more leisure. But when the revenue is spent on transfers, the income effects mean that they do consume more leisure making it more difficult to raise revenue. Thus, in the former case it is easier to raise revenue because of income effects and this lowers the deadweight cost burden. This striking result suggests that the marginal excess burden of wasteful government expenditure is less than for redistributional programs.

Ballard, Shoven and Whalley (1985) used a multisector, intertemporal, computational general equilibrium model to calculate simultaneously the welfare effects of all major taxes in the United States. They estimated the marginal deadweight loss from a 1 per cent increase in all distortionary taxes. For a plausible range of elasticities they found deadweight costs amount to from 17 to 56 per cent of revenue raised (Table 2.2). They also demonstrated that the deadweight cost is higher when elasticities and tax rates are larger.

Table 2.2: Marginal Deadweight Cost Estimates of Ballard, Shoven and Whalley

Labour supply elasticity (uncompensated)	Saving elasticity 0.0	0.4	0.8
		per cent of revenue	
0.0	17	21	24
0.15	27	33	38
0.30	39	48	56

Source: Ballard, Shoven and Whalley (1985)

Jorgenson and Yun (1990) also used a multisector general equilibrium model of the United States to calculate the welfare effects of the complete tax system. Their model differed from that of Ballard, Shoven and Whalley by specifying a very detailed representation of the tax system. In particular, distinctions were made between short- and long-lived assets and among assets held in the corporate, non-corporate and household sectors. Distinctions were also made between average and marginal tax rates and the different tax treatment of different types of income.

For the tax system after the 1986 tax reform, they found a marginal efficiency cost of 38 per cent of tax revenue and an average efficiency cost of 18 per cent of tax revenue.

They also calculated efficiency costs before the tax reform and compared them with earlier estimates (Table 2.3). They found generally higher estimates, especially for capital. It should be noted that they model capital taxes in much more detail than Ballard, Shoven and Whalley and therefore show inter-asset and inter-sectoral capital distortions to be very large. This is consistent with strong substitution possibilities among capital assets.

Table 2.3: Comparison of Marginal Deadweight Cost Estimates

	Ballard, Shoven and Whalley	*Jorgenson and Yun*
	per cent of tax revenue	
Capital	46	92
Labour	23	48
All	33	46

Source: Ballard, Shoven and Whalley (1985), Jorgenson and Yun (1990)

These studies illustrate that the deadweight costs of taxation can be very high, even for relatively low-tax countries such as the United States. The few studies which have been carried out for the high-tax, European 'welfare state' countries indicate that deadweight costs can become massive when very high taxes are combined with complex social welfare systems. For instance, using a two sector, two input general equilibrium model, Hansson and Stuart (1985; 345) found that the marginal cost of public funds in Sweden was around \$2.30 for government spending on transfer payments and \$1.70 for government spending on goods and services for each additional dollar of taxes collected. Marginal tax rates in Sweden at the time were around 70 per cent for the *average* taxpayer (inclusive of all taxes and income-dependent transfers).

3. EMPIRICAL HIGHLIGHTS OF THE NEW ZEALAND ECONOMY

3.1 Background

The New Zealand economy has undergone considerable change over the last 20 years. New Zealand was traditionally an agricultural exporting nation heavily reliant on exports to Britain. It was badly affected by Britain joining the European Community. The Muldoon government in the late 1970s engaged in large and unsustainable spending programs and attempts to support industry which produced burgeoning debt levels and led the country into a precarious economic state.

The Labour government elected in 1984 embarked on an ambitious reform program which reduced assistance levels dramatically, completely revamped the tax system and saw the commercialisation and privatisation of key state-owned enterprises. The focus of recent reforms has been the labour market where the centralised wage-fixing system has been replaced by a system of individual employment contracts.

The pace of reform in New Zealand has been rapid, aided by the unusual parliamentary system which has only one house elected on a first-past-the-post basis. The extent of reform undertaken has made New Zealand the focus of interest of other countries interested in gauging the success of the reforms. Until recently, the adjustment costs associated with the reforms appear to have been high and growth performance has been disappointing but evidence is now emerging that the benefits of the reform program are flowing through and New Zealand is well placed to emerge from the international recession ahead of other countries.

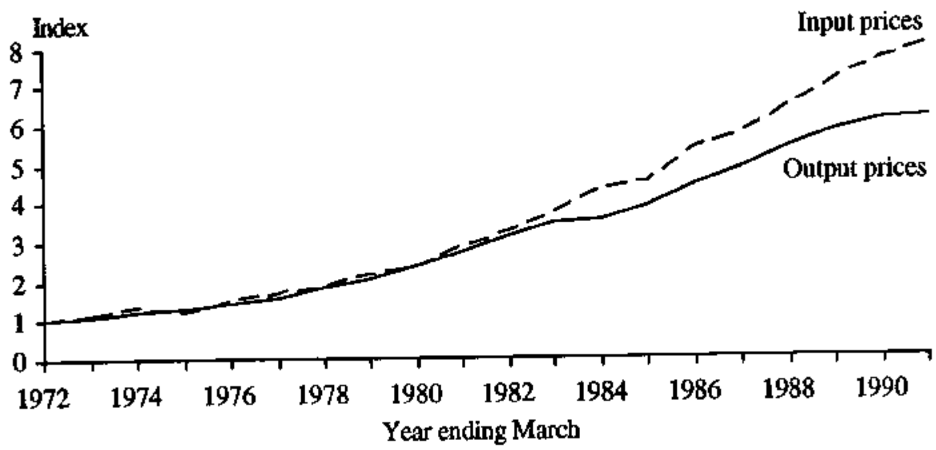
The tax system has been a major focus of the New Zealand reform program and the tax system now existing is regarded by many to be one of the best in the world. However, total tax levels remain high compared to many countries and government expenditure has largely continued unchecked leading to significant deficits and increased foreign debt. This points to the need for further reforms.

In the following section key price movements in the New Zealand economy over the last 20 years are reviewed. This is followed by a review of the performance of the economy's market sector in Section 3.3. The characteristics of the New Zealand tax system are then reviewed in Section 3.4. The derivation of the data reported in this Chapter and the principles used in its construction are outlined in Appendix A.

3.2 Price Movements

Output prices received by market sector producers increased at an annual trend rate of 10.3 per cent per annum between 1972 and 1991. However, the aggregate input price paid by producers increased at an annual trend rate of 11.6 per cent. As can be seen from Figure 3.1, overall output and input prices remained relatively close for the first of the two decades but steadily diverged after 1982.

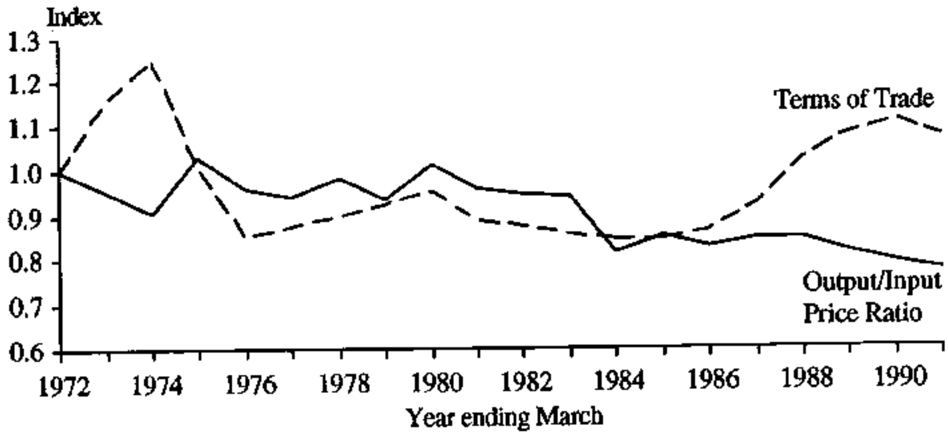
Figure 3.1: **Market Sector Total Output and Input Prices**



Source: Swan Consultants (Canberra) New Zealand database.

The declining price situation faced by New Zealand producers is illustrated in Figure 3.2 where the prices received to prices paid ratio for total outputs and inputs can be seen to have fluctuated but remained steady for the first half of the period before generally declining after 1982. The annual trend rate of decline for the whole period was 1.2 per cent. If producers are to maintain

Figure 3.2: **Prices Received to Prices Paid Ratios**



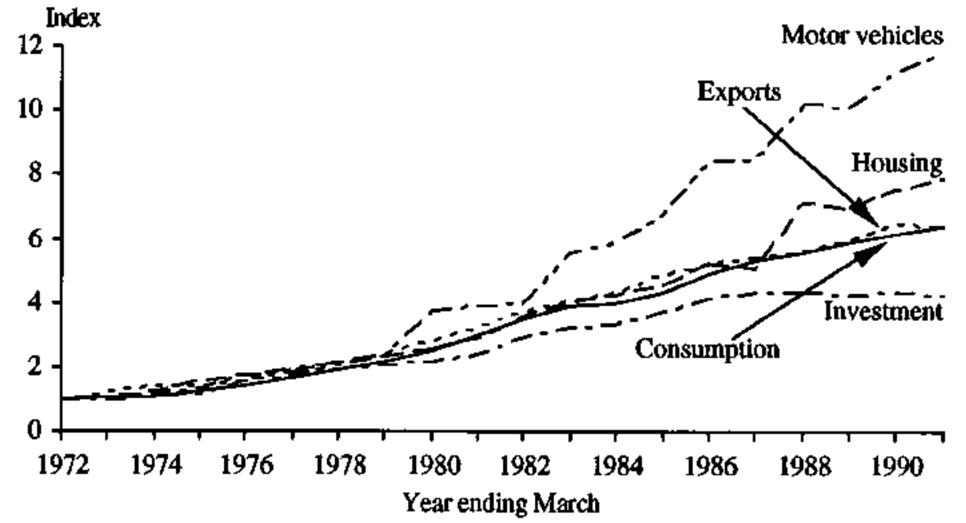
Source: Swan Consultants (Canberra) New Zealand database.

their profitability in the face of such declines in the prices received to prices paid ratio then offsetting productivity improvements must be made.

In terms of international price movements the New Zealand economy has fared better. The terms of trade graphed in Figure 3.2 shows the ratio of export prices to import prices. It illustrates that since 1985 export prices have improved relative to import prices meaning that New Zealand's exports have been able to purchase an increasing quantity of imports. For the 20 year period the terms of trade annual trend decline was only 0.2 per cent.

Price indexes for 5 output components - motor vehicles, housing investment, general consumption goods (excluding housing and transport), general investment and exports - are shown in Figure 3.3. Prices for the major outputs of general consumption goods and exports have moved together closely and increased at a trend annual rate of over 10 per cent. Producer prices for motor vehicles have increased the most rapidly with a trend growth rate of almost 15 per cent, followed by housing investment on 11 per cent. The price of general investment goods have increased the least rapidly with a trend rate of growth of 8.4 per cent.

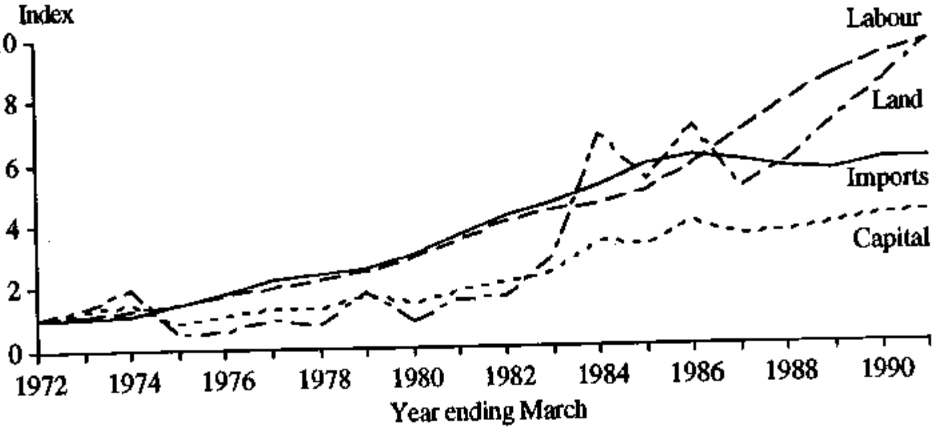
Figure 3.3: Producer Output Prices



Source: Swan Consultants (Canberra) New Zealand database.

Input prices shown in Figure 3.4 have exhibited more variability with land user cost prices increasing the most steeply at an annual trend rate of over 14 per cent. Labour prices have also risen sharply at a trend rate of 12.4 per cent. Import prices, on the other hand, have levelled off since 1985 to produce an annual trend increase of 10.4 per cent. Capital user costs have consistently remained low throughout the period with a trend increase of 8.7 per cent.

Figure 3.4: **Producer Input Prices**



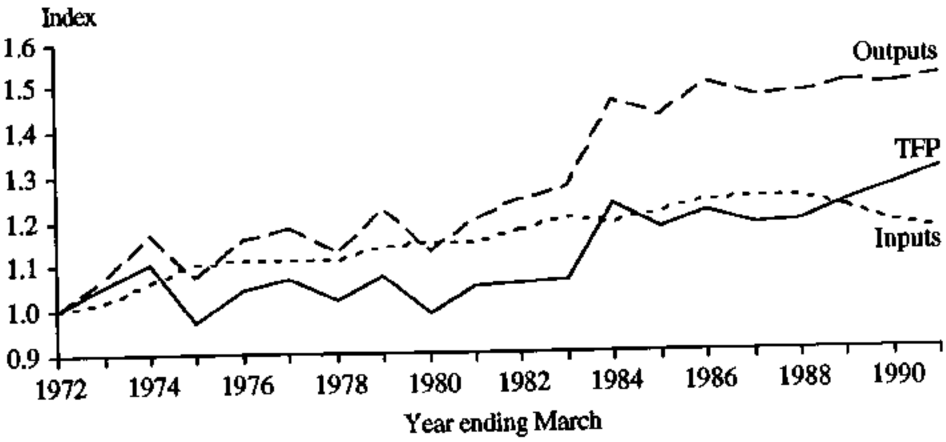
Source: Swan Consultants (Canberra) New Zealand database.

3.3 Economic Performance of the New Zealand Economy

The best summary measures of economic performance are total factor productivity and the economic rate of return. Total factor productivity (TFP) measures the amount of total outputs produced per unit of overall inputs. Improvements in TFP can be brought about by technical change, improved management and the elimination of inefficient work practices. The economic rate of return provides a measure of true profitability based on the current market value of assets.

The New Zealand economy's market sector TFP is presented in Figure 3.5 along with total output and total input quantity indexes. TFP performance is quite different between the first and second decades of the period covered. For the first half of the 20 year period, TFP remained

Figure 3.5: **Outputs, Inputs and Total Factor Productivity**



Source: Swan Consultants (Canberra) New Zealand database.

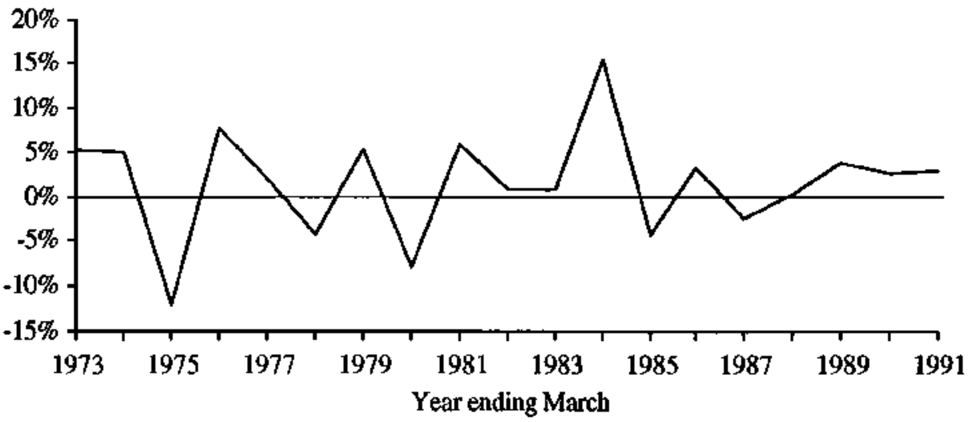
stationary apart from minor fluctuations around the trend. This coincided with the period of high assistance to industry and large expenditure of public resources on 'Think Big' projects. The deleterious effects of these polices on the economy can be seen from the dismal TFP performance.

The situation only began to improve after 1983 when extensive reforms were introduced. These reforms have led to productivity improvements but the economy's performance has remained sluggish as extensive restructuring has taken place with associated adjustment costs. Nevertheless, by the end of the 20 year period New Zealand's TFP level was 30 per cent above its 1972 level.

The annual trend rate of change in New Zealand's TFP for the period as a whole was 1.2 per cent. Although total output increased at a trend rate of 2.2 per cent over the 20 years, it has increased little since 1984. Recent productivity improvements have mainly been brought about by reductions in total input use, particularly since 1988. The main input whose use has fallen is labour which decreased by 13 per cent in effective terms between 1988 and 1991.

Year-to-year changes in TFP presented in Figure 3.6 have again centred around zero until the last few years reflecting the relatively poor TFP growth performance.

Figure 3.6: Total Factor Productivity Year-to-Year Changes

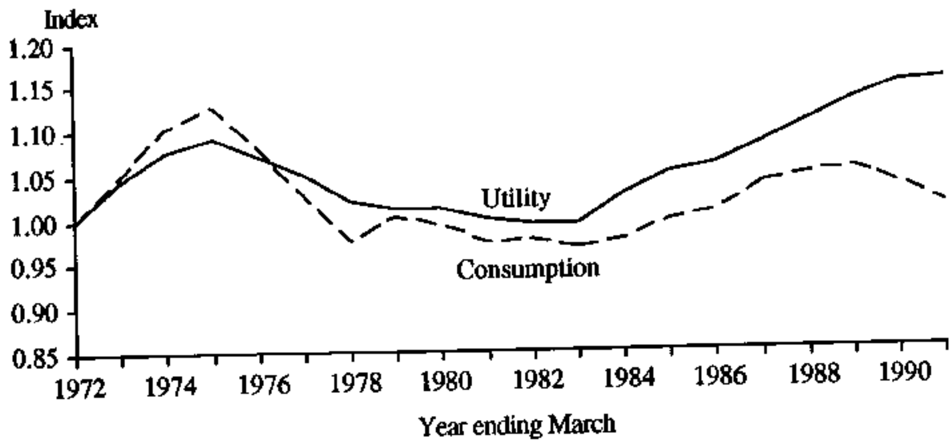


Source: Swan Consultants (Canberra) New Zealand database.

The relatively poor performance of the economy has been reflected in a very slow increase in the index of individual welfare or utility presented in Figure 3.7. This index represents the benefit the average person in the 15 to 64 years age group receives from the goods and services they consume. The goods and services included in the index are housing, transport, general consumption and leisure. Its derivation will be explained in the Chapter dealing with the consumer model. Over the 20 year period individual welfare has increased at a trend rate of only 0.4 per cent per annum. After an initial improvement in welfare between 1972 and 1975 of nearly 10 per cent, welfare levels then fell and were at levels slightly below their 1972 level between 1981 and 1983. Despite a steady increase after 1983, individual welfare levels were only 15 per cent better in 1991 than they were in 1972.

The individual consumption of goods and services index also shown in Figure 3.7 indicates that much of the recent improvement in individual welfare comes from increases in leisure. By the end of the period individual consumption levels were only slightly above what they had been 20 years earlier.

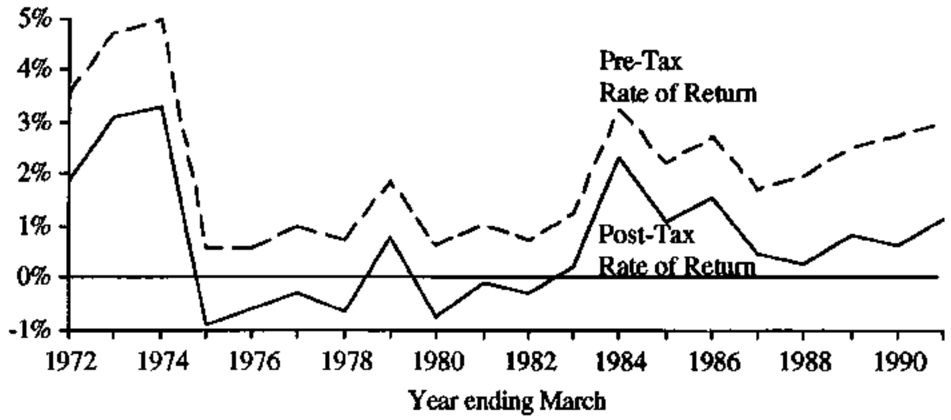
Figure 3.7: Individual Welfare and Consumption Indexes



Source: Derived from Swan Consultants (Canberra) New Zealand database.

The profitability of the private production sector is reflected in the real rates of return presented in Figure 3.8. The before-tax real rate of return averaged 2.1 per cent for the 20 year period. The highest before-tax real rate of return achieved was 5.0 per cent in 1974. However, the following year the real return plummeted to 0.6 per cent and stayed at low levels through until 1984. Since then the before-tax real return has remained in the range of 2 to 3 per cent. The post-tax real return, the return which drives investment decisions, has been far from healthy over most of the period. After starting at reasonable levels, the post-tax real return has been very low or negative for most of the period. It exceeded 3 per cent in only 1973 and 1974 before dropping to -0.9 per cent in 1975. The post-tax return remained negative through until 1983 with the exception of 1979. An increasing tax rate since 1984 has kept the post-tax real return at very low, albeit positive, levels despite the modest recovery in the before-tax return in recent years.

Figure 3.8: **Real Rates of Return**



Source: Derived from Swan Consultants (Canberra) New Zealand database.

The real after-tax rate of return for most western countries has been found to be in the range of 3 to 5 per cent (Robbins and Robbins 1992). The average real after-tax rate of return for the United States was found to be 3.3 per cent for the period from 1954 to 1990. The average real after-tax rate of return observed for New Zealand, however, over the 20 years to 1991 was only 0.7 per cent. Clearly, the after-tax profitability of the private sector has not been good and a serious re-examination of the taxation of capital in New Zealand is warranted if New Zealand is to become attractive as a place to invest.

3.4 The New Zealand Tax System

The extensive reforms to the New Zealand tax system introduced over the last decade have been guided by three broad principles (Toder and Himes 1992):

- the imposition of a broader-based income tax with flatter rates;
- more reliance on indirect taxes; and,
- a reduction of tax-created and welfare payment poverty traps.

In reforming the income tax, the government cut the top personal income marginal tax rate from 66 to 33 per cent. The current tax structure has only two rates - 24 per cent for income up to around $31,000 and 33 per cent for income over this amount. A number of tax credits for family support and tax rebates typically introduce a tax free income amount for most taxpayers. A comprehensive fringe benefits tax was introduced to capture in-kind payments to employees. Corporate tax rates are now set equal to the top personal rate at 33 per cent and full imputation is allowed on dividends paid to shareholders to eliminate double taxation of dividends.

Withholding taxes have been introduced on interest and dividends at rates of 24 and 33 per cent, respectively. However, some forms of income remain tax-exempt, most notably capital gains except for those people classified as asset traders.

The simplification of the income tax system and reduction in marginal tax rates was facilitated by the introduction of a single-rate comprehensive value-added tax, known as the Goods and Services Tax (GST), which replaced thé mish-mash of wholesale taxes existing beforehand. The GST applies at a uniform rate of 12.5 per cent and is generally regarded as one of the most 'pure' of its kind in the world with exports and financial transactions being about the only exemptions.

Quotas on imports which were prevalent during the late 1970s and early 1980s have been replaced with tariffs which are generally being phased down. Tariffs on many items remain high, however, by OECD standards.

Export incentives, accelerated depreciation and investment allowances, and other business investment tax incentives were generally eliminated. The reduction in the relative size of tax wedges on business investment and their absolute magnitude between 1984 and 1990 has been demonstrated by Rich (1991).

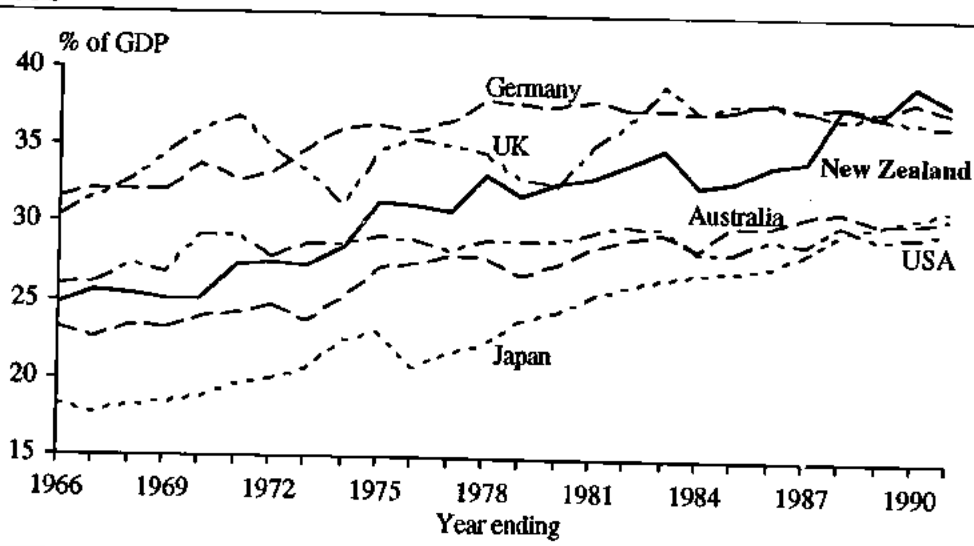
An area where the tax reforms have been less successful is the objective of reducing adverse effects on the incentive to work. While the decline in the top marginal tax rate has substantially increased the incentives to work for high income earners, effective marginal tax rates affecting labour supply decisions have not declined for lower income earners. The way social security benefits are provided has served to aggravate problems in this area.

Recent attention in the tax reform process has focused on the interface of the tax system with the rest of the world. A number of withholding taxes on international transactions have reduced the attractiveness of New Zealand as a place to invest although ad hoc processes such as the 'Approved Issuers' Levy' have been put in place to remove major impediments. A recent tax treaty with Australia has removed obstacles to New Zealand companies repatriating profits from Australian investments as tax paid on profits in Australia will now be recognised by New Zealand. Previously a withholding tax of 33 per cent had to be paid on all profits repatriated to New Zealand, regardless of whether foreign tax had already been paid or not.

In spite of the impressive gains made in reforming the New Zealand tax system, some major problems remain. The most striking of these has been the rapid growth of taxation revenue as a percentage of Gross Domestic Product (GDP). As shown in Figure 3.9, New Zealand now has a higher share of taxation in GDP than Germany, the United Kingdom, Australia, Japan and the

United States. In 1966 New Zealand's tax share of GDP at 24.7 per cent was only 1.5 percentage points higher than Australia's and 1.2 percentage points less than that of the United States. By 1991 New Zealand's GDP tax share of 38.2 per cent was 7.4 percentage points higher than Australia's and 8.3 percentage points higher than that of the United States. The increase in New Zealand's tax take was around double that for Australia and the United States.

Figure 3.9: **Tax Revenue as a Percentage of GDP — Selected OECD Countries**

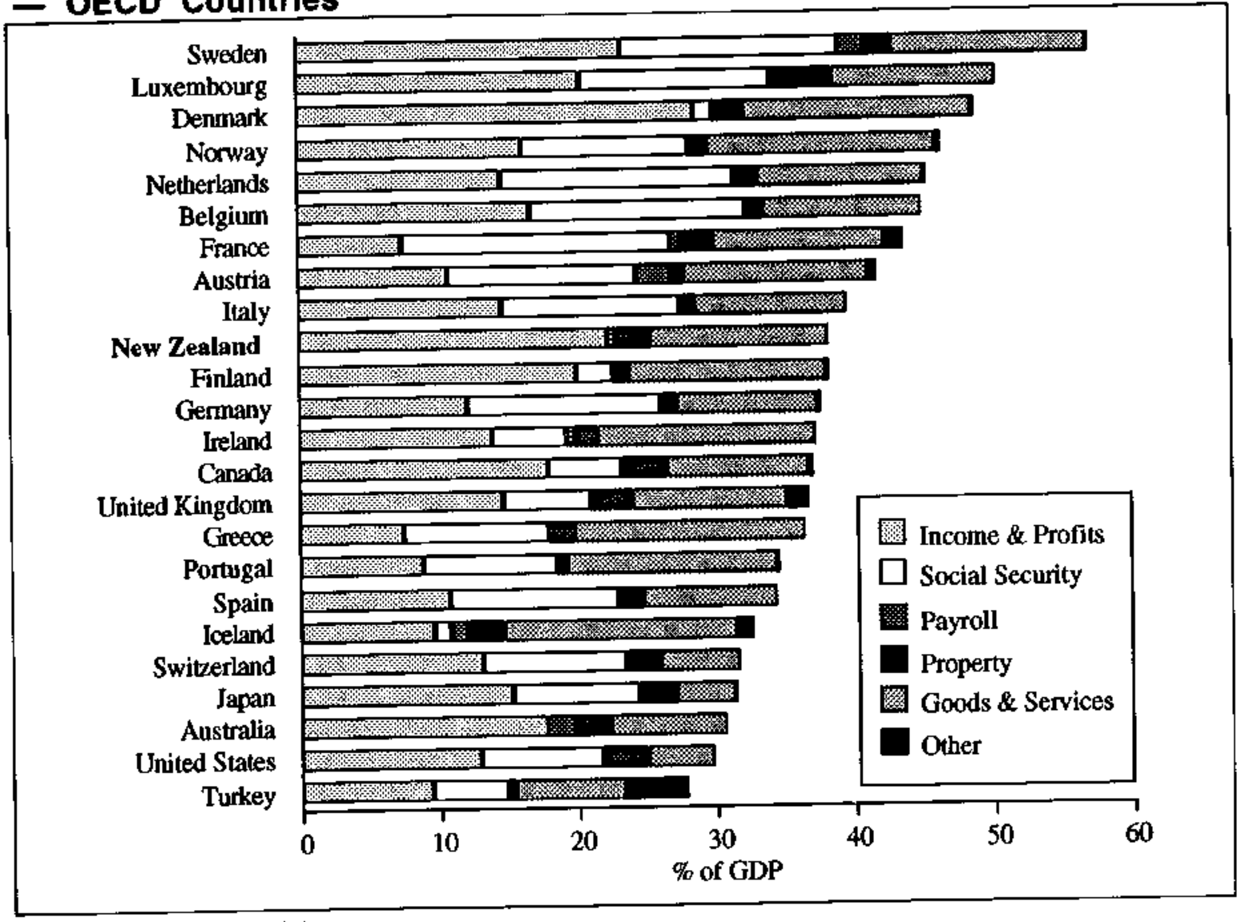


Source: OECD Revenue Statistics.

In 1991 New Zealand ranked tenth out of the 24 OECD countries in terms of the tax share of GDP (Figure 3.10). However, all those with higher tax shares are high tax European countries. In 1991 income and profits taxes accounted for 58 per cent of New Zealand's tax revenue. Although less than the OECD average of 62 per cent, this figure was still higher than that for Australia and the United Kingdom indicating that income taxes still play a leading role in New Zealand. Goods and services taxes accounted for one third of New Zealand tax revenue in 1991, 3.5 percentage points more than the OECD average. Countries where goods and services taxes played a larger part in the tax base included Norway, Finland and Ireland. Property taxes accounted for around 6 per cent of New Zealand tax collections in 1991 compared to the OECD average of 5 per cent. The remaining 2 per cent of revenue was accounted for by payroll taxes.

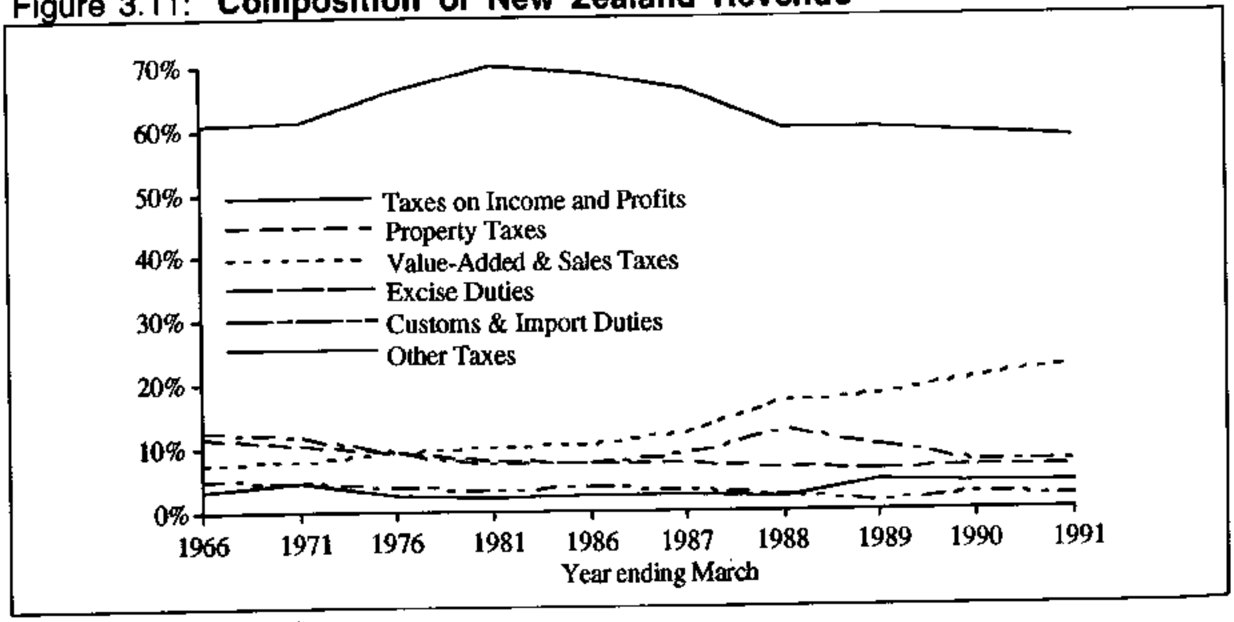
The changing composition of New Zealand tax revenue is shown in Figure 3.11. Over the last decade the share of income and profits taxes has fallen from around 70 per cent to 58 per cent while the importance of value-added and sales taxes has more than doubled from 10 to 22 per cent reflecting the introduction of the GST in 1986. Other taxes have remained relatively small contributors to total revenue with the importance of import duties declining and that of excise taxes fluctuating somewhat.

Figure 3.10: Composition of 1991 Tax Revenue as a Percentage of GDP — OECD Countries



Source: OECD Revenue Statistics.

Figure 3.11: Composition of New Zealand Revenue

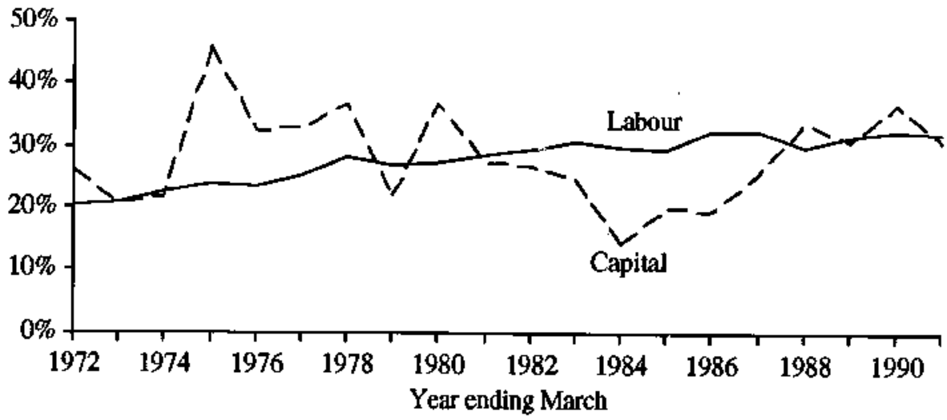


Source: OECD Revenue Statistics.

In calculating the deadweight losses caused by taxation it is necessary to know the size of the 'wedges' taxes impose between the price paid by the consumer or user and the price received by the producer or supplier. These tax wedges or tax rates on producer prices were estimated for New Zealand using taxation statistics from the International Monetary Fund's *Government Finance Statistics* and the OECD's *Revenue Statistics*. Before this information can be used to calculate the size of the tax wedges, however, it has to be allocated to the various factors of production and commodities. The process by which this was done is explained in detail in Appendix A. The six principal tax rates derived are those applying to labour, capital, general consumption (excluding housing and transport), motor vehicles, imports and housing property.

Tax rates on labour and capital income are presented in Figure 3.12. Labour income is defined to be the value of wages and salaries paid plus a return to the self-employed to cover the opportunity cost of their time. Capital income is calculated as the profit the private sector earns from its production activities and is defined as the value of its outputs (consumption goods, investment goods, exports and sales to government) less the value of variable inputs (imports and labour including the opportunity cost of the self-employed). In allocating tax payments to the two factors of production the main task is allocating the large payments by individuals between labour and capital. To do this, use was made of information supplied by The Treasury on details of source deduction tax payments and the income base for the residual 'other persons' payments category.

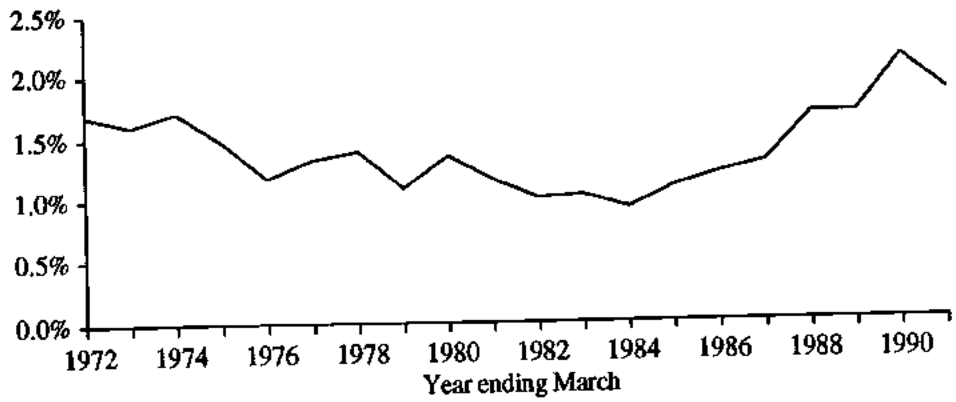
Figure 3.12: Tax Rates on Labour and Capital Income



Source: Swan Consultants (Canberra) New Zealand database.

The tax rate on labour income has increased throughout the last two decades from a rate of 20 per cent in 1972 to around 32 per cent in 1991. However, most of this increase occurred in the period between 1972 and 1983 with increases since 1983 being relatively minor. Capital tax rates on profit have fluctuated more widely due to the residual nature of profits as defined. After starting at levels similar to the labour tax rate, capital tax rates quickly increased to a very high level of 46 per cent in 1975 before generally falling back to a low point of around 15 per cent in 1984. Since then capital tax rates have again increased steadily to finish at levels similar to those applying to labour income.

Figure 3.13: Capital Tax Rate on Assets

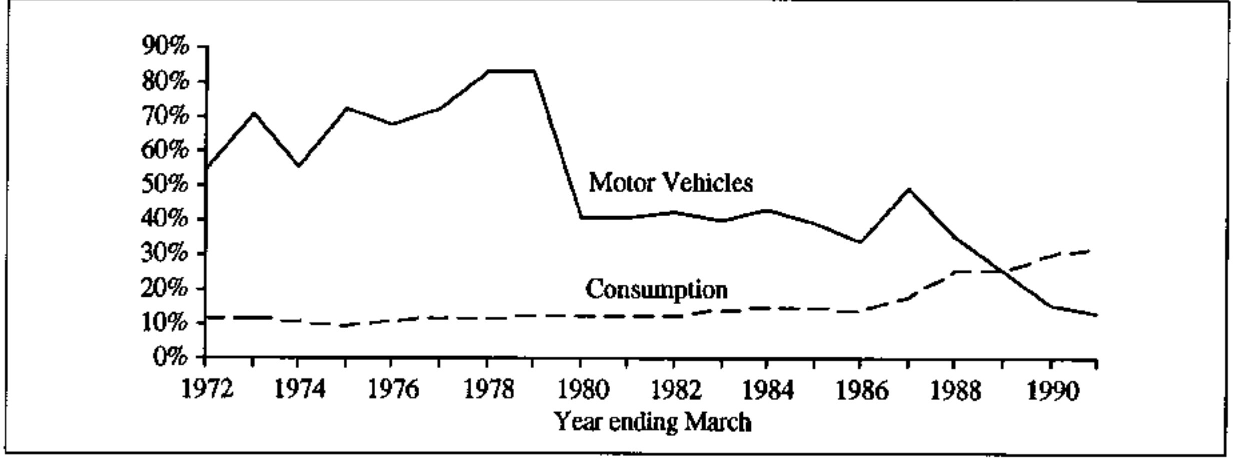


Source: Swan Consultants (Canberra) New Zealand database.

As noted earlier, real rates of return in New Zealand have not been healthy since the mid-1970s. Consequently, to obtain a more accurate representation of capital tax rates it is necessary to look at capital tax payments relative to the value of assets. It is this tax rate which drives investment decisions. From Figure 3.13 it can be seen that capital tax rates on assets fell from an early high of 1.7 per cent in 1974 to a low of 0.9 per cent in 1984 before increasing steadily to a very high rate of 2.1 per cent 1990. This illustrates that once the variability of profit and low rates of return are netted out in looking at the more stable and more important capital tax rate on assets series, changes to the New Zealand tax system since 1974 have fallen heavily on capital with tax rates more than doubling. In the same period labour tax rates increased by only one sixteenth. However, recent reforms have been aimed at easing some of the high capital tax rates, particularly by changing some withholding tax arrangements. The capital tax rate on assets fell from 2.1 per cent in 1990 to 1.8 per cent in 1991.

The increasing importance of indirect taxes is again illustrated in Figure 3.14 where the tax rate in terms of producer's prices on general consumption (excluding housing and transport) can be seen to have increased from around 11 per cent in 1972 to 32 per cent in 1991. Most of this increase has occurred since 1986 with the introduction of the Goods and Services Tax.

Figure 3.14: Consumption and Vehicles Tax Rates on Producers' Prices

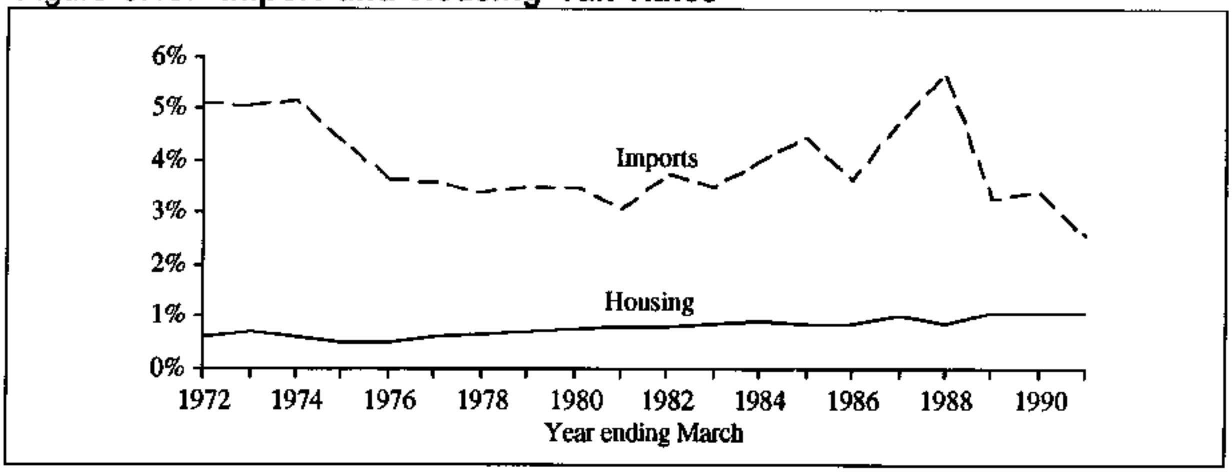


Source: Swan Consultants (Canberra) New Zealand database.

The producer price tax rate for an important consumer item, motor vehicles, can be seen to have changed dramatically over the last two decades. After starting at high levels in excess of 50 per cent in 1972 and increasing to a massive 83 per cent in 1978, the tax rate was halved in 1980 and has since been reduced further to end up at 13 per cent in 1991.

Finally, import duty rates and housing property tax rates are presented in Figure 3.15. The average import duty rate declined between 1972 and 1981 from 5.1 to 3.1 per cent. However, this marked a time when greater use was being made of import quotas to protect domestic industry. With the reforms progressively implemented from the early 1980s quotas were replaced initially by tariffs and then phased down. Consequently, average import duty rates again increased from 1981 to 1988 to peak at 5.7 per cent before falling away sharply after 1988 as the economy was opened up to international competition. The average import duty rate in 1991 was 2.6 per cent.

Figure 3.15: Import and Housing Tax Rates



Source: Swan Consultants (Canberra) New Zealand database.

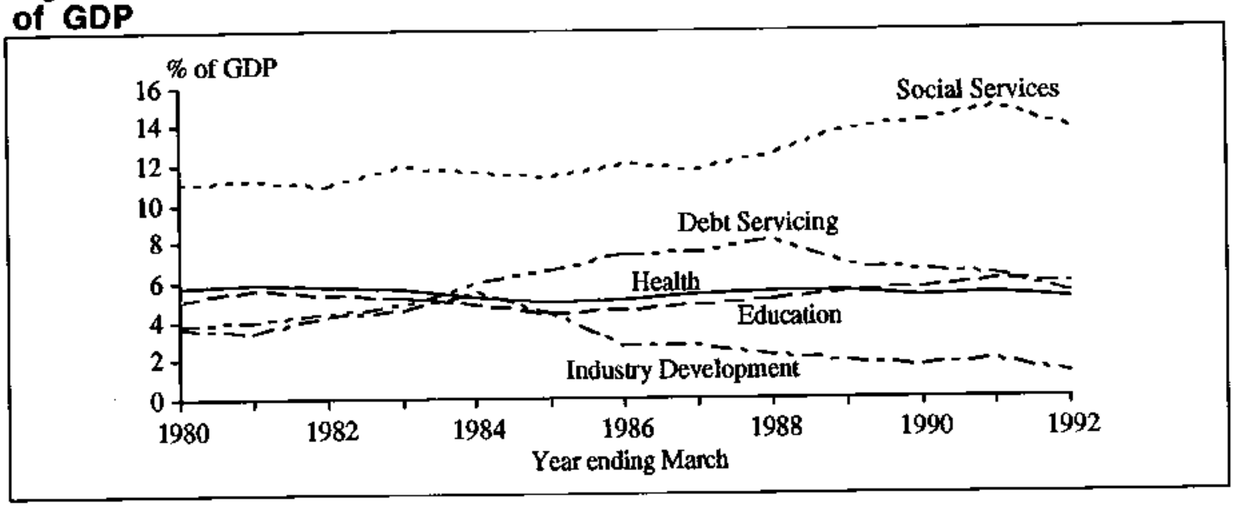
Housing property tax rates have increased steadily throughout the last two decades from 0.6 per cent in 1972 to 1.1 per cent in 1991. This is in line with experience in most OECD countries with the move to higher levels of cost recovery and user-pays pricing for services provided by local government.

3.5 Government Expenditure

While reform of the New Zealand tax system over the last decade has been impressive, it represents only one side of the government budget. Some beneficial reforms have also been made to government expenditure. However, major problem areas remain. The analysis of government expenditure and the fiscal position is complicated by the range of accounting conventions which have been adopted over the years and the tendency in recent years to remove some items from the government balance sheet as the public sector has been restructured and state owned enterprises have been privatised and corporatised (New Zealand Business Roundtable 1990). The composition of government expenditure expressed as a proportion of GDP using consistent data supplied by The Treasury is presented in Figure 3.16.

The most notable areas of reform in government expenditure have been the reduced expenditure on industry development and reduced debt servicing expenditure. Industry development expenditure fell from a peak of 5.4 per cent of GDP in 1984 to 1.2 per cent of GDP in 1992 as assistance levels to industry were reduced and the economy was exposed more to international competition. Debt servicing expenditure steadily increased from 3.9 per cent of GDP in 1980 to 8.0 per cent in 1988. It has since fallen back to 5.4 per cent although, as noted above, care should be exercised in interpreting debt servicing figures with recent rearrangements within the public sector.

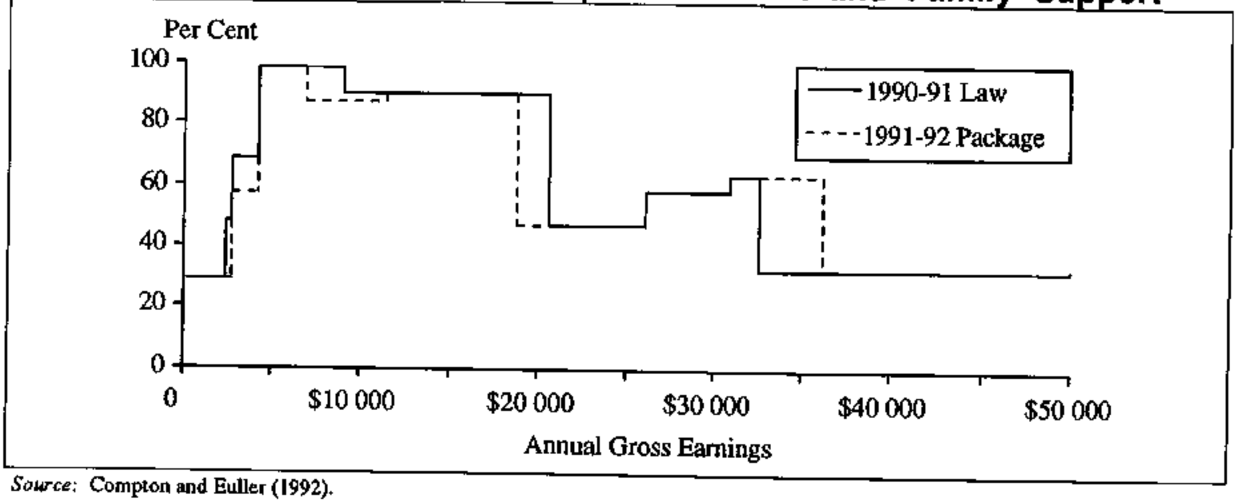
Figure 3.16: **Composition of Government Expenditure as a Percentage of GDP**



Source: The Treasury.

The largest single item of government expenditure remains social services and the proportion of GDP accounted for by this item has increased steadily until recently. Government expenditure on social services accounted for 11 per cent of GDP in 1980 and increased sharply between 1987 and 1991 to peak at 14.8 per cent before falling back to 13.7 per cent in 1992. Of major concern though is not only the volume of expenditure on social services but also the form of the expenditure and its effects on incentives. Generous benefits are paid to low income earners and these allow other income to be earned up to a threshold level from which time benefits are phased out as more non-benefit income is received. This leads to high effective marginal tax rates for most low income earners. In many cases the effective marginal tax rate is around 100 per cent up to incomes of $20,000. An example of an effective marginal tax rate schedule for a welfare recipient is presented in Figure 3.17. Clearly, when effective marginal tax rates are so high there is little reason for recipients to seek employment and contribute more to supporting themselves. This will have an adverse impact on economic performance as potential output from these individuals is forgone and bad demonstration effects reduce the incentives for those in the workforce to work harder.

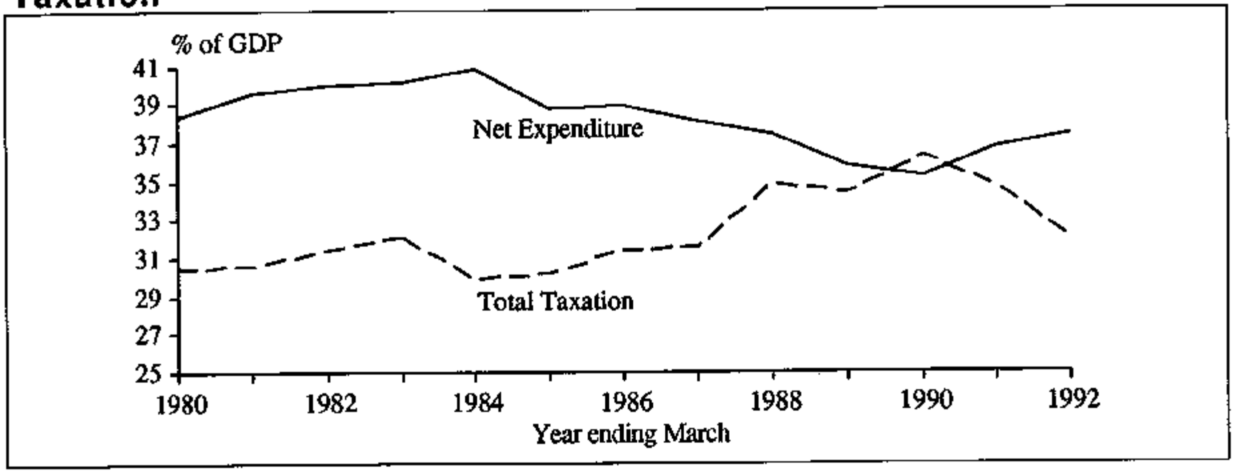
Figure 3.17: **Effective Marginal Tax Rates for Sole Parent with Three Children Receiving Domestic Purposes Benefit and Family Support**



Source: Compton and Euller (1992).

Throughout most of the 1980s there has also been a continuing imbalance between government expenditure and taxation revenue. Treasury figures for the central government in Figure 3.18 indicate that net expenditure has exceeded total taxation revenue for all years since 1980 except for 1990. This has been a significant contributing factor to the growth in New Zealand's foreign debt. In 1992 total net foreign debt stood at around 80 per cent of GDP. Net public debt stood at around 55 per cent of GDP in 1992-93 (Richardson 1992). This points to the need for greater discipline in restraining government expenditure so that debt levels can be reduced, paving the way for a sustainable reduction in taxation levels.

Figure 3.18: The Gap between Central Government Net Expenditure and Taxation



Source: The Treasury.

4. ALTERNATIVE MODELS OF MARGINAL EXCESS BURDEN

4.1 Introduction

Recall that in Chapter 2 above, we gave a diagrammatic and algebraic exposition of the partial equilibrium approach to measuring the marginal excess burden of a tax and expenditure increase.[1] This literature on excess burdens makes the following major point: since additional government expenditures have to be financed by raising taxes and since tax wedges generally distort choices of consumers and producers away from an efficient allocation of resources, the additional loss of efficiency due to the raising of a tax rate should be added to the monetary costs of the additional government spending. Thus a government project should earn a rate of return that is sufficiently high to cover the additional excess burden that is created by raising taxes.

Browning (1987) noted that a wide variety of estimates for the welfare costs of additional government spending have been obtained due to uncertainty over the magnitude of various elasticities of supply and demand. However, Stuart (1984), Ballard (1990) and Fullerton (1991) have all noted that another important source of differences in estimates of marginal excess burdens is due to differences in assumptions. Thus in this chapter we shall lay out our assumptions in some detail in the context of a highly simplified general equilibrium model of an economy. We shall make two sets of assumptions which lead to two alternative concepts of the marginal excess burden of a tax increase. We shall use the second concept in our model of the New Zealand economy that will be explained in Chapters 5, 6 and 7 below.

In Section 4.2 below, we consider an idealised planned economy where an optimal allocation of resources can be attained without tax instruments. This model is not presented for its realism, but to introduce our assumptions on consumers and producers and to illustrate what a first best allocation of resources looks like.

In Section 4.3, we introduce taxes and a decentralised market economy. Our first concept of marginal excess burden is introduced here.

In Section 4.4, we introduce our second concept of marginal excess burden which follows the example of Kay and Keen (1988) and uses a variant of Debreu's (1951) (1954) coefficient of

1 The term "marginal excess burden" is due to Stuart (1984; 352). The literature was initiated by Browning (1976) (1987) and extended by Findlay and Jones (1982), Stuart (1984), Hansson and Stuart (1985), Ballard, Shoven and Whalley (1985), Ballard (1988), (1990) and Fullerton (1991).

resource utilisation to measure the excess burden of a tax increase.[2] In this second concept, as a tax rate increases, consumers are given an offsetting transfer which keeps them at the same level of real income. Thus, our second concept of marginal excess burden can be viewed as a rigorous general equilibrium specification of the original Harberger (1964) – Browning (1976) marginal excess burden measure. Section 4.5 concludes with a nonmathematical summary of this chapter.

4.2 The Optimal Allocation of Resources

We consider a very simple model of a closed economy. There are three goods in the economy: (i) a consumption good C; (ii) labour L or leisure $h = H\text{-}L$ (where H is total hours potentially available for work in the period under consideration) and (iii) a fixed factor K (an aggregate of land and capital). There are three sectors in the economy: (i) a household sector that demands consumer goods and supplies labour; (ii) a private production sector that produces a composite good that is consumed both by consumers and the government and uses labour L_P as an input and (iii) a government sector that consumes goods G and uses the amount of labour L_G to produce general government services.

The technology of the private production sector can be represented by a production function f where

(1) $$C{+}G = f(L_P,K).$$

$C{+}G$ is the total output produced given that L_P units of labour are used.

The preferences of the household sector are represented by the utility function U. The utility level achieved u depends on consumption C and leisure h where

(2) $$u = U(C,h);$$

(3) $$h = H\text{-}L_P\text{-}L_G,$$

so that total labour supply is $L = L_p + L_G$.

The maximum level of welfare that is achievable in this economy can be obtained by maximising utility, $U\left(C, H - L_p - L_G\right)$, subject to the production function constraint, $C{+}G = F(L_P,K)$, with respect to consumption C and privately utilised labour supply L_P. The government requirements for goods G and labour L_G are held fixed. Upon substituting the

2 Debreu's work was preceded by that of Allais (1943) (1977). The loss measures of Allais and Debreu were put in a unified framework by Diewert (1983) (1984).

production function constraint into the utility function, our welfare maximisation problem reduces to:

(4) $$\max_{L_p} U\left(f\left(L_P, K\right) - G, H - L_G - L_P\right).$$

The first order necessary condition for solving (4) is:

(5) $$U_C f_L + U_h(-1) = 0.$$

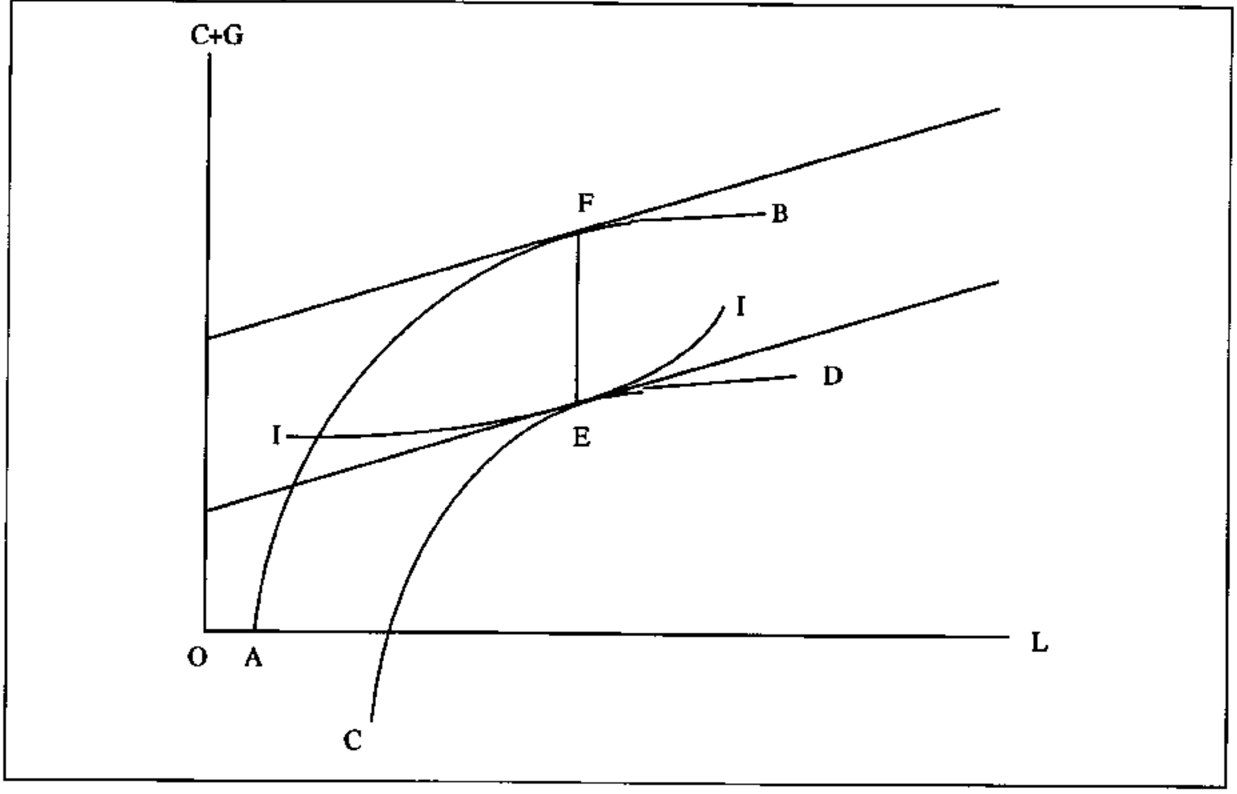
Thus at the optimal solution, we will have

(6) $$f_L\left(L_P, K\right) = U_h\left(C^*, h^*\right) / U_C\left(C^*, h^*\right).$$

Equation (6) implies that the slope of the production function will equal the slope of the consumer's indifference curve at the optimum.

The geometry of problem (4) is illustrated by Figure 4.1.

Figure 4.1: An optimal situation



The distance OA is equal to LG, the government's labour requirements. The total output that can be produced by the economy is the curve AB, the production function constraint. The distance $FE = AC$ is the government's goods requirement G. The curve CD is AB shifted down by G.

The indifference curve II is the highest one that is tangent to CD and thus the consumer's equilibrium point is E and the producer's equilibrium point is at F. Note that the slope of the line tangent to F is equal to the slope of the line tangent to E; this is the geometry behind condition (6) above.

Of course, in real life economies, the government expenditures on goods, G, and on labour, LG, must be financed by taxes or user charges. Thus in the following Section, we introduce taxes into the above model.

4.3 Marginal excess burdens: A first approach

In order to model a tax distorted equilibrium, we need to introduce the following tax rates: t_1 is the rate of taxation on consumption goods, t_2 is the rate of taxation on labour and t_3 is the rate of taxation on the fixed factor. We denote the producer price for the consumption good by p_1 and the producer price for labour by p_2. The consumer prices for these two goods are $p_1(1+t_1)$ and $p_2(1-t_2)$ respectively.

In order to obtain the equations which characterise a tax distorted equilibrium, it is convenient to use duality theory.[3] Thus we assume that the expenditure function dual to the utility function $U(C,h)$ is $e\left(p_1(1+t_1), p_2(1-t_2), u\right)$ and the profit function dual to the production function $f(L_P, K)$ is $\pi(p_1, p_2, K) = \pi(p_1, p_2)$ where we have dropped K since it is held fixed.

The equations which define a tax distorted equilibrium are (7) – (10) below.

(7) $$e_1\left[p_1(1+t_1), p_2(1-t_2), u\right] = \pi_1(p_1, p_2) - G$$

(8) $$e_2\left[p_1(1+t_1), p_2(1-t_2), u\right] = \pi_2(p_1, p_2) + H - L_G$$

(9) $$e\left[p_1(1+t_1), p_2(1-t_2), u\right] = (1-t_3)\pi(p_1, p_2) + p_2(1-t_2)H$$

(10) $$t_1 p_1 e_1\left[p_1(1+t_1), p_2(1-t_2), u\right] + t_2 p_2\left(H - e_2\left[p_1(1+t_1), p_2(1-t_2), u\right]\right) + t_3\pi(p_1, p_2) = p_1 G + p_2 L_G$$

Equations (7) and (8) are the demand equals supply equations for goods and labour, respectively: (9) is the household budget constraint and (10) is the government's budget constraint. Differentiation of a function with respect to its ith variable is denoted by a subscript i.

3 For expositions of duality theory, see Diewert (1974) (1993; Ch. 6) or Varian (1984; Ch. 1 and 3).

As is usual in general equilibrium theory, not all four equations (7) — (10) are independent. Hence we drop equation (10). We also require a normalisation on prices. We choose the producer price of labour p_2 to be the numeraire good and hence, we have

$$(11) \qquad p_2 = 1.$$

Equations (7) — (10) can now be regarded as 3 simultaneous equations in 6 unknowns: u (the level of household utility), G (the level of government expenditure), p_1 (the price of the consumer good), t_1 (the tax rate on consumer goods), t_2 (the tax rate on labour) and t_3 (the tax rate on capital).

We regard u, G and p_1 as endogenous variables and the tax rates t_1, t_2 and t_3 as exogenous variables. Thus equations (7) — (9) determine the functions $u(t_1, t_2, t_3)$, $G(t_1, t_2, t_3)$ and $p_1(t_1, t_2, t_3)$.

In order to determine the overall effects of a tax increase, we have to aggregate the consumer's change in utility with the change in government real expenditures. One way of aggregating utility u and real government expenditures on goods G is by assuming that an overall social welfare function that is additive in the two components exists.[4] Thus, define the following money metric[5] welfare indicator W as follows:

$$(12) \qquad W(u, G, P_1, P_2) \equiv e(P_1, P_2, u) + P_1 G + P_2 L_G$$

where $P_1 \equiv (1 + t_1)p_1$ and $P_2 \equiv (1 - t_2)p_2$ are reference consumer prices for the consumption good and labour (or leisure), respectively. Thus, we measure the overall welfare of the representative consumer by private (per capita) expenditures on goods and leisure, $e(P_1, P_2, u)$ plus (per capita) government expenditures on goods, $P_1 G$, plus (per capita) government expenditures on labour, $P_2 L_G$, where all expenditures are evaluated at the reference prices P_1 and P_2. As utility u and government expenditures G are changed due to the change in the tax rates t_1, t_2 or t_3, we hold the reference prices P_1 and P_2 constant in (12).

To determine welfare as a function of the tax rates t_1, t_2 and t_3, we simply substitute our solution functions $u(t_1, t_2, t_3)$ and $G(t_1, t_2, t_3)$ to the system of equations (7) — (9) into (12) to obtain the welfare function $W^*(t_1, t_2, t_3)$:

$$(13) \qquad W^*(t_1, t_2, t_3) \equiv e(P_1, P_2, u(t_1, t_2, t_3)) + P_1 G(t_1, t_2, t_3) + P_2 L_G$$

4 This type of assumption was used by Atkinson and Stern (1974; 174).

5 The term money metric scaling is due to Samuelson (1974; 1262).

In order to calculate the marginal excess burden of a tax increase in t_i, EB_i, we simply calculate minus the change in welfare due to the increase in t_i and divide by the change in real government spending on goods; i.e., define EB_i as follows for i=1,2,3:

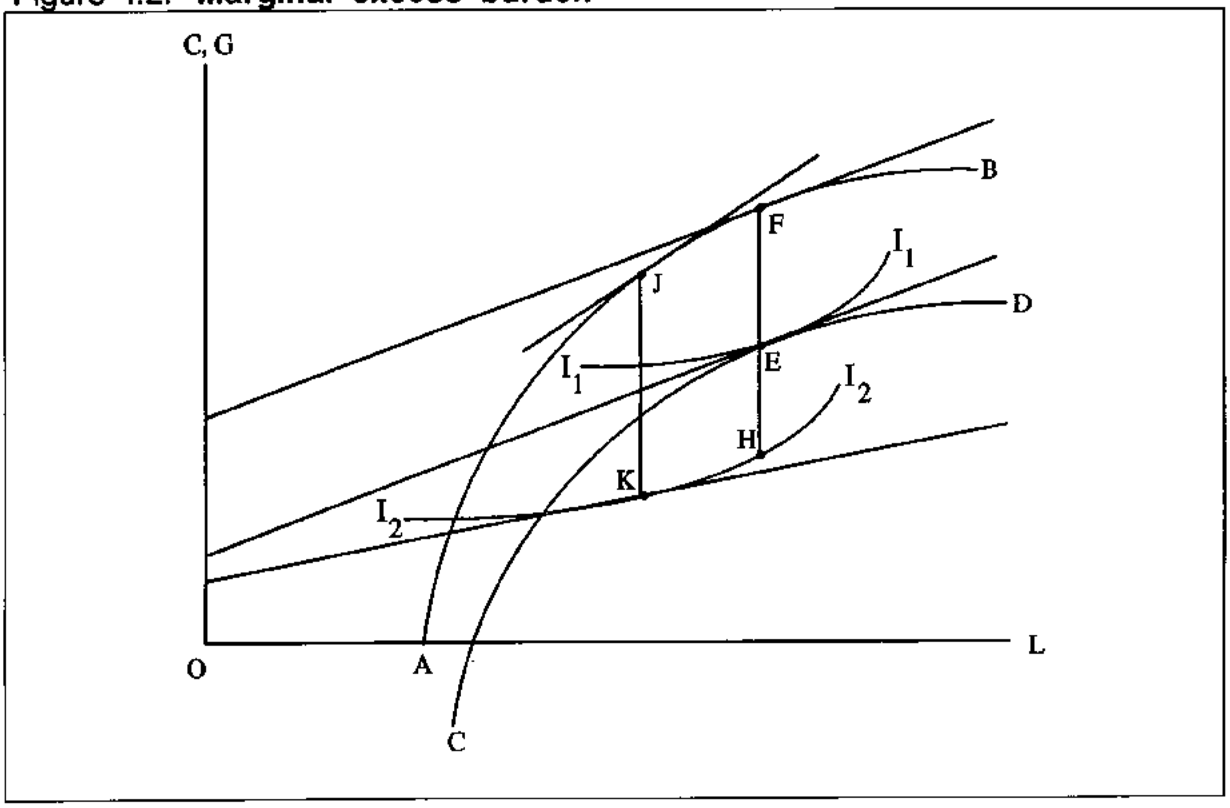
$$(14) \qquad EB_i = -\left[\partial W^*(t_1,t_2,t_3) / \partial t_i\right] / \left[\partial G(t_1,t_2,t_3) / \partial t_i\right]$$

$$(15) \qquad = -\left[e_u(P_1,P_2,u)u_i(t_1,t_2,t_3) + P_1 G_i(t_1,t_2,t_3)\right] / G_i(t_1,t_2,t_3)$$

where e_u denotes the partial derivative of $e(P_1,P_2,u)$ with respect to u, G_i denotes the partial derivative of $G(t_1,t_2,t_3)$ with respect to t_i and u_i denotes the partial derivative of $u(t_1,t_2,t_3)$ with respect to t_i for i=1,2,3. Note that EB_2 defined by (14) is a general equilibrium counterpart to the partial equilibrium excess burden measure $MEB(t_i)$ defined earlier by equation (3) in Section 2.1 above.

The marginal excess burden measures, EB_i defined by (14), can be illustrated by means of Figure 4.2. The initial producer equilibrium point is at the point F on the private sector production possibilities frontier AB. The government's labour requirements are OA and the government's initial goods requirements G_1 are FE. The initial consumer equilibrium is at the point E which is on the indifference curve I_1I_1 which corresponds to the initial utility level u_1.

Figure 4.2: **Marginal excess burden**



The tax rate t_1 on the consumer good is increased. This shifts the consumer's budget line down and the new consumer equilibrium is at the point K on the indifference curve I_2I_2 which corresponds to the lower utility level u_2. The new producer equilibrium is at the point J and the government's new consumption of goods G_2 is the distance JK. Measuring utility in terms of the consumption good, it can be seen that the decrease in utility $u_1 - u_2$ is equal to the distance EH. From the diagram, the distance JK is less than the distance FH. This corresponds to the inequality $G_2 < G_1 + u_1 - u_2$ or $u_2 + G_2 < u_1 + G_1$. Thus, as the tax rate on consumption goods t_1 increases, government spending G increases but utility u decreases and overall welfare measured in units of the consumer good, u+G, decreases. This welfare decrease divided by the government expenditure increase corresponds to the marginal excess burden measure $EB1$ defined by (14).

In the remainder of this Section, we shall compute the partial derivatives which occur in the right hand side of (15), which defines the excess burden measures EB_i. Unfortunately, the computations are rather long and complex and the reader who is not interested in the details is advised to skip to the end of this Section.

In order to calculate the partial derivatives $u_i(t_1, t_2, t_3)$ and $G_i(t_1, t_2, t_3)$, it is necessary to totally differentiate equations (7) — (9) above with respect to the endogenous variables G, u and P_1 and the exogenous tax variables t_1, t_2 and t_3. Using matrix notation, the resulting system of equations is:

$$
(16) \qquad \begin{bmatrix} 1, & e_{1u}, & e_{11}(1+t_1) - \pi_{11} \\ 0, & e_{2u}, & e_{21}(1+t_1) - \pi_{21} \\ 0, & e_u, & e_1(1+t_1) - (1-t_3)\pi_1 \end{bmatrix} \begin{bmatrix} dG_i \\ du \\ dp_1 \end{bmatrix}
$$

$$
= \begin{bmatrix} -e_{11}p_1, & e_{12}p_2, & 0 \\ -e_{21}p_1, & e_{22}p_2, & 0 \\ -e_1p_1, & -[H - e_2]p_2, & -\pi \end{bmatrix} \begin{bmatrix} dt_1 \\ dt_2 \\ dt_3 \end{bmatrix}
$$

where $e_i \equiv \partial e(P_1, P_2, u) / \partial P_i$ and $e_{ij} \equiv \partial^2 e(P_1, P_2, u) / \partial P_i \cdot \partial P_j$ are the first and second order partial derivatives of the expenditure function $e(P_1, P_2, u)$ with respect to the consumer prices P_i and P_j for $i, j = 1, 2$; $e_{iu} \equiv \partial^2 e(P_1, P_2, u) / \partial P_i \partial u$ is the cross partial derivative with respect to P_i and u for i=1,2 and $\pi_i \equiv \partial\pi(P_1, P_2) / \partial P_i$ and $\pi_{ij} \equiv \partial^2\pi(P_1, P_2) / \partial P_i \cdot \partial P_j$ are first and second order partial derivatives of the producer's profit function $\pi(P_1, P_2)$ with respect to the producer prices P_i and P_j for $i, j = 1, 2$.

From duality theory[6], the first derivatives of the profit and expenditure functions with respect to prices are equal to net supply functions and (Hicksian) consumer demand functions, respectively. Thus, using the notation developed in Section 4.2 above, we have:

(17) $$e_1 = C;\ e_2 = L;\ \pi_1 = C + G;\ \pi_2 = -L_P$$

Moreover, the second order derivatives e_{iu}, e_{ij} and π_{ij} satisfy the following restrictions:

(18) $$P_1 e_{1u}(P_1, P_2, u) + P_2 e_{2u}(P_1, P_2, u) = e_u(P_1, P_2, u);$$

(19) $$P_1 e_{11}(P_1, P_2, u) + P_2 e_{21}(P_1, P_2, u) = 0;$$

(20) $$P_1 e_{12}(P_1, P_2, u) + P_2 e_{22}(P_1, P_2, u) = 0;$$

(21) $$p_1 \pi_{12}(p_1, p_2) + p_2 \pi_{21}(p_1, p_2) = 0;$$

(22) $$p_1 \pi_{12}(p_1, p_2) + p_2 \pi_{22}(p_1, p_2) = 0.$$

The e_{ij} also satisfy the Hicks (1946) Samuelson (1947) symmetry conditions

(23) $$e_{12} = e_{21}$$

and the π_{ij} also satisfy Hotelling's (1932) symmetry conditions:

(24) $$\pi_{12} = \pi_{21}.$$

We also have the following sign restrictions on the second order partial derivatives of e and Π:[7]

(25) $$e_{11} \le 0,\ e_{22} \le 0 \text{ and } e_{12} = e_{21} \ge 0;$$

(26) $$\pi_{11} \ge 0,\ \pi_{22} \ge 0 \text{ and } \pi_{12} = \pi_{21} \le 0\ .$$

Moreover, if any one of the inequalities in (25) is strict, then they are all strict and if any one of the inequalities in (26) is strict, then they are all strict.

The derivative formula that is obtained by simply inverting the matrix on the left hand side of (16) is very difficult to interpret. Thus we have found it more instructive to calculate the

6 See Diewert (1974; 112 and 137) (1993; 131 and 166) for example.

7 For (25),see Hicks (1946; 311), Samuelson (1947; 64-69) or Diewert (1993; 149). For (26), see Hicks (1946; 321), Samuelson (1953; 10) or Diewert (1974; 143-45).

derivatives of $u(t_1, t_2, t_3)$ and $G(t_1, t_2, t_3)$ that appear in (15) in a two step procedure. In the first step, take P_1 times the first equation in (16) and add it to P_2 times the second equation in (16). Using (18) - (21), we obtain the following equation:

(27) $$P_1 dG + e_u du - \left[P_1\pi_{11} - P_2\pi_{21}\right]dp_1 = 0dt_1 + 0dt_2 + 0dt_3.$$

Recall that the P_i (the prices that consumers face) are related to the p_i (the prices that producers face) by the following equations:

(28) $$P_1 = p_1(1 + t_1);\ P_2 = p_2(1 - t_2)$$

where t_1 is the consumption tax rate and t_2 is the labour tax rate. Using (28), we have:

(29) $$\begin{aligned} P_1\pi_{11} + P_2\pi_{21} &= p_1(1 + t_1)\pi_{11} + p_2(1 - t_2)\pi_{21} \\ &= p_1 t_1 \pi_{11} - p_2 t_2 \pi_{21} && \text{using (21)} \\ &= (t_1 + t_2)p_1\pi_{11} && \text{using (21) again.} \end{aligned}$$

Substitution of (29) into (27) yields for $i = 1, 2, 3$:

(30) $$P_1\partial G / \partial t_i + e_u \partial u / \partial t_i = (t_1 + t_2)p_1\pi_{11}\partial p_1 / \partial t_i.$$

Note that the left hand side of (30) is (minus) the numerator of the excess burden measure EB_i defined by (15) above.

We can also use the last equation in (16) in order to eliminate the terms $\partial u / \partial t_i$ from equations (30). Using also equations (17), we obtain the following expressions for $\partial G / \partial t_i$:

(31) $$P_1\partial G / \partial t_1 = p_1 C + \left[(t_1 + t_3)C - (1 - t_3)G + (t_1 + t_2)p_1\pi_{11}\right]\partial p_1 / \partial t_1;$$

(32) $$P_1\partial G / \partial t_2 = p_2 L + \left[(t_1 + t_3)C - (1 - t_3)G + (t_1 + t_2)p_1\pi_{11}\right]\partial p_1 / \partial t_2;$$

(33) $$P_1\partial G / \partial t_3 = \pi + \left[(t_1 + t_3)C - (1 - t_3)G + (t_1 + t_2)p_1\pi_{11}\right]\partial p_1 / \partial t_3.$$

For small tax rates t_i and small government expenditures on goods G, the first terms on the right hand sides of (31), (32), and (33) which are large and positive, will dominate the remaining terms and hence G will increase as a tax rate t_i increases; i.e., the derivatives $\partial G / \partial t_i$ will have the expected positive signs. Thus the denominator derivatives, $G_i = \partial G(t_1, t_2, t_3) / \partial t_i$ in (15), will tend to be positive. However, the signs of the numerator derivatives, $-\left[e_u \partial u / \partial t_i + P_1 \partial G / \partial t_i\right]$ in (15), will be equal to the sign of

$-(t_1 + t_2)p_1\pi_{11}\partial p_i / \partial t_i$ in view of (30). Since t_1, t_2, p_1 and π_{11} will all generally be positive, we see that the sign of EB_i will generally be opposite to the sign of $\partial p_i / \partial t_i$. Thus in order to calculate the excess burden measures EB_i, we need only use the last two equations in (16) to calculate the derivatives $\partial p_1 / \partial t_i$ for $i = 1,2,3$. If increasing a tax rate t_i decreases the producer price of output (relative to the wage rate which we are holding constant), then EB_i will have the expected positive sign; i.e., increasing t_1 to finance additional government expenditures will lead to a decrease in the producer price of output which in turn will lead to a drop in output and utility. The decrease in utility will be sufficiently large to outweigh the increase in government consumption of goods and overall welfare will drop.

Using the last two equations in (16) to calculate the response of the output price p_1 to changes in the tax rates t_i leads to the following equations:

(34) $$\partial p_1(t_1, t_2, t_3) / \partial t_1 = \left[e_u e_{21} - Ce_{2u}\right]p_1 / D;$$

(35) $$\partial p_1(t_1, t_2, t_3) / \partial t_2 = -\left[e_u e_{22} + Le_{2u}\right]p_2 / D;$$

(36) $$\partial p_1(t_1, t_2, t_3 3) / \partial t_3 = -e_{2u}\pi / D$$

where total labour supply is $L = L_P + L_G$ and D is defined as:[8]

(37) $$D = e_{2u}\left[C(1 + t_1) - (1 - t_3)(C + G)\right] - e_u\left[e_{21}(1 + t_1) - \pi_{21}\right].$$

It is interesting to note the key role played by $e_{2u} \equiv \partial^2 e(P_1, P_2, u) / \partial P_2 \partial u = \partial h(P_1, P_2, u) / \partial u$, which is the response of leisure demand to an increase in real income u. If $e_{2u} = 0$ and the strict inequalities hold in (25) and (26), then $D < 0$, $\partial p_1 / \partial t_1 < 0$, $\partial p_1 / \partial t_2 < 0$ and $\partial p_1 / \partial t_3 = 0$. Thus in this case, overall welfare will decrease as we increase the tax rate on consumption t_1 and the tax rate on labour earnings t_2 and it will remain unchanged as we increase the tax rate t_3 on the fixed (in this model) factor capital. However, if e_{2u} is sufficiently large and positive and D remains negative, then we can obtain the rather anomalous results $\partial p_1 / \partial t_1 > 0$, $\partial p_1 / \partial t_2 > 0$ and $\partial p_1 / \partial t_3 > 0$ which means that overall welfare will increase as we increase t_1, t_2 and t_3. Assuming also that $\partial G / \partial t_i$ is positive for each i, we find under the above conditions that the marginal excess burden measures EB_i defined by (14) become negative so that there is an excess benefit instead of an excess burden associated with the tax increase. An intuitive explanation for this rather anomalous result can be

8 D is the determinant of the two by two submatrix involving du and dp_1 of the matrix on the left hand side of (16).

made as follows: the tax increase leads to a fall in real income or utility, the fact that e_{2u} is large leads to a large drop in the demand for leisure which in turn leads to a large increase in the supply of labour which leads to a large enough increase in output such that the increase in G outweighs the decline in u.[9]

The analysis in this Section can be summarised as follows: the marginal excess burden measures EB_i associated with an increase in the tax rate t_i were defined by (15). The derivatives in the numerators of (15) can be expressed in terms of initial tax rates t_i, the initial allocation of resources (C, h, L and G), the responses of (Hicksian) consumer demands to changes in prices e_{ij}, and the responses of producer net supply functions to changes in prices π_{ij}, using equations (30) and (35) — (37). Similar formulae for the derivatives of (15) can be obtained using (31) — (33) and (34) — (37). The resulting formulae for the marginal excess burdens are rather complex to say the least.

In addition to complexity, there is another major difficulty with the above approach to measuring excess burdens. The difficulty is that our method for measuring total welfare W defined by (12) by summing together consumer expenditures on private goods with expenditures by governments on goods is rather arbitrary. The problem becomes even more acute in a many consumer context since there is no universally accepted metric for aggregating changes in private utility with changes in government expenditures in order to obtain a measure of overall welfare change.[10] Thus, in the next section we pursue an approach to measuring the excess burdens due to tax increases which avoids this measurement problem.

4.4 Marginal excess burdens: A second approach

Our second approach to measuring the excess burden of a tax increase is based on the approach to efficiency measurement pioneered by Allais (1943) (1977) and Debreu (1951) (1954).[11] In order to avoid the problem of adding together a utility change with a change in public good production, we hold each consumer's utility constant as a tax rate is increased.

In the context of our representative consumer model described in Section 4.3 above, utility u is held constant by adding a transfer payment T to the consumer's income. The endogenous

9 Our intuitive explanation for the existence of marginal excess benefits follows that of Fullerton (1991; 305). For some values of the parameters in their applied general equilibrium models, Hansson and Stuart (1985; 333) and Ballard (1990; 269) found negative marginal excess burdens or positive excess benefits.

10 This point is made rather effectively in Kay and Keen (1988; 268).

11 See also Diewert (1981) (1983) (1984) (1985) and Kay and Keen (1988).

variables in our simple general equilibrium model become G (government expenditures on goods), T (the transfer) and p_1 (the producer price of output). The numeraire good is again labour and the producer price of labour p_2 is held constant. The exogenous variables are again t_1, t_2 and t_3, the tax rates on consumption, labour earings and profits, respectively. The new system of equations which describes our model is given by (7) and (8) (the demand equals supply equations for goods and labour) and equations (38) and (39) below:

$$(38) \qquad e\left[p_1(1+t_1),\ p_2\left(1-t_2\right), u\right] \quad = (1+t_3)\Pi\left(p_1, p_2\right) + p_2\left(1-t_2\right)H + T;$$

$$(39) \qquad t_1 p_1 e_1\left[p_1(1+t_1),\ p_2\left(1-t_2\right), u\right] + t_2 p_2 e_2\left[p_1(1+t_1), p_2(1-t_2), u\right] + t_3\pi\left(p_1, p_2\right) \quad = p_1 G + p_2 L_G + T$$

Equation (38) is the consumer's budget constraint and (39) is the government budget constraint.

As is usual in general equilibrium theory, the four equations (7), (8), (38) and (39) are dependent. We drop (39) and use the remaining equations to solve for G, T, and p_1 as functions of the tax rates t_1, t_2 and t_3. The partial derivatives of these solution functions can be obtained by totally differentiating (7), (8) and (38) with respect to G, T, p_1, t_1, t_2 and t_3. Using matrix notation, the resulting equations may be written as follows:

$$(40) \qquad \begin{bmatrix} 1, & 0, & e_{11}\left(1+t_1\right) - \pi_{11} \\ 0, & 0, & e_{21}\left(1+t_1\right) - \pi_{21} \\ 0, & -1, & C\left(1+t_1\right) - \left(1-t_3\right)(C+G) \end{bmatrix} \begin{bmatrix} dG \\ dT \\ dp_1 \end{bmatrix} = \begin{bmatrix} -e_{11}p_1, & e_{12}p_2 & ,0 \\ -e_{21}p_1, & e_{22}p_2 & ,0 \\ -Cp_1, & -Lp_2 & ,-\pi \end{bmatrix} \begin{bmatrix} dt_1 \\ dt_2 \\ dt_3 \end{bmatrix}$$

where we have also used (17) in evaluating the derivatives in (40).

We turn now to the problem of defining marginal excess burdens in our present model. Since utility remains constant, any benefits that an increase in taxation might generate are equal to the change in government purchases of goods G, valued at the initial consumer price of goods P_1. Thus our indicator of overall welfare in the present model is simply

$$(41) \qquad W\left(t_1, t_2, t_3\right) \equiv P_1 G\left(t_1, t_2, t_3\right)$$

where $G(t_1,t_2,t_3)$ (along with $T(t_1,t_2,t_3),\ldots,$ and $p_1(t_1,t_2,t_3)$) are the functions obtained by solving (7), (8) and (38). From Equation (39), we see that the government revenue raised, R, is equal to government expenditures on goods, p_1G, and labour, p_2L_G, plus government transfers to consumers, T. Thus we can define tax revenue as a function of the tax rates t_1, t_2 and t_3 as follows:

(42) $$R(t_1,t_2,t_3) \equiv p_1(t_1,t_2,t_3)G(t_1,t_2,t_3) + p_2L_G + T(t_1,t_2,t_3).$$

Our general equilibrium measure of the marginal excess burden associated with increasing the tax rate t_i, MEB_i, can now be defined as (minus) the rate of change in welfare defined by (41) divided by the rate of change in revenue defined by (42) with respect to t_i; i.e., for $i = 1,2,3$:

(43) $$MEB_i \equiv -\left[\partial W(t_1,t_2,t_3)/\partial t_i\right] / \left[\partial R(t_1,t_2,t_3)/\partial t_i\right]$$

$$= -W_i(t_1,t_2,t_3)/R_i(t_1,t_2,t_3)$$

(44) $$= -P_1G_i(t_1,t_2,t_3)/[p_{1i}(t_1,t_2,t_3)G(t_1,t_2,t_3)$$

$$+ p_1(t_1,t_2,t_3)G_i(t_1,t_2,t_3) + T_i(t_1,t_2,t_3)]$$

where W_i, R_i, G_i, p_{1i} and T_i are the partial derivatives of the functions $W(t_1,t_2,t_3),\ldots,$ $T(t_1,t_2,t_3)$ with respect to t_i for $i = 1,2,3$. There will be an excess burden associated with increasing t_i if MEB_i is positive, an excess benefit if MEB_i is negative.

The derivatives $G_i(t_1,t_2,t_3)$ that appear in (44) can be obtained by inverting the matrix on the left hand side of (40) but we shall follow the two step procedure that was used in the previous section in order to calculate these derivatives. Taking P_1 times the first equation in (40) and P_2 times the second equation in (40) (and using (18) — (20) yields the following equation:

(45) $$P_1dG + 0dT = \left[P_1\pi_{11} + P_2\pi_{21}\right]dp_1 + 0dt_1 + 0dt_2 + 0dt_3.$$

Substitution of (21) into (45) yields the following equations:

(46) $$P_1G_i(t_1,t_2,t_3) = (t_1+t_2)p_1\pi_{11}p_{1i}(t_1,t_2,t_3);\ i = 1,2,3.$$

Using the second equation in (40), it is very easy to solve for the partial derivatives $p_{1i}(t_1,t_2,t_3) \equiv \partial p_1(t_1,t_2,t_3)/\partial t_i$:

(47) $$\partial p_1(t_1,t_2,t_3)/\partial t_1 = -\left[e_{21}(1+t_1) - \pi_{21}\right]^{-1} e_{21}p_1 \le 0;$$

(48) $$\partial p_1(t_1,t_2,t_3) / \partial t_2 = \left[e_{21}(1+t_1) - \pi_{21}\right]^{-1} e_{22}p_2 \leq 0;$$

(49) $$\partial p_1(t_1,t_2,t_3) / \partial t_3 = 0$$

where the inequalities in (47) and (48) follow from (25) and (26).[12] Thus, an increase in t_1 or t_2 cannot increase the producer price of output.[13]

Substituting (46) and (49) yields:

(50) $$MEB_3 = 0;$$

i.e., the Allais-Debreu excess burden of a tax increase on profits is zero. This result is to be expected in the context of our model, which assumes that capital is a fixed factor which is not affected by a tax on its use. However, this result does not extend to a dynamic model where reproducible capital is endogenously determined. Thus the result (50) should not be used in the design of a real life tax system.[14]

In order to obtain explicit expressions for MEB_1 and MEB_2 in terms of tax rates and various supply and demand elasticities, we need to calculate the transfer derivatives $T_1(t_1,t_2,t_3)$ and $T_2(t_1,t_2,t_3)$. This can readily be done using the third equation in (40). The resulting partial derivatives are:

(51) $$T_1(t_1,t_2,t_3) = p_1C + \left[(t_1+t_3)C - (1-t_3)G\right]\partial p_1(t_1,t_2,t_3) / \partial t_1;$$

(52) $$T_2(t_1,t_2,t_3) = p_2L + \left[(t_1+t_3)C - (1-t_3)G\right]\partial p_1(t_1,t_2,t_3) / \partial t_2.$$

Finally, (46) — (48), (51) and (52) may be substituted into (44) in order to obtain formulae for the Allais-Debreu excess burden measures MEB_1 and MEB_2 in terms of the initial allocation of resources, the initial tax rates and the responses of net demand and supply functions to changes in prices (the e_{ij} and π_{ij}). The resulting formulae are too complex to be exhibited here. However, we can present results for an approximation to the general formulae (44) which will be accurate for small tax rates t_i and small government expenditures on goods G. Instead of calculating the full general equilibrium effects on government revenues of an increase in t_1 or

12 We need at least one of the inequalities $e_{21} \geq 0$ and $\pi_{21} \leq 0$ to be strict.

13 Compare the unambiguous results (47) — (49) with the indeterminate results (34) — (36) that were obtained in the previous section.

14 Theoretical and empirical research indicates that the efficiency costs of taxing the return to capital can be quite high; see Ballard, Shoven and Whalley (1985), Jorgenson and Yun (1986a) (1986b) (1990) (1991) and Diewert (1988; 23).

t_2, we approximate the revenue increase by the first order rate of increase that ignore price effects.[15] The resulting approximate derivatives are:

(53) $$R_1(t_1, t_2, t_3) \equiv p_1 C;$$

(54) $$R_2(t_1, t_2, t_3) \equiv p_2 L.$$

Note that the right hand sides of (53) and (54) are the initial tax bases for t_1 and t_2, respectively, the consumption and labour tax bases. Substitution of (46) — (48) and (53) — (54) into (44) leads to the following approximate Allais-Debreu excess burden measures, MEB_i^*:

(55) $$MEB_1^* = (t_1 + t_2)\pi_{11} e_{21} p_1 / [e_{21}(1 + t_1) - \pi_{21}] C \geq 0;$$

(56) $$MEB_2^* = -(t_1 + t_2)\pi_{11} e_{22} p_1 / [e_{21}(1 + t_1) - \pi_{21}] L \geq 0$$

where the inequalities in (55) and (56) follow from the restrictions on the net demand derivatives e_{ij} given by (25) and the restrictions on the net supply derivatives π_{ij} given by (26).

For ease of interpretation, (55) and (56) can be expressed in terms of elasticities of net demand and supply rather than in terms of the derivatives e_{ij} and π_{ij}. Define the cross elasticity of demand for consumption with respect to leisure as:

(57) $$\eta_{12} \equiv e_{12} P_2 / C \geq 0$$

and minus the cross elasticity of supply of output with respect to labour as:

(58) $$\sigma_{12} \equiv -\pi_{12} p_2 / Y \geq 0$$

where output $Y = C + G$ and the inequalities in (57) and (58) follow from the restrictions (25) and (26). The elasticity $\sigma_{12}(\eta_{12})$ is a measure of substitutability in production (consumption): the bigger $\sigma_{12}(\eta_{12})$ is, the more substitutability there is in production (consumption). Substitution of (57) and (58) into (55) and (56) leads to the following expressions for the

15 Terms involving the price derivatives $p_{1i}(t_1, t_2, t_3)$ are ignored in evaluating the revenue derivatives $R_i(t_1, t_2, t_3)$, where (46) is used to calculate $G_i(t_1, t_2, t_3)$ in terms of $p_{1i}(t_1, t_2, t_3)$ and (51) and (52) are used to calculate the derivatives $T_i(t_1, t_2, t_3)$ in terms of $p_{1i}(t_1, t_2, t_3)$.

approximate Allais-Debreu marginal excess burdens due to an increase in consumption and labour taxation respectively:[16]

(59) $$MEB_1^* = (t_1 + t_2)\sigma_{12}\eta_{12} / \left[\eta_{12}s_C(1+t_1) + \sigma_{12}(1-t_2)\right] \geq 0;$$

(60) $$MEB_2^* = (t_1 + t_2)\sigma_{12}\eta_{12}s_C / s_L\left[\eta_{12}s_C(1+t_1) + \sigma_{12}(1-t_2)\right] \geq 0$$

where $s_C \equiv P_1C / P_1Y$ and $s_L \equiv P_2L / P_1Y$ are the consumption and labour shares of output valued at consumer prices. A comparison of (59) and (60) shows that:

(61) $$MEB_2^* = (s_C / s_L)MEB_1^*.$$

Thus, if the consumption share of output, s_C, is greater than labour's share of output (valued at consumer prices), then the (approximate) marginal excess burden associated with raising labour taxes will exceed the burden associated with raising consumption taxes.

Examination of (59) and (60) shows that for normal parameter values, (approximate) marginal excess burdens will increase as the tax rates t_1 on consumption and t_2 on labour earnings increase and as substitutability in consumption and production increase (i.e., as η_{12} and σ_{12} increase).[17] Note also that MEB_1^* and MEB_2^* will equal zero if either σ_{12} or η_{12} equals zero. Hence to get positive excess burdens in our simple general equilibrium model, we must have strict substitutability in both production and consumption. This is similar to the situation which occurred in the partial equilibrium model developed in Section 2.1 above.[18] Finally, note that the excess burdens defined by (59) and (60) are approximately proportional to $t_1 + t_2$, the sum of the tax rates on consumption and labour earings.

The geometry of the numerators of the marginal excess burden measures defined by (43) can be illustrated using Figure 4.2 again. Assume that the initial producer equilibrium is at the point F and the initial consumer equilibrium is at the point H. The initial government consumption of goods is the distance FH. If the tax rate on consumption t_1 or the tax rate on labour t_2 is increased, then the consumer price line becomes less steeply sloped than the producer price line and thus producers move down the production possibilities set AB to the point J and consumers

16 We also used (20) — (24) in deriving (59) — (60).

17 These theoretical results are broadly consistent with the results obtained in the applied general equilibrium models of Stuart (1984; 360) and Ballard, Shoven and Whalley (1985; 128).

18 Compare the partial equilibrium formula for the marginal excess burden of a labour tax given by (10) in Section 2.1 with (60) in the present Section.

move along the indifference curve I_2I_2 to the point K. The new government consumption is JK which is less than the initial government consumption FH.

4.5 Summary of the Chapter

The existing elasticity measures of the marginal excess burden of a tax increase have been based on simple partial equilibrium models. Our goal in this chapter has been to develop excess burden measures that are valid in a general equilibrium context.

Our first general equilibrium approach assumed that society's objective function (or social welfare function) was equal to a constant dollar sum of private household consumption and leisure plus the constant dollar sum of government expenditures on goods and services. However, the resulting measure proved to be too complex and moreover, it seemed to be a bit arbitrary: why should the benefits of government expenditures be exactly additive to the consumer's constant dollar consumption of goods and leisure?

Thus, in our second approach to measuring marginal excess burdens developed in section 4.4, we held consumers' money metric utility over private goods constant as we raised taxes to finance increased government expenditures. We used the increased taxes to increase government expenditures on goods while holding government expenditures on labour constant. Since private utility is held constant and government expenditures on labour are held constant, our measure of social welfare became government expenditures on goods, at constant reference prices: see (41) in section 4.4.

The intuition behind our second model of marginal excess burden can be explained as follows. A tax rate is increased and the increased revenues are initially used to increase the outputs of the government sector. However, the increased tax wedge causes increased deadweight loss and, in particular, a decrease in private utility for consumers. To restore consumers to their pre tax increase levels of private utility, the government provides consumers with a tax transfer. It turns out that this tax transfer more than exhausts the increase in revenue that the initial tax increase created. Thus a government project that is financed by the initial tax increase should be valued by consumers by enough of a premium to overcome the effects of the increased loss of efficiency that is generated by the initial tax increase. This premium rate is our estimated marginal deadweight loss. We do not want to imply that government investments should not go ahead, but they should be sufficiently valuable to society that they can overcome the tax induced increase in deadweight loss. We are simply trying to provide approximate estimates of the required excess premium rate that government projects should earn.

In Chapter 7 below, we will develop a more realistic model of marginal excess burden using the Allais-Debreu approach explained here. In the next two chapters, we turn our attention to the empirical specification of producer and consumer models for the New Zealand economy.

5. A MODEL OF PRODUCER BEHAVIOUR FOR NEW ZEALAND

5.1 The theoretical model

Most empirical work on calculating marginal excess burdens is subject to some severe limitations: either the underlying theoretical model used is a partial equilibrium model [19] or an applied general equilibrium model is used which uses rather restrictive functional forms for producer's production functions and consumer's preference functions.[20] Finally, the elasticity estimates that are used in these models are often taken from empirical studies pertaining to other countries.[21]

In this Chapter, we use the data pertaining to the New Zealand economy that is developed in Appendix A below in order to estimate a system of private producer supply and demand equations. Flexible functional form techniques are used: i.e., the functional form we use to model the technology does not impose unwarranted a priori restrictions on elasticities of substitution between the outputs and inputs. In the present Section, we lay out the details of the model and in the following Section we present our empirical results.

The inputs and outputs in the New Zealand economy were aggregated into two classes of goods: (i) those that are variable during the course of a year and (ii) those that are fixed. There were five variable goods: (1) motor vehicle output; (2) general consumption and investment (including government consumption of goods); (3) exports of goods and services; (4) imports of goods and services and (5) labour input into the market sector (including the self employed but excluding general government employment). The two fixed factors or stocks were: (1) all non-land capital (non-residential structures, other construction, machinery and equipment and inventory stocks) and (2) the stock of land. General government holdings of these stocks were not included.

19 Comparing (59) and (60) in Chapter 4 with formula (10) in Chapter 2 shows that the general equilibrium estimates for marginal excess burdens can be quite different from the partial equilibrium estimates.

20 The three most commonly used functional forms in applied general equilibrium theory are the Cobb-Douglas, constant elasticity of substitution and Leontief (no substitution) functional forms. If the number of goods in the model is greater than two, each of the above functional forms imposes a severe a priori restriction on elasticities of substitution; e.g., strict complementarity is ruled out; see Diewert (1985a). For an excellent survey of applied general equilibrium modelling, see Shoven and Whalley (1984).

21 The applied general equilibrium models of Jorgenson and Yun (1986a) (1986b) (1990) (1991) are not subject to the above criticisms.

Our treatment of export, imports and consumption is not completely conventional but it has appeared in the literature in the past 15 years: see the articles by Kohli (1978) (1993) and Lawrence (1989). Consumption, exports and imports are all regarded as separate goods in our model. Of course, some goods are both consumed and exported. However, the transportation, marketing and storage of these "identical" goods will serve to make them different; eg. export margins will generally be different from domestic margins for the same good. Moreover, we are dealing with aggregates of thousands of goods in each of the categories, "exports" and "consumption". The relative proportions of each micro good in these aggregates are different and hence the price indexes for each of these aggregates will be quite different, even if each aggregate is composed of a different mix of exactly the same goods. The only practical way to deal with these aggregation difficulties is to treat "export" and "consumption" as separate goods. If they are in fact virtually the same, then this fact will show up as extremely high substitutability between the two goods in our econometric work. "Imports" and "consumption" are also treated as distinct goods: virtually all imports will have domestic inputs added to them in terms of transportation, storage, packaging, wholesaling and retailing inputs. As a matter of national income accounting conventions, imports do not simply disappear: after domestic value added has been added to them, they reappear as components of consumption.

We also treat New Zealand as a small country, which means that we assume that the prices of New Zealand's export and imports are set on foreign markets and treated as exogenous. We also hold the trade balance constant as we vary taxes in our simulation exercises. This is a completely conventional treatment of trade in applied general equilibrium models. Alternative treatments are possible: a world demand curve for New Zealand's exports and a world supply curve for New Zealand's imports could be estimated. However, this would entail a major modelling effort — an effort which was beyond our limited resources.

In what follows, $x \equiv \left(x_1, x_2, x_3, x_4, x_5\right)$ denotes a vector of variable net outputs for the New Zealand economy[22], $p \equiv \left(p_1, p_2, p_3, p_4, p_5\right)$ is the corresponding positive vector of variable input and output prices that producers face, $s \equiv \left(s_1, s_2\right)$ is a vector of stocks that are available to producers at the beginning of the year under consideration and $w \equiv \left(w_1, w_2\right)$ is a vector of ex post rental prices associated with the stocks.

The technology is represented by a GNP function (or variable profit function), $\pi(p,s,t)$, defined as follows:

[22] The components x_4 and x_5 are indexed with minus signs since imports and labour are inputs into the private production sector. We follow Kohli's (1978) treatment of international trade where all imports flow through the private production sector.

(1) $$\pi(p,s,t) \equiv \max_x \left\{ p \cdot x : (x,s) \text{ belongs to } S^t \right\}$$

where S^t is the private sector technology set in period t.[23] Note that if x_i is an input, then x_i is negative.

Estimating equations can be obtained by differentiating the profit function with respect to the prices p_i and stocks s_j:[24]

(2) $$x_i(p,s,t) = \partial\pi(p,s,t) / \partial p_i, i = 1,2,3,4,5;$$

(3) $$w_j(p,s,t) = \partial\pi(p,s,t) / \partial s_j, j = 1,2.$$

The functional form for π that we chose was a variation of the normalised quadratic functional form,[25] since this functional form allows us to impose the appropriate curvature conditions without destroying its flexibility properties. Using matrix notation, the function can be defined as follows:

(4) $$\pi(p,s,t) \equiv p \cdot Cs + p \cdot ch \cdot st + p \cdot gd \cdot st + \left(1/2\right) p \cdot Aph \cdot s / p \cdot g - \left(1/2\right) s \cdot Bsp \cdot g / h \cdot s$$

where the vectors $g \equiv (g_1, g_2, g_3, g_4, g_5)$ and $h \equiv (h_1, h_2)$ were chosen a priori to be the absolute values of the sample means of the observed $x^t \equiv (x_1^t, \ldots, x_5^t)$ and $w^t \equiv (w_1^t, \ldots, w_5^t)$, normalised so that:

(5) $$p^* \cdot g = 1; \; s^* \cdot h = 1$$

where the p^* and s^* were fixed vectors.[26] The variable t which appears in (4) is a scalar time variable which serves as a proxy for technological change. The parameter vectors c and d and the parameter matrices $A = \left[a_{ij}\right]$, $B = \left[b_{ij}\right]$ and $C = \left[c_{ij}\right]$ are to be estimated, subject to some restrictions. In order to identify the components of c and d, we imposed the following linear restriction:

(6) $$d \cdot s^* = 0.$$

23 Notation: $p \cdot x \equiv \sum_{i=1}^{5} p_i x_i$ is the inner product of the vectors p and x.

24 See Diewert (1974; 137 and 140) (1993; 166 and 168).

25 See Diewert and Wales (1987) (1992) and Lawrence (1988) (1989) (1990).

26 We chose p^* and s^* to be vectors of ones.

In order for $\pi(p,s,t)$ to be a well behaved profit function (convex in p and concave in s), we set A and B to be the following products:[27]

(7) $$A = U^T U; B = V^T V$$

where U^T denotes the transpose of the matrix U, and U and V are upper triangular matrices satisfying the following restrictions:

(8) $$Up^* = 0_5; \; Vs^* = 0_2$$

where 0_5 and 0_2 are vectors of zeros of dimension 5 and 2, respectively.

Differentiating the profit function (4) with respect to the components of p leads to the following system of 5 estimating equations:

(9) $$x = Cs + ch \cdot st + gd \cdot st + Aph \cdot s / p \cdot g - \left({}^1/_2\right) p \cdot Aph \cdot sg / (p \cdot g)^2 - \left({}^1/_2\right) s \cdot Bsg / h \cdot s.$$

A vector of ex post rental prices w for the stocks can be obtained by differentiating π defined by (4) with respect to the components of the fixed stock vector s. The following two additional estimating equations are obtained:

(10) $$w = C^T p + hc \cdot pt + dg \cdot pt + \left({}^1/_2\right) p \cdot Aph / p \cdot g - Bs\, p \cdot g / h \cdot s + \left({}^1/_2\right) s \cdot Bs\, p \cdot gh / (h \cdot s)^2.$$

For simplicity, we omitted the superscript t from x, p, w and s in equations (9) and (10).

The ex post rental prices w^t were constructed so that in each period t, variable profits were distributed to the two fixed factors so that the following adding up equations were satisfied;

(11) $$p^t \cdot x^t = w^t \cdot s^t, \; t = 0,1,2,\ldots,19.$$

Thus, equations (9) cannot be statistically independent from equations (10); i.e., we must drop at least one of the 7 estimating equations in (9) and (10). In order to obtain estimates that were invariant to the equation dropped, we pre-multiplied both sides of the ith equation in (9) by $p_i^t / \left(p^t \cdot g s^t \cdot h\right)$ for $i = 1,2,3,4,5$ (call the resulting dependent variables y_i^t) and we pre-multiplied both sides of the jth equation in (10) by $s_j^t / \left(p^t \cdot g s^t \cdot h\right)$ for $j = 1,2$ (call the resulting dependent variables z_j^t). These transformations of the estimating equations (9) and

27 See Diewert and Wales (1987; 52-53) for further explanation.

(10) reduced heteroskedasticity and in view of (11), the resulting dependent variables satisfied the following restrictions:

(12) $$\sum_{i=1}^{5} y_i^t - \sum_{j=1}^{2} z_j^t = 0, \quad t = 0,1,2,\ldots 19.$$

We appended normally distributed errors u_i^t and v_j^t to the transformed estimating equations (9) and (10) with means 0 and variance-covariance matrix Σ. In view of the restrictions (12) on the dependent variables, the errors must satisfy the following restrictions:

(13) $$1_5 \cdot v^t - 1_2 \cdot s^t = 0 \quad \text{for} \quad t = 0,1,\ldots,19.$$

where $v^t \equiv \left(v_1^t,\ldots,v_5^t\right)$ and $s^t \equiv \left(s_1^t, s_2^t\right)$. Thus Σ must be a singular variance-covariance matrix satisfying

(14) $$\left[1_5^T, -1_2^T\right]\Sigma = \left[0_5^T, 0_2^T\right].$$

With the above statistical specification of the errors, non-linear maximum likelihood programs such as SHAZAM (see White (1978)) can be used to estimate the unknown parameters which appear in (4), after dropping any one of the transformed estimating equations (9) and (10). The resulting estimates will be invariant to the equation dropped.[28] Our treatment here is completely consistent with standard techniques that are used in the theory of demand, where the data are also subject to an adding up constraint.

5.2 Empirical results for the production model

Producer prices p_i^t and quantities x_i^t for the five variable outputs and inputs were constructed for the New Zealand economy for the 20 years ending 31 March, 1972 to 31 March, 1991. Corresponding data for the two stocks s_j^t and their ex post rental prices were also constructed. The details of our data construction procedures can be found in Appendix A with the specific data used in our producer regressions being presented in Tables A25 and A26.

The non-linear regression program in SHAZAM was used to estimate the unknown coefficients appearing in (4). The five (transformed) equations in (9) and the first (transformed) equation in (10) were used as estimating equations. As mentioned in the previous Section, our estimates are invariant to the equation deleted. The R^2 between the observed and predicted variables for the 6 equations were: 0.608, 0.813, 0.725, 0.438, 0.935 and 0.629. The R^2 appear to be rather low for time series results but recall that we have transformed each variable which

28 See Diewert and Wales (1994) for more discussion on this point.

appears on the left hand sides of (9) and (10) so that the resulting variables are approximately constant. Hence our fits are actually quite satisfactory.

The parameter estimates from our non-linear regression are reported below in Table 5.1. Full computer print-outs of the regression models including a complete range of diagnostic statistics are available from the authors on request.

Table 5.1: Parameter estimates for the production model

Parameter	Estimate	*t* Statistic
c11	0.3980	0.91
c12	0.9190	2.08
c21	31.8170	15.04
c22	18.0660	8.99
c31	8.8370	11.17
c32	5.9410	7.45
c41	-10.1160	-14.15
c42	-7.8630	-11.19
c51	-19.4380	-18.85
c52	-14.1010	-13.68
c1	0.0090	0.09
c2	-0.2209	-1.06
c3	0.3234	6.00
c4	-0.0652	-0.89
c5	0.4018	4.03
d1	-0.1722	-4.27
u12	0.7050	0.21
u13	0.3700	0.33
u14	-1.9140	-1.35
u15	0.5540	0.27
u23	-0.5340	-0.41
u24	1.0780	0.49
u25	2.7810	2.38
u34	-0.5280	-0.40
u35	1.9600	1.30
u45	0.0000	0.00
v12	0.0000	0.00

Estimates of the main diagonal elements u_{ii} of the $U = \left[u_{ij}\right]$ matrix can be obtained using the following equations (which are based on the first set of restrictions in (8)):

(15) $$u_{ii} = -\sum_{j=i+1}^{5} u_{ij}, \quad i = 1,2,3,4;$$

(16) $$u_{55} = 0.$$

Similarly, the second set of restrictions in (8) can be used in order to obtain estimates of the main diagonal elements v_{ii} of the $V = \left[v_{ij}\right]$ matrix:

(17) $\quad v_{11} = -v_{12}; \quad v_{22} = 0.$

Finally, the restriction (6) can be used to obtain an estimate for d_2:

(18) $\quad d_2 = -d_1.$

From Table 5.1, it can be deduced that the variable goods substitution matrix $A = U^T U$ has rank 3 instead of the maximum possible rank 4 and the stock substitution matrix $B = V^T V$ has rank 0 instead of the maximum possible rank 1. With the exception of u_{25}, the statistical significance of the components of these substitution matrices is generally low. However, the components of the C matrix and the components of the c and d vectors are generally highly significant.

A measure of the technical progress that took place during year t can be obtained by differentiating the profit function $\pi(p,s,t)$ with respect to t and dividing by $\pi(p,s,t)$ evaluated at $p = p^t$ and $s = s^t$. The resulting measure of technical progress turned out to be 0.061 for 1972 and trended upward to 0.106 for 1991, averaging 8.2 per cent per year for the twenty years in our sample. Since variable profits are only about one quarter of the total returns to labour and capital, the average rate of 8.2 per cent translates into an average total factor productivity improvement of about 2 per cent per year. The positive and statistically significant parameter estimates for c_3 and c_5 indicate that the technical progress was mainly export augmenting and labour saving.

Since[29] the fitted net output of variable good i in period t, $\tilde{x}_i^t$, can be obtained by differentiating $\pi(p^t, s^t, t)$ with respect to p_i, the jth price elasticity of net supply for good i in period t can be defined as

(19) $$\sigma_{ij}^t \equiv \left(p_j^t / \tilde{x}_i^t\right)\partial^2\pi\left(p^t, s^t, t\right) / \partial p_i \partial p_j; \quad i,j, = 1,\ldots,5.$$

The sample means of the net supply elasticities are listed in Table 5.2.

From viewing Table 5.2, it can be seen that with the exception of the price elasticity of demand for labour (which averaged -0.47), the elasticities were rather small in magnitude. However, there were some interesting trends in the annual elasticity estimates: σ_{11}^t (the own price elasticity of supply for motor vehicles) trended upwards from 0.06 in 1972 to 0.12 in 1991; σ_{22}^t (the own price elasticity of supply for general output) trended up from 0.23 to 0.36; σ_{33}^t (the own price elasticity of supply for exports) stayed approximately constant at 0.16; σ_{44}^t (the

29 Recall equation (2) above; thus we have $\tilde{x}_i^t = \partial\pi\left(p^t, s^t, t\right) / \partial p_i$ for $i = 1,2,3,4,5$.

Table 5.2: **Average price elasticities of net supply σ_{ij}**

	With respect to price of:				
Change in quantity of:	*Motor vehicles*	*Consumption & investment*	*Exports*	*Imports*	*Labour*
Motor vehicles	0.09	0.19	0.10	-0.52	0.13
Consumption and investment	0.01	0.28	0.06	-0.11	-0.24
Exports	0.01	0.15	0.16	-0.03	-0.29
Imports	0.04	0.25	0.03	-0.30	-0.02
Labour	-0.01	0.33	0.17	-0.02	-0.47

own price elasticity of demand for imports) stayed approximately constant at -0.30 and then trended to -0.24 during the last 5 years and σ^{l}_{55} (the own price elasticity of demand for labour) trended up in magnitude from -0.35 in 1971 to -0.71 in 1991.[30] From our discussion in Section 4.4 above, the increasing magnitudes of σ^{l}_{22} and σ^{l}_{55} suggests that the excess burden of increased government spending in New Zealand will probably be increasing over time. As we shall see in Chapter 7 below, this expectation of increasing excess burdens turns out to be true.

We turn now to the specification of our consumer model for New Zealand.

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30 We have found this same upward trend in the magnitude of the price elasticity of demand for labour for most OECD countries in similar production models. This suggests that increases in wage rates have led to greater rates of unemployment in these countries.

6. A MODEL OF CONSUMER BEHAVIOUR FOR NEW ZEALAND

6.1 The consumer model

In this Chapter, we use the data for New Zealand explained in Appendix A below to estimate a system of consumer demand and labour supply equations. As in the previous Chapter, we do not want to restrict a priori elasticities of substitution so we again use flexible functional form techniques. In the present Section we present our theoretical model and in the following Section we present empirical results.

We assume that a representative consumer has preferences defined over 4 current period goods: (1) the consumption of the services of the current stock of motor vehicles; (2) general consumption (excluding motor vehicles and housing); (3) the consumption of the services of the current stock of housing; and (4) the consumption of leisure.

The economy's total consumption of the above 4 goods was divided by the adult, working age population, aged 15-64 inclusive. Each working age adult was given a time endowment of 2000 hours per year. Per capita leisure h was defined as 2000-L where L is per capita hours of work supplied during the year under consideration. The resulting (rental) prices p_i^t and per capita quantities x_i^t are listed in Table A24 of Appendix A.

The consumer's preferences can be represented by the expenditure function, $e(u, p)$, which is dual to the utility function, $u = f(x)$, where p and x are price and quantity vectors pertaining to consumer expenditure categories.[31] As in the previous Chapter, we again use a normalised quadratic functional form,[32] since curvature conditions can be imposed on this functional form without destroying its flexibility. The functional form used in this Chapter is defined as follows:

$$(1) \qquad e(u,p) \equiv \begin{cases} a \cdot p + b \cdot pu + \left(\frac{1}{2}\right) p \cdot Cpu \,/\, p \cdot g & \text{for } u \le u^* \\ a \cdot p + b \cdot pu^* + c \cdot p\left(u - u^*\right) + \left(\frac{1}{2}\right) p \cdot Cpu \,/\, p \cdot g & \text{for } u > u^* \end{cases}$$

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31 For expositions of the use of duality theory in modelling consumer preferences, see Diewert (1974; 120-133) (1993; 148-154).

32 See Diewert and Wales (1987) (1988a) (1988b) (1993). We used the linear spline model described in Diewert and Wales (1993; 83) with one break point.

where $g \equiv (g_1, g_2, g_3, g_4)$ is a predetermined parameter vector; u^* is a predetermined level of utility; $a \equiv (a_1, a_2, a_3, a_4)$, $b \equiv (b_1, b_2, b_3, b_4)$ and $c \equiv (c_1, c_2, c_3, c_4)$ are parameter vectors to be estimated and $C \equiv [c_{ij}]$ is a symmetric parameter matrix to be determined. The parameter vectors a, b and c satisfy the following restrictions:

(2) $$a \cdot p^* = 0; \; b \cdot p^* = 1; \; c \cdot p^* = 1$$

where p^* is a predetermined price vector.[33] The parameter matrix C satisfies the following restrictions:

(3) $$C = -U^T U$$

where $U = [u_{ij}]$ is an upper triangular matrix which satisfies the following restrictions:

(4) $$Up^* = 0_4.$$

The restrictions (2) — (4) impose money metric scaling[34] on the utility function; i.e., utility change can be measured in terms of income or expenditure change at the reference prices p^*.

The ith Hicksian demand function, $x_i(u, p)$ can be obtained by differentiating the expenditure function with respect to the ith consumer price, p_i; i.e., we have:

(5) $$x_i(u, p) = \partial e(u, p) / \partial p_i, \quad i = 1, 2, 3, 4.$$

The Hicksian demand functions defined by (5) have (unobservable) utility as an independent variable. We obtain an analytic expression for utility in period t, u^t, by setting the expenditure function evaluated at period t utility, u^t, and period t prices, $p^t \equiv (p_1^t, p_2^t, p_3^t, p_4^t)$, equal to period t expenditures on the 4 goods, Y^t. We then solve the resulting equation $e(u^t, p^t) = Y^t$ for $u^t = g(Y^t, p^t)$. The function g is the consumer's indirect utility function and it is substituted into the equations (5) in order to obtain the following system of estimating equations:

(6) $$x_i^t = \partial e\left[g\left(Y^t, p^t\right), p^t\right] / \partial p_i, \quad i = 1, 2, 3, 4.$$

To reduce heteroskedasticity, we multiply both sides of the ith equation in (6) by p_i^t / Y^t, which transforms (6) into a system of expenditure share equations. Since these shares sum to

33 We chose $p^* = 1_4$, a vector of ones.

34 The term money metric scaling is due to Samuelson (1974) but the concept may be found in Hicks (1946).

unity in each period, we must drop one of those share equations when estimating the parameters using a non-linear regression package. We dropped the last equation, but as was the case in the previous Chapter, our estimates are invariant to the equation dropped.

Examination of definition (1) above shows that the term $b \cdot pu$ changes into the terms $b \cdot pu^* + c \cdot p(u - u^*)$ as u passes through the break point u^*. Thus, income elasticities of demand can change arbitrarily as u passes through u^*. We have not yet discussed how this break point u^* was chosen, a task which we now undertake.

It is known that constructing a chain Fisher (1922) ideal quantity index using the per capita price and quantity data tabled in Appendix A will give a close approximation to the period t indirect utility, $u^t = g(Y^t, p^t)$.[35] For more evidence to support this assertion, see Table 6.1 which lists u^t estimates in column 2 (based on our parameter estimates of the expenditure function $e(u, p)$ defined by (1) — (4) above) and lists the chain Fisher quantity indexes in column 3. The units are in thousands of 1972 New Zealand dollars. As can be seen from examining Table 6.1, the index number estimates of per capita real consumption (including the

Table 6.1: **Estimates of real per capita utility**

Year	*Utility estimate*	*Quantity index estimate*
1972	3.085	3.085
1973	3.219	3.225
1974	3.319	3.327
1975	3.368	3.374
1976	3.303	3.305
1977	3.238	3.239
1978	3.142	3.139
1979	3.115	3.113
1980	3.120	3.117
1981	3.078	3.072
1982	3.066	3.061
1983	3.066	3.058
1984	3.166	3.156
1985	3.239	3.227
1986	3.269	3.255
1987	3.342	3.328
1988	3.410	3.398
1989	3.489	3.485
1990	3.541	3.543
1991	3.551	3.554

35 See Diewert and Wales (1993; 101). To obtain the close correspondence, the quantity index must be set equal to expenditures in the base period, which is the period which has prices equal to the reference prices p^*. In our case, the base period was the first period.

consumption of leisure) coincide with the econometric estimates of indirect utility to three significant figures. Note that real consumption trends up from 1972 to 1975 ($3,085 to $3,374 in constant 1972 New Zealand dollars), trends down until 1983 (hitting a low of $3,058) and then trends up to 1991, ending up at $3,554.

The information in the last column of Table 6.1 (which can be computed without econometric estimation) allows us to choose the break point u^*. We set $u^* \equiv 3.39$, which means that only the last 4 observations will be in the utility region $u > u^*$. With this choice of u^*, the system of estimating equations defined by (6) can be determined by differentiating the expenditure function defined by (1). The first 16 observations in our sample are assumed to be in the region $u \leq u^*$ and the last 4 observations are assumed to be in the regions $u > u^*$. This completes the theoretical specification of our model.

6.2 Empirical results for the consumer model

The model based on the transformed equations (6) (where the last equation was dropped since the expenditure shares sum to one in each period) was run using the non-linear regression program in SHAZAM. Autocorrelation proved to be a problem, so the model was rerun using the AUTO option.[36] The resulting parameter estimates are listed Table 6.2.

Table 6.2: **Parameter estimates for the consumer model**

Parameter	*Estimate*	*t ratio*
a1	0.0175	0.24
a2	0.3363	0.65
a3	0.2305	8.85
b1	0.0387	1.65
b2	0.5119	3.12
b3	-0.0074	-0.91
c1	0.0641	1.36
c2	-0.7405	-3.03
c3	0.0672	5.15
u12	0.1416	1.33
u13	0.0276	3.39
u14	-0.0643	-0.66
u23	-0.0172	-1.96
u24	-0.4538	-6.38
u34	-0.0345	-3.90
ρ	0.6757	9.81

36 The same autocorrelation coefficient ρ was estimated for each equation.

Estimates for a_4, b_4 and c_4 were obtained using the estimates listed in Table 6.2 and equations (2). Estimates for the diagonal elements u_{ii} of the U matrix were obtained using equations (4). The parameters describing the consumer model were significantly different from zero for the most part. The R^2 between observed and predicted variables in the three estimating equations were 0.9227, 0.9273 and 0.9996, which was quite satisfactory considering that the dependent variables were shares.

Since the period t fitted demand for commodity i, $\tilde{x}_i^t$, is equal to the derivative of the estimated expenditure function with respect to the ith price evaluated at the period t data, $\tilde{u}^t \equiv g\left(Y^t, p^t\right)$ and p^t (i.e., we have $\tilde{x}_i^t = \partial e\left(\tilde{u}^t, p^t\right) / \partial p_i$), the Hicksian price elasticity of demand for consumer good i with respect to price j can be defined as

(7) $$\eta_{ij}^t \equiv \left(p_j^t / \tilde{x}_i^t\right)\partial^2 e\left(\tilde{u}^t, p^t\right) / \partial p_i \partial p_j; \quad i, j = 1, \ldots, 4.$$

The sample means of the demand elasticities η_{ij}^t are listed in Table 6.3.

Table 6.3: Average compensated price elasticities of demand

	With respect to price of:			
Change in quantity of:	*Motor vehicles*	*General consumption*	*Housing*	*Leisure*
Motor vehicles	-0.29	0.36	0.060	-0.14
General consumption	0.03	-0.41	0.005	0.38
Housing	0.05	0.05	-0.030	-0.07
Leisure	-0.02	0.82	-0.010	-0.79

From Table 6.3, it can be seen that the demand for housing (good 3) is quite inelastic: no price change significantly changes the demand for housing. The demand for motor vehicles (good 1) is also inelastic with respect to changes in the price of housing and the price of leisure (good 4) but motor vehicle demand is moderately substitutable with general consumption (good 2) since the average cross elasticity of demand for motor vehicles with respect to general consumption is 0.36. General consumption is quite substitutable with leisure since the two average cross elasticities are 0.38 and 0.82. The average price elasticity of demand for leisure, -0.79, is quite high in magnitude. This price elasticity of demand ranged between -0.64 in 1991 to -0.93 in 1976.

Hicksian real income elasticities of demand[37] can be defined as follows:

(8) $$\eta_{iu}^t \equiv \left(\tilde{u}^t / \tilde{x}_i^t\right)\partial^2 e\left(\tilde{u}^t, p^t\right) / \partial p_i \partial u; \quad i = 1, \ldots, 4.$$

37 These elasticities are equal to ordinary income elasticities of demand.

The sample average income elasticities were: η_{1u} = 0.99; η_{2u} = 0.42; η_{3u} = 0.14 and η_{4u} =2.40. These results are a bit unusual since it is generally thought that the income elasticity of demand for housing exceeds unity. However, over the first 16 observations in our sample, real income (or utility) changed very little so we cannot expect to obtain very accurate estimates for income elasticities of demand. The average η_{ui} over the last 4 observations (when real incomes increased quite dramatically) were: η_{1u} =1.46; η_{2u} = 1.21; η_{3u} = 1.11 and η_{4u} = 5.13. Thus, over the last four years in our sample, it appears that motor vehicles, housing and leisure all had income elasticities exceeding unity.

We turn now to a general equilibrium model of excess burdens for the New Zealand economy that utilises the consumer model described in this Chapter and the producer model described in the previous Chapter.

7. MARGINAL EXCESS BURDENS IN NEW ZEALAND

7.1 The theoretical model

In this Chapter, we bring together the producer model of Chapter 5 and the consumer model of Chapter 6 and construct a small (static) general equilibrium model for the New Zealand economy.

Let C_i denote the per capita[38] consumption of good i for i=1,2,3,4. As in Chapter 6, consumer good 1 is the services of motor vehicles, good 2 is general consumption, good 3 is the services of the beginning of the period housing stock and consumer good 4 is the consumption of leisure. Denote the per capita stock of vehicles by S_1, the per capita stock of housing by S_3 and the per capita stock of time that is potentially available for labour supply during the year under consideration by H.[39] The prices that consumers face for the four consumer goods are denoted by P_1, P_2, P_3 and P_4.[40] These consumer data are listed in Table B.1 of Appendix B.

Let Y_i denote the per capita net output of producer good i for i=1,...,5. As in Chapter 5, producer good 1 is new motor vehicles produced or imported during the year, good 2 is general consumption plus investment plus government consumption of goods, good 3 is exports of goods and services, good 4 is (minus) imports of goods and services during the year under consideration and good 5 is (minus) the demand for labour. The prices that the market sector of the economy faces for the five producer goods are denoted by p_1, $p_2(1+s_2), p_3(1+s_3), p_4(1+t_4)$ *and* p_5 where s_2 is the subsidy rate on general output, s_3 is the subsidy rate on exports and t_4 is the total indirect tax and tariff rate on imports.[41]

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38 The population variable is the adult population between ages 15 and 64 inclusive. All "per capita" variables have been formed by dividing by this population.

39 We chose H to be 2000 hours. After converting to monetary units and producer prices, H turned out to be 3.3098.

40 Note that we have changed our notation for the consumer prices and quantities compared to that used in Chapter 6.

41 We have changed the notation for the producer prices and quantities compared to that used in Chapter 5. Denote the producer prices used in this Chapter by p_i and the corresponding producer prices used in Chapter 5 and listed in Appendix A by p_i^*, $i = 1,\ldots,5$. The relationships between the 5 sets of prices are as follows: $p_1 = p_1^*$; $p_2(1+s_2) = p_2^*$; $p_3(1+s_3) = p_3^*$; $p_4(1+t_4) = p_4^*$ and $p_5 = p_5^*$. The subsidy rates s_2 and s_3 and the tariff rate t_4 are listed in Table B.3. The per capita fitted Y_i used in this Chapter are listed in Table B.2 of Appendix B.

There are seven equations in our static general equilibrium model. They are listed below as:

(1) $C_1 = Y_1 + S_1;$

(2) $C_2 = Y_2 - I - G;$

(3) $C_3 = S_3;$

(4) $B = p_3 Y_3 + p_4 Y_4;$

(5) $C_4 = Y_5 - L_G + H;$

(6)
$$E = (1 - t_6)\pi + p_5(1 - t_5)H + P_1 S_1 + P_3 S_3 - p_1[1 - (\delta_1 + r)]Y_1$$
$$- P_3 t_3 S_3 - B - p_2 I - p_2 D + T;$$

(7)
$$p_1 t_1 Y_1 + p_2 t_2 C_2 + P_3 t_3 C_3 - p_4 t_4 Y_4 + p_5 t_5 (H - C_4) + t_6 \pi$$
$$- p_2 s_2 Y_2 - p_3 s_3 Y_3 + p_2 D = p_2 G + p_5 L_G + T.$$

The tax rates t_1 to t_6 (on purchases of motor vehicles, general consumption, housing, imports, labour and profits, respectively) as well as the subsidy rates on general output s_2 and on exports s_3 are listed in Table B.3 of Appendix B.[42] Estimates of real per capita government expenditures on goods G and on labour L_G may be found in Table B.4 of Appendix B along with some additional variables used in equations (1) to (7) above.

Before we present detailed interpretations of equations (1) to (7), we need to express the consumer prices P_1, P_2 and P_4 in terms of the producer prices p_i:

(8) $P_1 = [t_1 + (r + \delta_1)]p_1;$

(9) $P_2 \equiv (1 + t_2)p_2;$

(10) $P_4 \equiv (1 - t_5)p_5;$

42 We set $s_2 = s_3$; i.e., we assumed a common subsidy rate on all output due to a lack of more specific information. The housing tax rate t_3^* is the housing tax rate applied to the purchase price rather than the rental price. To calculate the rental price tax rate t_3 from t_3^*, use $t_3 = t_3^* / [t_3^* + (r + \delta_3)]$ where r is the real after tax interest rate and $\delta_3 \equiv 0.015$ is the housing depreciation rate. The motor vehicle depreciation rate used was $\delta_1 \equiv 0.1385$.

where $\delta_1 \equiv 0.1385$ is the depreciation rate for motor vehicles and r is the after tax real rate of return. The right hand side of (8) is the rental price for motor vehicles assuming that the motor vehicle inflation rate is equal to the general inflation rate. The real rates of return for the New Zealand economy are listed in Table B.4 of Appendix B. The variables E (per capita consumer expenditures) and π (per capita gross profits) also appear in equations (6) and (7) above. These variables are defined in terms of per capita consumer purchases C_i and per capita producer net outputs Y_i as follows:

(11) $$E \equiv \sum_{i=1}^{4} P_i C_i;$$

(12) $$\pi \equiv p_1 Y_1 + p_2(1+s_2)Y_2 + p_3(1+s_3)Y_3 + p_4(1+t_4)Y_4 + p_5 Y_5.$$

Now we can provide explanations for each of the equations (1) — (7) in our static general equilibrium model. All quantity variables are expressed in per capita terms (or, more accurately, on a per working age population basis).

Equation (1) is the demand (C_1) equals supply equation for motor vehicles. Supply is made up of new additions (Y_1) plus the existing stock (S_1). Equation (2) is the demand $(C_2 + I + G)$ equals supply (Y_2) equation for the general output of the economy. Equation (3) equates the demand for housing (C_3) to the stock available at the beginning of the period (S_3).[43] B is the (exogenous) balance of trade for the New Zealand economy (in per capita terms) and in equation (4), B is equated to the per capita value of exports $(p_3 Y_3)$ minus the per capita value of imports $(p_4 Y_5)$.[44] Thus B is the balance of trade surplus (deficit if B is negative) converted into New Zealand dollars.[45] In equation (5), the demand for leisure (C_4) is equated to the stock of economically relevant time in the period (H) minus time worked in the government sector $(-L_G)$ minus time worked in the private sector (Y_5).[46] Equation (6) is the representative consumer's budget constraint and equation (7) is the government's budget constraint in per capita terms. The terms on the left hand side of (7) are per capita tax revenues on motor vehicles $(p_1 t_1 Y_1)$, general consumption $(p_2 t_2 C_2)$, housing $(P_3 t_3 C_3)$, imports $(-p_4 t_4 Y_4)$, labour earnings $(p_5 t_5 [H - C_4])$ and profits $(t_6 \pi)$ less per capita subsidy expenditures on general output $(-p_2 s_2 Y_2)$ and exports $(-p_3 s_3 Y_3)$ plus the general government

43 New additions to the stock of housing are included in investment I.

44 Recall that Y_4 is indexed with a minus sign.

45 Thus p_3 is the foreign export price and p_4 is the overseas import price converted into New Zealand dollars.

46 Remember Y_5 is indexed with a minus sign since it is an input.

per capita budget deficit (p_2D).[47] The terms on the right hand side of (7) are per capita government expenditures on goods (p_2G) and labour (p_5L_G) at producer prices plus the per capita transfer T that is required to keep consumers at their initial utility level as exogenous tax and subsidy rates are varied. T is always set equal to zero before the tax change takes place.

Given equations (1) — (5) and (7) and the identities (8) — (12), we can derive the consumer's budget constraint (6) from the remaining equations. On the left hand side of (6), we have per capita expenditures on consumer goods including leisure, (E). On the right hand side, we have the following sources of income: per capita after tax profits $([1-t_6]\pi)$; the value of the consumer's time endowment $(p_5[1-t_5]H)$; the value of consumer stocks of motor vehicles (P_1S_1) and housing (P_3S_3). Also appearing on the right hand side of (6) are some terms expressing the tax treatment of stocks (the terms $-p_1[1-(\delta_1+r)Y_1]$ and $-P_3t_3S_3$) as well as some adjustments for the treatment of trade, investment and financing the deficit (the terms $-B-p_2I-p_2D$). The final term on the right hand side of the consumer's budget constraint is T, new transfer income from the government which compensates the consumer for any adverse changes in tax or subsidy rates.

Since the 7 equations (1) — (7) are dependent, we drop equation (7) in what follows. We replace the per capita consumption variables C_i by the price derivatives of the consumer's expenditure function, $\partial e\left[u, p_1\left(t_1+\left(\delta_1+r\right)\right), p_2\left(1+t_2\right), P_3, p_5\left(1-t_5\right)\right] / \partial P_i$ for i=1,2,3,4 and we replace the per capita net output variables Y_i by the derivatives of the per capita profit function $\pi\left(p_1, p_2\left(1+s_2\right), p_3\left(1+s_3\right), p_4\left(1+t_4\right), p_5\right)$ with respect to its ith price variable for i=1,2,3,4,5. The endogenous variables in the resulting system of 6 equations (1) — (6) are the following 6 variables: T, G, p_1, p_2, P_3 and p_5. The international prices for exports and imports, p_3 and p_4, are regarded as being exogenous to the model and these international prices act as numeraire prices for our model in each time period.

The utility level u, the stock levels S_1 and S_3, investment I, the balance of trade B, the government's labour requirements L_G and the real government deficit D were all regarded as exogenous variables.[48] The tax and subsidy rate variables were the exogenous variables of interest. We totally differentiated equations (1) — (6) with respect to our 6 endogenous

47 D can be more accurately described as the real per capita deficit minus real per capita transfers from the government to consumers.

48 Our econometric models of consumer and producer behaviour were used to generate the per capita consumption and net output variables C_i^t and Y_i^t. Then equations (1) — (5) and (7) were used to generate estimates for $S_1^t, I^t, S_3^t, B^t, L_G^t$ and D^t respectively. All of these variables are listed in Appendix B.

variables and 7 of our exogenous tax and subsidy instruments. We did not differentiate with respect to t_3, the property tax rate, because the treatment of housing requires an intertemporal model. Various second derivatives of the expenditure function and the per capita profit function appeared in the resulting 6 simultaneous equations. We estimated these derivatives by converting our elasticity estimates discussed in chapters 5 and 6 above into derivatives. After inverting a 6 by 6 matrix for each period (using the matrix operations in the econometrics program SHAZAM), we were able to calculate the partial derivatives of G, T, p_2 and p_5 with respect to the t_i and s_j.

We utilise the Allais-Debreu excess burden concept discussed in Section 4.4 above. Since utility is held constant, our indicator of overall welfare is simply the value of government consumption of goods G times the (constant) consumer price of general consumption P_2. Thus, define welfare as a function of the exogenous tax and subsidy rates as follows:

$$(13) \qquad W\left(t_1,t_2,t_4,t_5,t_6,s_2,s_3\right) \equiv P_2 G\left(t_1,t_2,t_4,t_5,t_6,s_2,s_3\right).$$

The left hand side of the government budget constraint is essentially net government revenues and the right hand side is essentially government expenditures. Since the right hand side of (7) has fewer terms than the left hand side, we define the net revenue function R as a function of the exogenous tax and subsidy instruments as follows:

$$(14) \qquad R\left(t_1,t_2,t_4,t_5,t_6,s_2,s_3\right) \equiv p_2\left(t_1,\ldots,s_3\right)G\left(t_1,\ldots,s_3\right) + p_5\left(t_1,\ldots,s_3\right)L_G + T\left(t_1,\ldots,s_3\right)$$

where $G\left(t_1,\ldots,s_3\right)$, $T\left(t_1,\ldots,s_3\right)$, $p_1\left(t_1,\ldots,s_3\right)$, $p_2\left(t_1,\ldots,s_3\right)$, $P_3\left(t_1,\ldots,s_3\right)$ and $p_5\left(t_1,\ldots,s_3\right)$ are the solution functions to the system of simultaneous equations (1) — (6). The Allais-Debreu general equilibrium measure of the marginal excess burden associated with increasing the tax rate t_i, $MEB\left(t_i\right)$, is defined as in Section 4.4 as (minus) the rate of change in welfare defined by (13) divided by the rate of change in revenue defined by (14) with respect to t_i; i.e., for i=1,2,4,5,6:

$$(15) \qquad MEB\left(t_i\right) \equiv -\left[\partial W\left(t_1,\ldots,s_3\right)/\partial t_i\right] / \left[\partial R\left(t_1,\ldots,s_3\right)/\partial t_i\right].$$

Similar measures of marginal excess burden associated with decreasing the subsidy rate s_j can be defined as follows for j=2,3:

$$(16) \qquad MEB\left(s_j\right) \equiv -\left[\partial W\left(t_1,\ldots,s_3\right)/\partial s_j\right] / \left[\partial R\left(t_1,\ldots,s_3\right)/\partial s_j\right].$$

7.2 Empirical results

The marginal excess burden measures defined by (15) and (16) were evaluated using the elasticities and data generated by our models of producer and consumer behaviour for New Zealand for the 20 years in our sample. The resulting marginal excess burdens are presented in Table 7.1.

Table 7.1: Marginal excess burdens for New Zealand

Year	$MEB(t_1)$ Motor vehicles	$MEB(t_2)$ General consumption	$MEB(t_4)$ Imports	$MEB(t_5)$ Labour	$MEB(s_2)$ General production	$MEB(s_3)$ Exports
1972	-0.0341	0.049	0.019	0.053	0.037	0.038
1973	-0.0016	0.049	0.024	0.053	0.038	0.038
1974	-0.0027	0.053	0.027	0.057	0.043	0.038
1975	0.0071	0.071	0.029	0.075	0.056	0.065
1976	-0.0104	0.063	0.020	0.063	0.045	0.052
1977	-0.0057	0.070	0.026	0.073	0.054	0.056
1978	-0.0046	0.075	0.027	0.081	0.059	0.062
1979	-0.0026	0.065	0.023	0.067	0.048	0.047
1980	-0.0506	0.077	0.023	0.080	0.061	0.049
1981	-0.0349	0.075	0.022	0.079	0.058	0.047
1982	-0.0275	0.081	0.022	0.083	0.060	0.050
1983	-0.0510	0.077	0.020	0.083	0.058	0.041
1984	-0.0371	0.071	0.021	0.080	0.055	0.037
1985	-0.0489	0.076	0.023	0.088	0.061	0.039
1986	-0.0560	0.084	0.023	0.100	0.069	0.042
1987	-0.0161	0.099	0.029	0.121	0.088	0.061
1988	-0.0166	0.116	0.031	0.139	0.109	0.077
1989	-0.0142	0.126	0.035	0.157	0.122	0.072
1990	-0.0435	0.137	0.042	0.183	0.147	0.072
1991	-0.0401	0.137	0.037	0.183	0.141	0.066
Average	-0.0253	0.083	0.026	0.095	0.070	0.052

The marginal excess burden $MEB(t_6)$ associated with increasing the profits tax was zero in each period and hence was not listed in Table 7.1. This zero excess burden result is entirely due to our treatment of capital and investment: we assumed that investment was exogenously determined and not affected by capital taxation. In order to remove this assumption we would need to construct a complete intertemporal general equilibrium model and time constraints did not allow us to undertake this extension of our model. However, as was mentioned in Chapter 4, existing intertemporal general equilibrium models do find large excess burdens associated with the taxation of capital and so we would expect to also find large marginal excess burdens due to capital taxation.[49]

49 See Ballard, Shoven and Whalley (1985), Jorgenson and Yun (1986a) (1986b) (1990) (1991) and Diewert (1988; 23).

From Table 7.1, we see that the marginal excess burden of financing increased government expenditures by increasing the tax rate t_1 on new motor vehicles is actually a marginal excess benefit which averaged 2.53 per cent over the sample period. This means that, on average, a government project financed by increased motor vehicle taxation could earn a real rate of return which was 2.53 per cent *below* the normal real rate of return and consumer overall welfare would remain unchanged. This anomalous result is due to the fact that motor vehicles appeared to be complementary to many goods, both in consumption and production.

The important marginal excess burdens are $MEB\left(t_2\right)$ and $MEB\left(t_5\right)$, those burdens associated with increasing consumption and labour taxation. Both of these excess burdens are quite significant: an average of 8.3 per cent for consumption taxation and an average of 9.5 per cent for labour taxation. Because we use a general equilibrium framework, our deadweight cost estimates apply year after year once a change in taxation has occurred. Consequently, if a government project is to be justified taking deadweight losses into account, it must provide a return each year which exceeds its direct cost (including a normal return) by at least the amount of the deadweight cost. This is equivalent to earning an ongoing real rate of return over and above the normal rate of return by at least the estimated percentage of deadweight costs. Thus, a government project financed by additional consumption (labour) taxation should have on average earned a real rate of return 8.3 per cent (9.5 per cent) above the normal real rate of return in order to overcome the adverse effects of increased taxation. These are very large excess rates of return since in most countries the after tax real rate of return is between 1 and 3 per cent.[50]

However, the sample average excess burdens do not tell the whole story. Examination of Table 7.1 and the tax rates listed in Table B.3 of Appendix B show that as tax rates in the New Zealand economy increased, marginal excess burdens have also tended to increase. Thus, the marginal excess burden associated with increased consumption (labour) taxation grew from 4.9 per cent (5.3 per cent) in 1972 to 13.7 per cent (18.3 per cent) in 1991. These are spectacular rates of increase.

It can be seen from Table 7.1 that the marginal excess burden associated with increasing the tax rate on international trade t_4 averages 2.6 per cent during the sample period. The annual $MEB\left(t_4\right)$ showed only a gradual upward trend. The general tendency for excess burdens to increase markedly over time was offset in this case by the reductions in trade taxes that took place over the 1970s and 1980s.

50 We estimated the private sector's average real rate of return to be 0.6% over the 20 years in our sample.

From Table 7.1, we see that the average marginal excess burdens associated with financing increased government expenditures by *reducing* the subsidy rate to domestic output producers s_2 and to exporters s_3 were 7.0 per cent and 5.2 per cent, respectively. This means that increasing s_2 or s_3 would produce marginal benefits. The reason for this result is that increasing s_2 is approximately equivalent to reducing the general output tax rate t_2 and increasing s_3 is approximately equivalent to reducing the tariff rate t_4. Hence, these increases in subsidy rates tend to move the economy towards a more optimal tax structure and hence reduce excess burdens. Looking at trends in the marginal excess burdens associated with decreasing subsidies, we see that $MEB(s_2)$ trends upward form 3.7 per cent in 1972 to 14.1 per cent in 1991 while $MEB(s_3)$ trends upward from 3.8 per cent to 6.6 per cent. The more rapid growth in $MEB(s_2)$ reflects the more rapid growth in t_2 compared to t_4 over the 20 years.

7.3 Conclusion

In our simple theoretical model of excess burden developed in Section 4.4 above, we showed that the cost of financing increased government expenditures (while keeping consumer's real consumption of market goods constant) was approximately proportional to the sum of the tax rates on consumption and labour.[51] This theoretical result received some support from our more detailed empirical model for New Zealand. Over the 20 years in our sample period, the sum of the consumption tax and labour tax grew from 31.6 per cent in 1972 to 63.8 per cent in 1991, an approximate doubling. Over the same period, the marginal excess burdens associated with increasing general consumption taxation grew from 4.9 per cent to 13.7 per cent and those associated with increasing labour taxation grew from 5.3 per cent to 18.3 per cent. Thus, the marginal excess burdens approximately tripled over this period.

This greater than proportional growth in marginal excess burdens can be attributed to the fact that many key elasticities (both on the production and consumption sides of our model) grew over the sample period and bigger elasticities lead to bigger excess burdens.

The higher tax rates that occurred in the New Zealand economy were driven by increasing government spending, particularly on social services, and increasing government debt levels. The phenomenon of increasing per capita debt levels is not limited to the New Zealand economy — many countries have had the same problem. These countries may also find that high levels of debt (which eventually lead to high tax rates) can have a substantial cost. In the case of New

51 Recall equations (59) and (60) in Chapter 4.

Zealand in 1991, reducing government expenditures by cutting labour taxes could have led to a real rate of return on this "investment" of 18.3 per cent.

The strength of our study is that we have developed a rigorous general equilibrium framework within which to calculate marginal excess burdens. Instead of using restrictive functional forms to model consumer and producer behaviour or relying on guesstimates of the relevant elasticities as most earlier studies have, we have estimated all the required elasticities econometrically using flexible functional form techniques. Our econometric model of the New Zealand economy has some degree of disaggregation and incorporates major consumer durables.

However, our study is also subject to a number of limitations: (i) the model is static; we have not modelled the investment and capital accumulation decisions; (ii) in modelling the labour supply decision, we assumed that all unemployment was voluntary and we ignored the discrete aspect of being in the labour force; (iii) we had only one class of household and hence we may have some aggregation over consumers bias; (iv) our model had only 7 goods in it and hence may be subject to some aggregation over commodities bias; (v) we assumed that average and marginal tax rates were the same; (vi) our elasticity estimates are biased downwards[52] and hence it is probable that our excess burden measures are also biased downwards.

The priority for future work should be to extend the model to make it intertemporal and include explicit modelling of the capital accumulation process. This will enable marginal excess burdens associated with capital taxation to be calculated.

52 This downward bias is due to the fact that we have frozen the allocation of capital during each year. The Le Chatelier Principle of Samuelson (1947; 36-38) and Hicks (1946; 206) suggests that long run elasticities will be bigger than short run elasticities; see also Diewert (1974; 146-150) (1985b; 224). Also Diewert (1985b; 237) shows that excess burdens in a dynamic model will generally exceed the discounted present value of corresponding static excess burdens i.e., growth can only augment the effect of static distortions (at least to the second order).

8. CONCLUSIONS

The New Zealand economy has undergone considerable reform in the last decade. Reform of the tax system has been an integral part of this process. More reliance has been placed on indirect taxes with the introduction of what is regarded as one of the most comprehensive and 'pure' goods and services taxes in the world, the income tax has been made broader-based but with a flatter rate structure and import tariffs have been scaled down. However, tax revenue as a proportion of gross domestic product has continued to increase and remains high relative to comparable countries. In 1991 New Zealand's share of taxation in GDP was 38.2 per cent compared with 29.9 per cent in the United States and 30.8 per cent in Australia (OECD 1991).

Government expenditure has consistently exceeded taxation revenue by a large margin for all but one of the last 12 years leading to increasing levels of public indebtedness. In 1992-93 net public debt stood at 55 per cent of GDP (Richardson 1992). In addition, the way many social security benefits are provided has a major negative impact on the incentive to work.

The key findings of this study that the marginal excess burdens associated with labour and consumption taxation have increased from 5 per cent to over 18 per cent and from 5 per cent to 14 per cent, respectively, over the last 20 years have important implications for the public policy debate in New Zealand. They indicate that the costs of allowing average tax rates to continue to increase are becoming increasingly high. Conversely, the New Zealand economy would reap large benefits from reduced government spending and taxation.

Over the 20 year period the average tax rate on labour income less than doubled while the marginal excess burden associated with labour taxation more than tripled. The more than proportional growth in the marginal excess burden can be attributed in part to the increasing flexibility of the New Zealand economy and points to the urgent need to review taxation levels.

The penalty these marginal excess burdens place on the real rate of return required for government projects to overcome the adverse effects of increased taxation (9.5 per cent on average over the last 20 years) are very large compared to the very meagre 0.7 per cent average real return earned by the private sector over the same period. This means that to be justified on economic grounds government spending has to provide a real rate of return around 20 times higher than that for the private sector.

The growth in the tax take in New Zealand has been driven by high levels of government expenditure, particularly on social services, and increasing government debt levels. In the case of New Zealand in 1991 the high cost of taxation can be alternatively illustrated by considering that a reduction in government spending financed by reduced labour taxes would have led to a real rate of return on this "investment" of 18.3 per cent. A more urgent priority, however, is likely to be a reduction in government spending accompanied by a period of unchanged taxation levels to facilitate the reduction of government debt. This would pave the way for a sustainable long-run reduction in taxation levels and associated gains to the New Zealand economy.

The results of our study are well within the range of deadweight loss estimates of previous studies for other countries. The model uses a rigorous general equilibrium framework and its key parameters are based on econometric estimates derived from flexible functional forms using the latest techniques rather than the guesstimates and restrictive assumptions of earlier studies. The results are all plausible. For instance, the finding that increasing subsidy rates on both general production and exports actually improves welfare by acting to partially offset the adverse effects of taxes on general production and imports further highlights the costs of taxation and the distortions in the allocation of resources they cause.

The importance of these issues is further highlighted by the fact that our deadweight loss estimates are likely to be relatively conservative. By estimating a static model which treats investment as exogenous and capital as fixed each period we have not been able to calculate the marginal excess burden of capital taxation. Other studies which have attempted to introduce dynamics and model capital accumulation decisions have shown that the marginal excess burden of capital taxation is generally higher than that for labour. This is especially likely to be the case for a small economy such as New Zealand trading in a world of ever-increasing capital mobility. Extension of the model to allow an assessment of the impacts of capital taxation should be a priority.

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APPENDIX A: DATA CONSTRUCTION

A1 Introduction

Estimation of the deadweight costs of taxation using a comprehensive modelling framework requires extensive time-series information on a range of key economic variables. While the quality of data routinely published on New Zealand has improved markedly in recent years, consistent time-series for many key variables remain non-existent or have significant gaps. Consequently, a major focus of this project has been the construction of a consistent time-series database for the New Zealand economy to permit detailed econometric work to be carried out.

The availability of reliable, consistent data was regarded as a top priority given the critical role that elasticity estimates play in the calculation of deadweight losses. Econometric models of the type estimated to derive the key elasticity estimates require time-series of price and quantity information for at least a 20 year period.

Efforts to date have concentrated on building up a consistent database for the period 1971-72 to 1990-91. The principal sources used in constructing the database were publications of the New Zealand Department of Statistics, the Organisation for Economic Co-operation and Development and the International Monetary Fund. In addition, other sources such as Valuation New Zealand were important in deriving point estimates of asset values from which asset value time-series were constructed. The New Zealand Treasury was also very helpful in providing information on the composition of tax collections and the tax base.

Compilation of the database has centred around variables necessary for econometric estimation of the models of consumer and producer response. An integral part of this has been construction of a consistent time-series of taxation payments classified by 7 major categories.

The static consumer model estimated required value, price and quantity information on 4 consumption categories:

- housing;
- motor vehicles;
- general consumption (excluding transport and housing); and,
- leisure.

Data has also been collected for the future estimation of a dynamic or intertemporal consumer model. The additional data series required for this relate to the components of household wealth (other than housing and motor vehicles), foreign debt and discount rates.

The production model estimated required value, price and quantity information on the following output and input categories:

- Outputs:
  - motor vehicles;
  - general consumption excluding housing and transport (private and public);
  - housing investment;
  - general investment:
    - — non-residential and other construction investment;
    - — plant, machinery and transport equipment investment;
    - — changes in inventories (agricultural and non-agricultural);
  - exports;
- Variable Inputs:
  - imports;
  - labour;
- Fixed Inputs:
  - capital:
    - — non-residential and other construction stocks;
    - — plant, machinery and transport equipment stocks;
    - — inventory stocks (agricultural and non-agricultural); and,
  - land.

In constructing the databases for the consumer and producer models it is necessary to specify the series in terms of consumer and producer prices, respectively. This requires detailed information on the magnitude and composition of tax payments and government subsidies which form the wedges between prices paid by the consumer and those received by the producer or supplier. Detailed information on the composition of tax revenue is not always readily available and considerable effort has been devoted to allocating tax payments, particularly between the primary factors, labour and capital.

An important distinction which arises in all econometric studies of this type is the difference between stocks and flows. Most outputs from the production sector and some of the inputs to it are produced and consumed in the one period. This makes their measurement relatively easy. However, many of the inputs used in the production process and many of the major consumption items are durable assets and last several periods (or decades in some cases). Measuring the amount of these durable items consumed in any one period becomes problematic and requires measurement of the flow of services provided by the asset over its lifetime. Measurement of the stock, or total value of the asset held is also not straightforward due to the presence of inflation and alternative assumptions about depreciation rates. While some time-series do exist for housing flows in particular, they have been constructed using national accounting rather than economic conventions. Consequently, in this study considerable time has been spent constructing the major stocks and flows in a consistent manner using economic conventions.

Data for New Zealand tends to be presented using a wide variety of conventions regarding the starting and end points of the year covered. Until recently most Department of Statistics data was presented for the year ending in March. However, other New Zealand agencies used different conventions and some Department of Statistics series also used different coverage. Recently there has been a move to present New Zealand data more consistently on a June year basis. Some OECD data are presented on a calendar year basis. Wherever possible, data used in this study have been converted to a March year basis and the convention adopted is that reference to a particular year refers to the year **ending** in March of that year.

In describing the data used in this study we commence with the principal data series used in the static consumer model. We then describe the construction of private production asset stock series which will be used in future work on intertemporal consumer models and which are currently also used in the producer model. After introducing other series which are inputs to the producer model, we describe the taxation data used and its allocation to the various factors and commodities. This enables us to construct producer price based series for the producer model and to derive the user cost of fixed inputs. Finally, the data actually used as input to the consumer and producer econometric models are listed.

A2 Static Consumer Model Data

In estimating a model of consumer demand responsiveness it is necessary to have price and quantity data on each of the main items consumed. Housing and transport are important stock items held and used by consumers. Accordingly, they have received special treatment in national accounts. However, as noted above, the treatment of these important consumer stocks and the estimation of consumption flows from them have typically not been optimal from an economic point of view. Consequently, we begin by constructing our own estimates of these stocks and flows and deduct national accounts estimates of them from total consumption to form a new general consumption category excluding housing and transport. The demand for leisure is then specified in terms of the balance between the consumer's endowment of time and his supply of labour.

Housing

A series for the stock of residential dwellings in New Zealand was formed from information on the gross additions to the dwelling stock each year obtained from the Department of Statistics, a point estimate of the dwelling stock on 1 April 1988 of 1,109,500 units and an assumed rate of retirement from the stock or demolition rate. Information on stock levels in 1982 and 1988 and gross additions to the stock between these years indicated that the rate of demolition for this period was 0.48 of one per cent. Consequently, a retirement rate of 0.5 of one per cent was assumed throughout the 20 year period. It was further assumed that the services of new housing additions do not become available to consumers until the following period.

The estimated housing stock series was constructed as follows:

(A1) $$S_t = 0.995\, S_{t-1} + A_{t-1} \qquad \text{for } t > 1989$$

$$S_t = \left(S_{t+1} - A_t\right) / \, 0.995 \qquad \text{for } t < 1989$$

where S_t is the dwelling stock and A_t is gross additions in year t.

An average house price series was constructed from average sale price information for the calendar years 1986 to 1989 presented in the 1991 *New Zealand Pocket Digest of Statistics* spliced with the Urban House Property Price Index from the *Monthly Abstract of Statistics* for the remaining years.

The resulting estimates of the housing stock value, price and quantity are presented in Table A1.

For the consumer model, the flow of services consumed from the housing stock was assumed to be proportional to the stock in quantity terms. The user cost of the consumption flow was specified as follows:

(A2) $$UC_h = \left(r + d_h + t_h\right) P_h S_h$$

where UC_h is the user cost of housing, r is the real post-tax rate of return, d_h is the rate of economic depreciation on housing, t_h is the rate of property tax on housing and P_h and S_h are the price and quantity of the housing stock, respectively. The rate of economic depreciation on housing was assumed to be 1.5 per cent per annum. The other variables will be derived later.

Although not used in the current modelling work, a series for the value of residential land has also been derived using the above information on the total value of land and housing and the

Table A1: Housing Stock

Year Ending March	Gross Dwelling Additions	Estimated Dwelling Stock	Estimated Average Sale Price	Estimated Stock Value
	No.	No.	$/dwelling	$mil
1972	24 333	789 243	10 503	8 290
1973	32 773	809 630	12 017	9 729
1974	39 734	838 355	15 446	12 949
1975	33 101	873 897	21 354	18 661
1976	32 189	902 629	22 821	20 599
1977	30 154	930 305	24 505	22 797
1978	21 205	955 807	26 026	24 876
1979	19 050	972 233	26 574	25 837
1980	15 197	986 422	28 026	27 646
1981	14 442	996 687	30 861	30 758
1982	19 006	1 006 145	39 001	39 240
1983	15 999	1 020 121	50 438	51 453
1984	20 226	1 031 019	54 802	56 502
1985	21 782	1 046 090	61 984	64 841
1986	23 035	1 062 641	70 896	75 337
1987	20 128	1 080 363	82 908	89 571
1988	19 886	1 095 089	94 189	103 145
1989	19 583	1 109 500	100 411	111 406
1990	22 851	1 123 536	109 794	123 357
1991	20 820	1 140 769	118 974	135 722

average cost of new dwelling units excluding land obtained from the *Monthly Abstract of Statistics*. The value of dwellings excluding land is estimated using the following formula:

$$V_D = P_{ND}\left(0.75(1-d_h)^{t-1972}(S_{1972} - R_{1972} - \ldots - R_{t-1}) + (1-d_h)^{t-1972+1} A_t\right) \quad \text{(A3)}$$

where V_D is the value of dwellings, P_{ND} is the price to construct a new dwelling (excluding land) and R_t is the retirement of dwellings in year t. The assumption implicit in this formula is that the average dwelling in 1972 would cost 75 per cent of the cost of a new dwelling to restore to its existing condition or, in other words, was 25 per cent depreciated in economic terms.

The value of residential land was then derived as the residual between the total value of the residential housing stock including land and the estimated value of the average dwelling derived using (A3). The resulting estimates of the value of residential land are presented in Table A2.

Table A2: Residential Land

Year Ending March	*Average Cost (Excluding Land)*	*Estimated Land Price*	*Estimated Land Value*	*Land Quantity*
	$/dwelling	$/dwelling	$mil	No.
1972	10 126	2 909	2 296	789 243
1973	11 162	3 645	2 951	809 630
1974	13 709	5 132	4 302	838 355
1975	16 513	8 867	7 749	873 897
1976	18 435	8 852	7 990	902 629
1977	21 039	8 541	7 946	930 305
1978	23 754	7 996	7 643	955 807
1979	26 189	6 749	6 562	972 233
1980	30 414	5 082	5 013	986 422
1981	36 075	3 771	3 758	996 687
1982	44 738	5 567	5 601	1 006 145
1983	49 697	13 420	13 690	1 020 121
1984	51 216	16 812	17 334	1 031 019
1985	54 527	21 651	22 649	1 046 090
1986	60 907	25 946	27 571	1 062 641
1987	67 622	33 095	35 755	1 080 363
1988	79 312	35 929	39 346	1 095 089
1989	82 240	40 175	44 575	1 109 500
1990	90 048	44 036	49 476	1 123 536
1991	95 922	49 061	55 967	1 140 769

Transport

A similar procedure was again followed in forming an estimate of motor vehicle stocks. Additions to the stock of personal transport equipment were available in both current and constant dollars for the years 1982 to 1991 from the Department of Statistics. For years prior to 1982 the constant dollar series was indexed backwards according to changes in the number of new vehicle registrations. The price of additions to the vehicle stock was indexed back before 1982 using import price indexes for transport equipment.

A composite additions series was formed and used in conjunction with a point estimate of the value of personal transport from the "Who Gets What" Review of $14,600 million in 1988 to form a stock series. A difference from the procedure used to form the housing stock series was that services from additions to the stock of motor vehicles were assumed to be available to consumers in the year of purchase rather than with a one year delay. Consequently, the following formula was used to form the stock estimates:

(A4) $$S_t = \left(1 - d_V\right) S_{t-1} + A_t \qquad \text{for } t > 1988$$
$$S_t = \left(S_{t+1} - A_{t+1}\right) / \left(1 - d_V\right) \qquad \text{for } t < 1988$$

where d_V is the economic depreciation rate for motor vehicles. The depreciation rate was set at 13.85 per cent. This depreciation rate was used as it produced the same increase in the motor vehicle stock between 1972 and 1991 as the number of licensed private cars obtained from the Department of Statistics *1992 Year Book.*

In the consumer model the consumption flow of motor vehicles is assumed to be proportional to the stock of motor vehicles plus current additions in quantity terms. The user cost of the consumption flow is specified as:

$$UC_V = \left(r + d_V\right)P_V S_V. \quad \text{(A5)}$$

The value, price and quantity of motor vehicle additions and the estimated stock of motor vehicles are presented in Table A3.

Table A3: **Consumer Motor Vehicle Stocks**

	Motor Vehicle Additions			Motor Vehicle Stock	
March Year	*Value* $mil	*Price* Index	*Quantity* $1972mil	*Value* $mil	*Quantity* $1972mil
1972	219.63	1.0000	219.63	1 280.26	1 280.26
1973	242.82	1.0674	227.48	1 420.14	1 330.42
1974	294.62	1.1010	267.58	1 556.57	1 413.74
1975	306.97	1.3100	234.32	1 902.50	1 452.26
1976	343.29	1.7101	200.74	2 482.86	1 451.86
1977	363.47	1.9694	184.56	2 826.82	1 435.34
1978	382.01	2.4753	154.32	3 442.87	1 390.87
1979	439.89	2.7292	161.18	3 710.10	1 359.41
1980	626.38	3.4187	183.22	4 630.14	1 354.35
1981	796.17	3.5470	224.46	4 934.73	1 391.23
1982	1 024.15	3.6410	281.29	5 388.02	1 479.84
1983	1 202.00	4.9878	240.99	7 560.83	1 515.87
1984	1 257.19	5.4057	232.57	8 316.61	1 538.49
1985	1 583.25	6.1264	258.43	9 703.19	1 583.84
1986	1 835.71	7.3249	250.61	11 830.36	1 615.09
1987	1 894.99	8.1622	232.17	13 251.84	1 623.56
1988	2 089.19	8.9446	233.57	14 600.00	1 632.27
1989	2 060.57	8.1440	253.02	13 512.65	1 659.22
1990	2 979.79	8.3639	356.27	14 935.25	1 785.69
1991	3 495.41	8.6652	403.38	16 825.68	1 941.75

General Consumption (Excluding Housing and Transport)

In forming a series for general consumption (excluding housing and transport) it was necessary to obtain the Private Final Consumption Expenditure series and extract the national accounting estimates of housing and transport since we are forming our own estimates of these components. Private Final Consumption Expenditure in current and constant dollars was obtained from the OECD *National Accounts* for the period 1972 to 1985 and from the Department of Statistics' *Key Statistics* for the years 1986 to 1991.

National accounting estimates of housing consumption had to be formed from a number of sources. The value of Final Consumption Expenditure on Gross Rent was obtained from the OECD National Accounts for the years 1983 to 1991. Constant dollar estimates were available for 1983 to 1989 enabling the construction of a price index for these years. The value of Final Consumption Expenditure on Gross Rent was indexed back to 1972 using changes in the Contribution to GDP of Ownership of Owner-Occupied Dwellings obtained from the December 1986 Department of Statistics' *Monthly Abstract of Statistics*. The price index for the years 1983 to 1989 was spliced with the rent price index obtained from the OECD's *Main Economic Indicators* for the period 1972 to 1982 and with the Department of Statistics' Consumer Price Index for Housing for the years 1990 and 1991.

The national accounting estimates of transport consumption were taken to be the additions to the motor vehicle stock series presented above. Having value, price and quantity estimates for the housing, transport and total consumption categories it was then necessary to recover consistent estimates of the price and quantity of the residual category, general consumption (excluding housing and transport). This was done by assuming that the overall price index was a chain Laspeyres index of the three components. This permits the residual or third component price index to be recovered as follows:

(A6) $$P_3^t = V_T^{t-1} P_T^t / \left(P_T^{t-1} X_3^{t-1}\right) - \left(P_1^t X_1^{t-1} + P_2^t X_2^{t-1}\right) / X_3^{t-1}$$

where P_T and V_T are the price and value of the overall aggregate category, respectively, and 1, 2 and 3 refer to the three components. By setting the initial price of the residual equal to one, the second period price can be recovered using (A6). The second period quantity is then obtained by dividing the residual value by its price for that period. This permits (A6) to be used to recover the residual price for the third period and so on.

The value, price and quantity of Private Final Consumption Expenditure and the value and price of the national accounting estimate of housing consumption are presented in Table A4. The value, price and quantity of the general consumption (excluding housing and transport) component are presented in Table A5.

Table A4: Private Final Consumption Expenditure

Year Ending March	Private Final Consumption Expenditure Value $mil	Price Index	Quantity $1972mil	Estimated National Accounts— Housing Consumption Value $mil	Price Index
1972	4 210	1.0000	4 210	582	1.0000
1973	4 751	1.0541	4 507	663	1.0993
1974	5 459	1.1168	4 888	782	1.2349
1975	6 206	1.2206	5 084	922	1.4215
1976	7 098	1.4064	5 047	1 207	1.6362
1977	8 162	1.6702	4 887	1 367	1.8094
1978	9 181	1.9438	4 723	1 587	1.9987
1979	10 353	2.1534	4 808	1 596	2.1745
1980	12 105	2.5299	4 785	1 652	2.3705
1981	14 244	2.9840	4 773	1 868	2.6819
1982	16 639	3.4134	4 875	2 257	3.1987
1983	19 123	3.9588	4 830	2 639	3.8846
1984	20 689	4.1672	4 965	2 939	4.2632
1985	23 395	4.5374	5 156	3 453	4.9274
1986	27 712	5.2903	5 238	4 571	6.4062
1987	32 570	6.0084	5 421	5 494	7.5731
1988	37 225	6.7159	5 543	6 460	8.7767
1989	40 733	7.2402	5 626	7 750	10.3840
1990	43 952	7.7387	5 680	8 392	10.9447
1991	46 076	8.1859	5 629	9 065	11.7183

Table A5: General Consumption (Excluding Housing and Transport)

March Year	General Consumption (Excluding Housing and Transport) Value $mil	Price Index	Quantity $1972mil
1972	3 408	1.0000	3 408
1973	3 845	1.0455	3 678
1974	4 382	1.0980	3 991
1975	4 977	1.1815	4 213
1976	5 548	1.3505	4 108
1977	6 432	1.6309	3 944
1978	7 212	1.9099	3 776
1979	8 317	2.1248	3 914
1980	9 826	2.5220	3 896
1981	11 580	3.0179	3 837
1982	13 358	3.4529	3 869
1983	15 282	3.9171	3 901
1984	16 493	4.0834	4 039
1985	18 359	4.3836	4 188
1986	21 305	4.9890	4 270
1987	25 181	5.6257	4 476
1988	28 676	6.2469	4 590
1989	30 922	6.6630	4 641
1990	32 580	7.1651	4 547
1991	33 516	7.5696	4 428

Labour Supply

Estimates were formed of the value and quantity of labour employed in the market and non-market sectors and of the self-employed. The value of wages, salaries and supplements paid to employees in the market and non-market sectors were obtained from the December 1986 *Monthly Abstract of Statistics* for the years 1972 to 1979 and from the OECD *National Accounts Detailed Tables Volume 2* for the period from 1979 onwards. The average wage paid to full-time employees and the average compensation of private sector employees were obtained from OECD *Economic Outlook* data supplied by EconData Pty Ltd. Dividing the value of wages for the market and non-market sectors by the wage rate provided an estimate of the full-time equivalent employment quantities in these sectors.

Forming estimates of the value and quantity of self-employed labour is more problematic given the scarcity of information on the self-employed. The number of self-employed was obtained from OECD *Economic Outlook* data supplied by EconData Pty Ltd. It should be noted that the OECD has attempted in this data source to remove anomalies in published New Zealand data arising from methodological changes associated with the change-over from the Department of Labour to the Department of Statistics as the collection agency for labour information.

It was assumed that the self-employed have an opportunity cost equal to three quarters the average compensation obtained by employees in the private sector. This reflects the fact that there is significant underemployment among some sections of the self-employed. The average compensation for employees has fallen behind the wage rate in recent years as the importance of part-time employment has increased. There are also major measurement problems with this sector of the economy in particular with significant amounts of output not being reported. This is a problem common to the national accounting systems of all OECD economies. The problem can only be overcome using historical data by either arbitrarily increasing output or by reducing input. Since there is no information on which outputs should be increased, it was considered preferable to reduce the input of the self-employed. The input of the self-employed was converted to full-time equivalents by dividing the return to the self-employed by the wage rate for employees.

The value of market and non-market sector wages, the average wage rate and the compensation for private sector employees are presented in Table A6. The estimated return to the self-employed and the number of self-employed are presented in Table A7 along with total value, price and quantity of private sector labour. The private sector labour series are in before-tax, producer prices and will be used in the production model. The price the consumer responds to,

Table A6: Employee Labour Data

March Year	*Market Sector Wages & Salaries*	*Non-Market Wages & Salaries*	*Wage Rate*	*Private Sector Compensation*
	$mil	$mil	$/employee	$/employee
1972	2 678	728	3 310	3 530
1973	3 008	823	3 706	3 987
1974	3 540	976	4 188	4 442
1975	4 282	1 157	4 870	5 122
1976	4 879	1 389	5 606	5 873
1977	5 511	1 548	6 384	6 564
1978	6 243	1 848	7 298	7 450
1979	7 137	2 280	8 053	8 448
1980	8 324	2 655	9 448	9 788
1981	9 754	3 314	11 148	11 619
1982	11 739	3 954	13 131	13 724
1983	12 913	4 324	14 289	14 837
1984	13 150	4 427	14 966	15 345
1985	14 614	4 628	16 356	16 273
1986	17 262	5 399	19 124	18 607
1987	20 143	6 681	22 439	21 816
1988	22 695	7 568	25 670	24 526
1989	23 918	8 201	28 451	27 070
1990	24 136	8 638	30 576	28 020
1991	24 277	8 851	31 884	27 286

Table A7: Self-Employed and Private Sector Labour Data

March Year	*Return to Self-Employed*	*Number of Self-Employed*	*Private Sector Labour*		
			Value	*Price*	*Quantity*
	$mil	000s	$mil	Index	$1972mil
1972	619	234	3 297	1.0000	3 297
1973	703	235	3 711	1.1197	3 314
1974	798	240	4 338	1.2653	3 429
1975	946	246	5 228	1.4713	3 553
1976	1 112	252	5 991	1.6938	3 537
1977	1 261	256	6 772	1.9289	3 511
1978	1 446	259	7 689	2.2051	3 487
1979	1 647	260	8 784	2.4332	3 610
1980	1 919	261	10 243	2.8547	3 588
1981	2 297	264	12 051	3.3683	3 578
1982	2 761	268	14 500	3.9675	3 655
1983	3 003	270	15 916	4.3171	3 687
1984	3 128	272	16 278	4.5217	3 600
1985	3 368	276	17 982	4.9418	3 639
1986	3 930	282	21 192	5.7779	3 668
1987	4 709	288	24 852	6.7796	3 666
1988	5 328	290	28 023	7.7557	3 613
1989	5 896	290	29 814	8.5960	3 468
1990	6 043	288	30 179	9.2382	3 267
1991	6 025	294	30 302	9.6332	3 146

however, in terms of decisions regarding labour supply is the after-tax return to labour. The after-tax return to all labour, the after-tax wage rate index and the corresponding quantity are given in Table A8. The calculation of labour tax payments will be outlined below in the taxation section.

Table A8: After-Tax Labour, Population and Foreign Debt

Year Ending March	*After-Tax Return to Labour*	*After-Tax Wage Rate*	*After-Tax Labour Supply*	*Population Aged 15-64*	*Estimated Foreign Debt*
	$mil	Index	$1972mil	No.	$mil
1972	3 211	1.0000	3 211	1 721 750	3 634
1973	3 591	1.1116	3 230	1 759 250	3 134
1974	4 123	1.2304	3 351	1 805 500	2 584
1975	4 858	1.4032	3 462	1 854 500	3 904
1976	5 663	1.6292	3 476	1 896 500	5 622
1977	6 224	1.8088	3 441	1 923 500	6 344
1978	6 874	1.9922	3 450	1 940 750	7 092
1979	8 105	2.2343	3 628	1 954 000	7 625
1980	9 400	2.6079	3 604	1 966 250	8 893
1981	11 009	3.0254	3 639	1 989 250	10 516
1982	12 995	3.5022	3 711	2 009 250	12 885
1983	14 073	3.7627	3 740	2 042 000	15 591
1984	14 514	3.9730	3 653	2 083 750	20 063
1985	15 925	4.3630	3 650	2 115 000	35 403
1986	17 971	4.8948	3 671	2 132 750	39 191
1987	21 319	5.7457	3 710	2 149 250	45 476
1988	24 951	6.8153	3 661	2 179 000	47 009
1989	26 071	7.3896	3 528	2 197 750	45 554
1990	26 257	7.8331	3 352	2 215 000	48 771
1991	26 703	8.2354	3 242	2 235 791	50 847

Leisure

The consumer model is actually specified in terms of the consumer's demand for leisure. This was calculated by allocating all persons in the working age population a total endowment of hours and then subtracting from this the quantity of total effective labour supplied. The working age population was taken to be that in the 15 to 64 years age group. Estimates of the population falling within this age group were obtained from OECD *Economic Outlook* data supplied by EconData Pty Ltd and are presented in Table A8. It was assumed that each person in this age group has a total allocation of 2,000 hours per annum which they could devote to labour supply.

Foreign Debt

Although not used in the static consumer model, a foreign debt series was supplied by The Treasury for use in future intertemporal modelling. The Department of Statistics has only presented estimates of New Zealand's total net foreign debt since 1989. The Reserve Bank of New Zealand has constructed a net foreign debt series from a variety of sources for use in its econometric model. This series was used to backdate the Department of Statistics series to 1974. The series was backdated to 1972 using proportional changes in official foreign debt. The estimated foreign debt series is presented in Table A8.

A3 Private Sector Production Assets

Information on private sector production assets will be required to form wealth estimates for use in an intertemporal consumer model. It is currently used as direct input to the producer model where the asset stock quantity is the quantity measure of fixed inputs and capital formation or investment (including residential housing investment) is an important output component for the private sector.

In forming estimates of private production assets the same stock and flow issues discussed in relation to housing and motor vehicles apply. It is necessary to first obtain information on investment series or additions to the stock, make assumptions about depreciation rates and then combine this with a reliable point estimate of the stock value.

The major categories of private sector production assets included in this study are: non-residential and other construction; plant, machinery and transport equipment; non-agricultural inventories; agricultural inventories; and, business and agricultural land.

Non-Residential and Other Construction, and Plant, Machinery and Equipment

In forming estimates of these stocks it was necessary to first obtain information on relevant private sector capital formation. Detailed series on Gross Fixed Capital Formation for the economy as a whole had to be built up from a number of sources and then estimates of government capital formation were subtracted to form a series on private sector capital formation.

Economy-wide Gross Fixed Capital Formation is presented in Table A9. Data for the years 1972 to 1980 was obtained from the December 1986 *Monthly Abstract of Statistics*. Data for 1981 and 1982 were obtained from the Department of Statistics' *New Zealand System of*

National Accounts 1980-81 to 1986-87 while data for 1983 to 1988 were taken from the *New Zealand System of National Accounts 1982-83 to 1988-89.* Data for 1989 to 1991 were derived by pro-rating the total Gross Fixed Capital Formation figures obtained from the *Key Statistics* according to the ratios observed in 1988.

Table A9: Gross Fixed Capital Formation

March Year	*Residential Building*	*Non-Residential Building*	*Other Construction*	*Plant and Equipment*
	$mil	$mil	$mil	$mil
1972	306	292	247	670
1973	416	331	300	835
1974	562	407	306	912
1975	683	553	360	1 099
1976	769	612	512	1 352
1977	855	665	535	1 478
1978	676	695	672	1 501
1979	716	762	653	1 748
1980	731	747	674	1 914
1981	881	821	808	2 244
1982	1 180	1 034	1 136	3 247
1983	1 311	1 164	1 307	3 962
1984	1 562	1 246	1 363	4 267
1985	1 783	1 457	1 350	4 980
1986	2 057	1 961	1 462	5 816
1987	2 416	2 408	1 437	5 393
1988	2 759	3 029	1 090	5 969
1989	2 707	2 836	1 289	6 059
1990	3 041	3 186	1 448	6 806
1991	3 061	3 206	1 458	6 850

Deflators for the Gross Fixed Capital Formation components are presented in Table A10. They were formed from Department of Statistics information for the period 1972 to 1983 spliced with OECD *National Accounts* deflators for the period 1983 to 1991. The deflator for residential buildings was derived from Department of Statistics information on construction prices per square metre for new houses while that for non-residential buildings and other construction was based on the construction price per square metre for 'new other buildings'. A land improvement deflator was derived from land development cost information for farm capital expenditure. The plant, machinery and transport equipment deflator was derived as the average of the import price indexes for Electric Machinery and Machinery Other Than Electric. From 1983 onwards OECD deflators for Residential Buildings, Non-Residential Buildings, Other Construction and Land Improvement, and Other were used.

Table A10: **Gross Fixed Capital Formation Deflators**

March Year	*Residential Building*	*Non-Residential Building*	*Other Construction*	*Plant and Equipment*
	Index	Index	Index	Index
1972	1.0000	1.0000	1.0000	1.0000
1973	1.0950	1.0954	1.1170	1.1897
1974	1.2839	1.2840	0.9741	1.3173
1975	1.6054	1.6053	0.9298	1.3114
1976	1.7766	1.8180	1.1748	1.1472
1977	1.9436	1.8509	1.1782	1.1507
1978	2.1712	1.8838	1.4301	1.0561
1979	2.3507	1.8553	1.3888	1.1229
1980	2.5491	1.9156	1.3305	1.1429
1981	2.9196	1.9978	1.4624	1.1690
1982	3.5313	2.6831	1.5813	1.4989
1983	4.0605	3.0537	1.6281	1.6708
1984	4.1944	3.1524	1.6685	1.7360
1985	4.5586	3.3401	1.7921	1.9656
1986	5.2327	3.7483	2.0133	2.1923
1987	5.0597	4.2155	2.2125	2.2168
1988	7.1538	4.5215	2.4940	2.0714
1989	6.9413	4.9453	2.9648	1.9163
1990	7.5375	4.8967	3.0475	1.9246
1991	7.8570	5.1854	2.9985	1.8783

Table A11: **Government Absorption of Capital**

March Year	*Residential Building*	*Non-Residential Building*	*Transport Equipment*	*Plant and Machinery*
	$mil	$mil	$mil	$mil
1972	94	17	4	17
1973	128	23	5	23
1974	123	23	5	23
1975	158	29	7	29
1976	207	40	9	34
1977	204	35	5	43
1978	215	38	10	49
1979	232	49	12	51
1980	225	42	8	66
1981	241	47	13	79
1982	254	57	13	85
1983	267	66	21	94
1984	261	71	35	100
1985	288	81	27	128
1986	399	123	31	104
1987	359	111	28	166
1988	330	102	25	152
1989	304	94	23	141
1990	311	96	24	144
1991	347	107	27	160

Detailed information on the composition of government absorption of capital was obtained from the December 1986 Monthly Abstract of Statistics for the years 1977 to 1985. For years prior to 1977 total government Gross Fixed Capital Formation was pro-rated using the ratios of 1977. Similarly, for years after 1985 the total figure was pro-rated using the ratios of 1985. Estimated government absorption of capital is presented in Table A11.

The point estimate of the Non-Residential and Other Construction stock value was taken from the "Who Gets What?" Review figure of $73,500 million for 1987. This was deflated by 16 per cent to provide a point estimate of private sector Non-Residential and Other Construction stocks. The deflation factor of 16 per cent was taken from the average ratio of public to total Non-Residential and Other Construction capital formation over the period. The point estimate was then backdated and updated using the constant price private Non-Residential and Other Construction capital formation series converted to 1987 prices. A depreciation rate of 2 per cent was assumed. The resulting estimates of the private Non-Residential and Other Construction stocks are presented in Table A12.

Table A12: **Private Sector Non-Residential and Other Construction Stocks**

Year Ending March	*Non-Residential & Construction Price* Index	*Capital Formation Value* $mil	*Capital Formation Quantity* $1972mil	*Stock Value* $mil	*Stock Quantity* $1972mil
1972	1.0000	428	428	8 867	8 867
1973	1.0905	480	440	9 943	9 118
1974	1.2770	567	444	11 973	9 376
1975	1.5844	726	458	15 262	9 632
1976	1.7881	877	490	17 699	9 898
1977	1.8446	961	521	18 797	10 190
1978	1.8956	1 114	588	19 918	10 508
1979	1.8850	1 134	602	20 519	10 885
1980	1.9951	1 154	578	22 483	11 269
1981	2.1368	1 341	628	24 834	11 622
1982	2.8139	1 859	661	33 815	12 017
1983	3.1666	2 138	675	39 385	12 438
1984	3.2552	2 277	699	41 875	12 864
1985	3.4747	2 438	702	46 235	13 306
1986	3.9014	2 901	744	53 612	13 742
1987	4.3447	3 375	777	61 740	14 210
1988	4.7372	3 687	778	69 651	14 703
1989	5.3098	3 727	702	80 641	15 187
1990	5.3209	4 227	794	82 929	15 585
1991	5.5035	4 210	765	88 431	16 068

There were no point estimates available for the stock of Plant, Machinery and Transport Equipment. A starting stock was formed by summing the imports of Machinery and Transport Equipment for the period 1961 to 1971 inclusive expressed in constant 1971 dollars. This provided a starting stock estimate of $3,309 million for the economy as a whole. This figure was deflated by 3 per cent (the ratio of government to total capital formation for this category over the 20 year period) to provide an estimate of private sector opening Plant, Machinery and Transport Equipment stocks. This was then updated using the private sector Plant, Machinery and Transport Equipment capital formation series expressed in 1972 constant prices and an assumed depreciation rate of 13 per cent. The resulting estimates of the private Plant, Machinery and Transport Equipment stocks are presented in Table A13.

Table A13: **Private Sector Plant, Machinery and Transport Equipment Stocks**

Year Ending March	*Plant & Equipment Price*	*Capital Formation Value*	*Capital Formation Quantity*	*Stock Value*	*Stock Quantity*
	Index	$mil	$1972mil	$mil	$1972mil
1972	1.0000	649	649	3 210	3 210
1973	1.0480	807	770	3 733	3 562
1974	1.0342	884	855	4 089	3 954
1975	1.2518	1 063	849	5 369	4 289
1976	1.7610	1 309	743	7 880	4 475
1977	1.9178	1 430	746	8 897	4 639
1978	2.1245	1 442	679	10 016	4 715
1979	2.3268	1 685	724	11 229	4 826
1980	2.5029	1 840	735	12 348	4 934
1981	2.8683	2 152	750	14 464	5 043
1982	3.2390	3 149	972	17 359	5 359
1983	3.5448	3 847	1 085	20 375	5 748
1984	3.6832	4 132	1 122	22 550	6 122
1985	4.1703	4 825	1 157	27 038	6 484
1986	4.6513	5 681	1 221	31 917	6 862
1987	4.7032	5 199	1 105	33 277	7 075
1988	4.3946	5 792	1 318	32 844	7 474
1989	4.0658	5 895	1 450	32 330	7 952
1990	4.0833	6 638	1 626	34 887	8 544
1991	3.9850	6 663	1 672	36 284	9 105

Non-Agricultural Inventories

Information on non-agricultural inventories was obtained from the Department of Statistics' *Monthly Abstract of Statistics* and *Key Statistics*. The value of non-agricultural inventories was taken to be the sum of stocks of materials and finished goods in manufacturing, retail stocks and the narrow definition of wholesale stocks. The deflator used for non-agricultural inventories was the price index for all New Zealand industry inputs (excluding labour) from the International Monetary Fund's *International Financial Statistics Yearbook.* The value, price and quantity of non-agricultural inventories are presented in Table A14.

Table A14: Non-Agricultural Inventories

March Year	Non-Agricultural Inventories Value $mil	Price Index	Quantity $1972mil
1972	1 649	1.0000	1 649
1973	1 698	1.0690	1 588
1974	2 055	1.2051	1 705
1975	2 725	1.3026	2 092
1976	3 075	1.4756	2 084
1977	3 624	1.8056	2 007
1978	3 979	2.1023	1 893
1979	4 239	2.3448	1 808
1980	5 269	2.7604	1 909
1981	5 780	3.3918	1 704
1982	6 688	3.9637	1 687
1983	7 053	4.5624	1 546
1984	6 930	4.8109	1 440
1985	8 230	5.1546	1 597
1986	9 461	5.9453	1 591
1987	10 020	6.2866	1 594
1988	10 607	6.7854	1 563
1989	10 537	7.1409	1 476
1990	10 895	7.6457	1 425
1991	11 100	8.0000	1 388

Agricultural Inventories

Estimates of the stock of agricultural inventories were built up from Department of Statistics data on numbers of four types of livestock and unit values for each of these categories consisting of average export prices plus assistance based on information included in New Zealand Meat and Wool Board *Annual Reports.* The four livestock types considered were: sheep, cattle, deer and goats. Livestock numbers for the four types are presented in Table A15 while overall unit values for each type are presented in Table A16. An aggregate price index and quantity of livestock inventories was formed by aggregating the four components using a Fisher index. The aggregate value, price and quantity are presented in Table A17.

Table A15: Livestock Inventory Numbers

March Year	*Livestock Numbers*			
	Sheep	*Cattle*	*Deer*	*Goats*
	000s	000s	000s	000s
1972	58 912	7 995	n.a.	n.a.
1973	60 883	8 631	n.a.	n.a.
1974	56 684	8 924	n.a.	n.a.
1975	55 883	9 311	n.a.	n.a.
1976	55 320	9 292	n.a.	n.a.
1977	56 400	9 017	n.a.	n.a.
1978	59 105	8 738	n.a.	n.a.
1979	62 163	8 418	n.a.	n.a.
1980	63 523	8 022	42	49
1981	68 772	8 131	104	53
1982	69 884	8 035	109	68
1983	70 301	7 913	151	93
1984	70 263	7 631	196	150
1985	69 739	7 777	259	230
1986	67 854	7 921	320	427
1987	67 470	8 279	392	723
1988	64 244	7 999	500	1 054
1989	64 600	8 058	606	1 301
1990	60 569	7 828	780	1 222
1991	57 852	8 034	976	1 063

Table A16: Livestock Inventory Unit Values

March Year	*Livestock Unit Values*			
	Sheep	*Cattle*	*Deer*	*Goats*
	$/head	$/head	$/head	$/head
1972	5.00	114.21	60.06	30.03
1973	10.39	131.16	99.33	49.67
1974	11.74	129.09	109.73	54.87
1975	6.36	76.32	80.85	40.43
1976	7.90	117.24	109.96	54.98
1977	12.45	135.06	150.50	75.25
1978	10.35	139.39	137.11	68.55
1979	11.58	263.16	162.40	81.20
1980	14.09	294.70	174.21	87.11
1981	13.32	293.77	184.41	92.20
1982	9.94	322.48	219.42	109.71
1983	7.33	391.46	188.52	94.26
1984	3.28	466.71	229.98	114.99
1985	11.21	595.11	220.83	110.41
1986	16.74	453.95	240.36	120.18
1987	17.26	480.33	275.02	137.51
1988	14.48	476.26	183.37	91.69
1989	10.51	556.85	212.94	106.47
1990	18.67	666.83	318.18	159.09
1991	11.69	634.41	260.40	130.20

Table A17: Total Livestock Inventories and Business and Agricultural Land Stocks

March Year	Total Livestock Inventories Value	Price	Quantity	Business and Agricultural Land Value	Price
	$mil	Index	$1972mil	$mil	Index
1972	1 207	1.0000	1 207	8 254	1.0000
1973	1 765	1.3728	1 286	8 906	1.0790
1974	1 818	1.4200	1 280	11 688	1.4161
1975	1 066	0.8141	1 309	16 942	2.0527
1976	1 526	1.1715	1 303	19 632	2.3785
1977	1 920	1.4942	1 285	22 071	2.6741
1978	1 830	1.4297	1 280	24 000	2.9079
1979	2 935	2.3198	1 265	26 022	3.1529
1980	3 271	2.6551	1 232	28 905	3.5021
1981	3 329	2.6089	1 276	34 232	4.1475
1982	3 317	2.6098	1 271	46 313	5.6112
1983	3 650	2.8931	1 262	59 914	7.2592
1984	3 854	3.1272	1 232	61 349	7.4330
1985	5 493	4.3854	1 253	67 061	8.1250
1986	4 860	3.8237	1 271	72 625	8.7992
1987	5 349	4.0328	1 326	77 120	9.3438
1988	4 928	3.8064	1 295	84 057	10.1843
1989	5 434	4.1291	1 316	84 172	10.1982
1990	6 793	5.3025	1 281	87 272	10.5738
1991	6 166	4.7158	1 307	95 245	11.5397

Business and Agricultural Land

The quantity of business and agricultural land was assumed to have remained fixed over the 20 year period. A point estimate of the value of business and agricultural land of $77,120 million in 1987 was obtained from the "Who Gets What?" Review. This was combined with price information from Valuation New Zealand to form a time-series of the land stock value.

Three price indexes provided by Valuation New Zealand were used. A price index of rural land was available for the whole 20 year period. Price indexes for industrial and commercial land were available from 1980 onwards. In the absence of any other information on urban land prices prior to 1980, both the industrial and commercial land price indexes were extended back to 1972 using information on Average Section Sale Prices provided by Valuation New Zealand. The three land price indexes were then weighted together using information on the number of assessable properties in each category and average sale prices for 1992 provided by Valuation New Zealand. This produced a weight of 0.68 for the rural land price index and 0.16 for each of the industrial and commercial price indexes.

The estimated stock value and overall price index for business and agricultural land are presented in Table A17.

A4 Additional Data Required for the Producer Model

Before proceeding to look at the taxation data and the derivation of the producer model data in terms of producer prices it is necessary to introduce three additional series. These relate to government final consumption expenditure, exports and imports.

Government Consumption

Data on Government Final Consumption Expenditure in current and constant prices was obtained from the OECD *National Accounts* for the period 1972 to 1985 and from the Department of Statistics' *Key Statistics* for 1986 to 1991. However, the majority of government consumption expenditure relates to payments the government makes to its employees to provide services to the public rather than the direct purchase of goods and services from the private sector. To obtain an accurate representation of the government's purchases of private sector output it is necessary to subtract non-market sector wage and salary payments from Government Final Consumption Expenditure. The value, price and quantity of Government Final Consumption Expenditure and the value and quantity of government purchases from the private sector are presented in Table A18.

Exports and Imports

Information on the price and quantity of aggregate New Zealand exports and imports were obtained from OECD *Economic Outlook* data supplied by EconData Pty Ltd. As with other data these series were converted to a March year basis. The value, price and quantity of aggregate exports and imports are presented in Table A19.

A5 Taxation Data

The principal taxation data sources used in this study were the IMF's *Government Finance Statistics* and the OECD's *Revenue Statistics*. These sources publish taxation statistics using a common set of classifications for most countries. The primary taxation data used is presented in Table A20. Data on individual, corporate and 'unallocable' income taxes, payroll tax, sales and excise taxes on motor vehicles, other sales taxes, import duties, and property and land taxes were taken from the *Government Finance Statistics*. Data on excise taxes, total indirect taxes and subsidies were taken from the *Revenue Statistics*.

Table A18: Government Consumption and Government Purchases

March Year	Government Final Consumption Expenditure Value $mil	Price Index	Quantity $1972mil	Government Purchases Value $mil	Quantity $1972mil
1972	886	1.0000	886	158	158
1973	1 023	1.0883	940	200	184
1974	1 176	1.2026	978	200	166
1975	1 443	1.3631	1 059	286	210
1976	1 732	1.5599	1 110	343	220
1977	1 937	1.7582	1 102	389	221
1978	2 363	2.0611	1 146	515	250
1979	2 882	2.4018	1 200	602	251
1980	3 314	2.7985	1 184	659	235
1981	4 134	3.4595	1 195	820	237
1982	4 988	4.0991	1 217	1 034	252
1983	5 555	4.5473	1 222	1 231	271
1984	5 858	4.6904	1 249	1 431	305
1985	6 334	4.9595	1 277	1 706	344
1986	7 345	5.6704	1 295	1 946	343
1987	8 930	6.7669	1 320	2 249	332
1988	10 128	7.6026	1 332	2 560	337
1989	11 052	8.3582	1 322	2 851	341
1990	11 771	8.8916	1 324	3 133	352
1991	12 335	9.2093	1 339	3 484	378

Table A19: Exports and Imports

March Year	Export Value $mil	Export Price Index	Export Quantity $1972mil	Import Value $mil	Import Price Index	Import Quantity $1972mil
1972	1 549	1.0000	1 549	1 515	1.0000	1 515
1973	1 831	1.2078	1 516	1 729	1.0399	1 663
1974	2 264	1.4215	1 593	2 317	1.1350	2 042
1975	2 267	1.4354	1 579	3 241	1.4190	2 284
1976	2 654	1.5626	1 699	3 440	1.8380	1 872
1977	3 674	1.9364	1 897	4 102	2.2089	1 857
1978	4 157	2.1640	1 921	4 450	2.4061	1 850
1979	4 712	2.3877	1 974	4 753	2.5833	1 840
1980	5 919	2.8350	2 088	6 150	2.9836	2 061
1981	7 081	3.2684	2 167	7 551	3.6796	2 052
1982	8 236	3.6889	2 233	9 008	4.2242	2 132
1983	9 209	4.0109	2 296	10 323	4.6960	2 198
1984	10 647	4.3390	2 454	11 207	5.1491	2 177
1985	12 730	4.8897	2 603	14 107	5.7864	2 438
1986	14 592	5.2922	2 757	15 297	6.1362	2 493
1987	14 999	5.4175	2 769	15 534	5.8944	2 635
1988	16 475	5.7366	2 872	16 041	5.6045	2 862
1989	17 937	6.0686	2 956	16 511	5.6232	2 936
1990	19 306	6.5875	2 931	19 517	5.9566	3 276
1991	20 281	6.4533	3 143	20 089	6.0376	3 327

Table A20: **Taxation Statistics**

Year Ending March	*Individual Income Tax*	*Corporate Income Tax*	*Unallocable Income Tax*	*Payroll Tax*	*Sales and Excise Taxes on Vehicles*
	$mil	$mil	$mil	$mil	$mil
1972	851	300	11	41	77
1973	1 001	304	10	46	100
1974	1 304	383	12	34	105
1975	1 684	439	13	1	129
1976	1 874	407	15	0	138
1977	2 313	499	17	0	152
1978	2 927	546	17	0	173
1979	3 214	426	21	0	200
1980	3 805	647	21	0	182
1981	4 698	585	24	0	229
1982	5 832	667	36	0	303
1983	6 591	850	55	0	341
1984	6 707	702	44	0	376
1985	7 185	1 113	51	0	442
1986	9 212	1 270	86	104	463
1987	11 073	1 221	138	167	411
1988	11 609	2 026	165	213	312
1989	12 863	1 903	212	521	183
1990	13 400	2 513	883	483	65
1991	13 177	1 715	1 417	490	7

Year Ending March	*Other Excise Taxes*	*Import Duties*	*Property and Land Tax*	*OECD Total Indirect Taxes*	*OECD Subsidies*
	$mil	$mil	$mil	$mil	$mil
1972	199	78	134	662	108
1973	207	88	151	754	129
1974	217	120	173	850	163
1975	225	142	204	917	238
1976	305	125	240	1 103	391
1977	350	147	280	1 300	243
1978	432	150	321	1 469	277
1979	522	166	364	1 725	428
1980	513	212	427	1 998	352
1981	531	231	515	2 344	348
1982	597	336	631	2 914	578
1983	770	356	703	3 440	755
1984	885	444	741	3 847	655
1985	1 010	624	854	4 509	596
1986	1 130	556	977	4 852	362
1987	1 494	736	1 121	6 675	302
1988	2 536	912	1 129	8 864	323
1989	2 265	536	1 283	9 118	197
1990	2 046	653	1 536	10 875	210
1991	1 922	512	1 538	11 440	190

In estimating deadweight losses associated with raising government revenue it is necessary to allocate taxes to the relevant factors of production and commodities. This permits the modelling of the wedges which taxation and subsidies introduce between prices paid by consumers (and producers for their inputs) and those received by suppliers and their impact on economic efficiency. To this end, the classifications used by both the IMF and OECD are not that useful and taxes have to be reallocated in a more meaningful way.

The major task is the allocation of taxes between the two primary factors of production, labour and capital. While some classifications can readily be assigned to one factor - payroll tax to labour and corporate tax to capital - the major task is allocating the large individual income tax category between the two factors. It should be noted that under our classification of inputs the return to the self-employed is treated as an opportunity cost of their time and so a portion of the taxes they pay will be allocated to labour to reflect their labour input. Only the return (and the tax) in excess of this opportunity cost should be allocated to capital.

In allocating the individual income tax category between labour and capital, use was made of information kindly supplied by the New Zealand Treasury, some of which was previously unpublished. This consisted of a time-series of Pay-As-You-Earn tax payments or source deductions and a breakdown of the non-employee tax base for 1991. The source deduction time-series provided the minimum level of allocation to labour representing payments by employees. Source deductions averaged 78 per cent of total individual income tax payments over the period. The residual, or 'other persons', category is then made up of payments which could be associated with the opportunity costs of the self-employed and payments from capital income. The 'other persons' tax base information for 1991 supplied by The Treasury indicated that 60.18 per cent of the residual category could be allocated to 'Self-employment' and 'Shareholder Salary'. The latter category was described as payments to employees of their own company. Consequently, 60.18 per cent of the individual income tax payments residual was allocated to labour as the opportunity cost of the self-employed.

Labour direct tax payments were then taken to consist of, on average, 91.3 per cent of individual income tax payments plus payroll taxes. Capital direct tax payments were taken to be the balance of individual income tax payments plus corporate income tax payments plus 'unallocable' income tax payments. In the case of New Zealand, 'unallocable' income tax payments consist of non-resident withholding tax, property speculation tax, absentee income tax, and tax on foreign sourced dividends, interest and dividends. These items are clearly all capital taxes and so all of the 'unallocable' category was allocated to capital.

In allocating indirect tax payments to commodities, use was made of additional material in the *Revenue Statistics* plus assumptions about the allocation of GST payments to form a time-series of sales and excise taxes on motor vehicles. Indirect taxes on other commodities were estimated as the residual left after deducting property and land taxes, import duties and the estimated motor vehicle tax series from the OECD's Total Indirect Taxes series.

A breakup of property and land taxes between residential and business properties was also required. Estimates of residential property and land taxes were formed by grossing up Indirect Taxes Paid, Ownership of Owner-Occupied Dwellings obtained from the *Monthly Abstract of Statistics* and the *New Zealand System of National Accounts* by a factor of 1.3055 to allow for the number of residential households not owner-occupied. This ratio was obtained by taking the average of the sum of Total Output of the Ownership Sector plus Final Consumption Expenditure of Resident Households: Rental Payments and Associated Costs to Total Output of the Ownership Sector obtained from the *New Zealand System of National Accounts: 1982-83 to 1988-89*. Business property and land taxes were then taken to be the difference between total property and land taxes and the estimated residential series.

The taxes allocated to labour, capital, motor vehicles, other commodities, residential land and business land are presented in Table A21.

Table A21: Allocated Taxation Data

Year Ending March	*Labour Direct Tax*	*Capital Direct Tax*	*Sales and Excise Tax on Vehicles*	*Other Indirect Taxes*	*Housing Property Tax*	*Business Property Tax*
	$mil	$mil	$mil	$mil	$mil	$mil
1972	814	388	77	373	52	82
1973	943	418	100	415	65	86
1974	1 192	540	105	452	70	103
1975	1 527	610	129	442	74	130
1976	1 717	579	138	600	89	151
1977	2 096	733	152	721	117	163
1978	2 663	826	173	825	140	181
1979	2 959	702	200	996	174	190
1980	3 498	975	182	1 177	208	219
1981	4 355	952	229	1 369	247	268
1982	5 459	1 077	303	1 644	302	329
1983	6 167	1 329	341	2 040	368	335
1984	6 192	1 262	376	2 287	406	335
1985	6 685	1 664	442	2 589	428	426
1986	8 620	2 052	463	2 856	503	474
1987	10 213	2 386	621	4 197	593	528
1988	10 641	3 372	544	6 279	724	405
1989	11 944	3 555	412	6 887	863	420
1990	12 560	4 719	396	8 290	939	597
1991	12 450	4 349	395	8 995	1 021	517

A6 Producer Model Data

Having introduced all the basic data used in the producer model, it remains to derive the necessary variables in terms of producer prices. In the case of motor vehicle outputs the price received by producers was assumed to be the consumer price given in Table A3 less the sales and excise tax rate. The sales and excise tax rate is derived as the ratio of these tax payments from Table A21 relative to the consumer value of motor vehicle additions from Table A3. Thus the price facing motor vehicle producers is given by:

(A7) $$P_p = \left(1 - t_V\right)P_c$$

where t_V is the sales and excise tax rate on vehicles and P_c is the consumer price.

The price facing producers for imports was assumed to be that given in Table A19 plus the import duty rate (the ratio of import duties from Table A20 to the duty-free value of imports from Table A19):

(A8) $$P_p = \left(1 + t_M\right)P_M$$

where t_M is the import duty rate and P_M is the duty-free import price.

Subsidies are assumed to be evenly distributed between the production of exports and general consumption (excluding housing and transport). Thus, the subsidy rate was derived as the ratio of subsidy payments from Table A20 to the consumer value of exports (Table A19) plus the consumer value of general consumption (private from Table A5 and public from Table A18). The producer price of exports can then be defined as:

(A9) $$P_p = (1 + s)P_X$$

where s is the subsidy rate and P_X is the export price.

General consumption (excluding housing and transport) is subject to sales and other indirect taxes but its production also receives subsidies. Its producer price is therefore given by:

(A10) $$P_p = (1 + s)\left(1 - t_c\right)P_c$$

where t_c is the indirect tax rate on general consumption and P_c is the consumer price.

The tax rates on motor vehicles, general consumption and imports and the general subsidy rate used to convert consumer prices and duty-free import prices to producer prices are given in Table A22.

Table A22: Tax and Subsidy Rates

March Year	*Vehicles Tax Rate*	*Consumption Tax Rate*	*Import Duty Rate*	*Subsidy Rate*
	%	%	%	%
1972	35.24	10.46	5.13	2.11
1973	41.22	10.26	5.08	2.20
1974	35.57	9.87	5.17	2.38
1975	41.89	8.40	4.39	3.16
1976	40.32	10.18	3.62	4.58
1977	41.90	10.56	3.59	2.32
1978	45.37	10.67	3.37	2.33
1979	45.38	11.16	3.49	3.14
1980	29.01	11.23	3.45	2.15
1981	28.76	11.04	3.06	1.79
1982	29.59	11.43	3.73	2.55
1983	28.36	12.35	3.45	2.94
1984	29.87	12.76	3.96	2.29
1985	27.92	12.90	4.42	1.82
1986	25.22	12.28	3.63	0.96
1987	32.77	15.30	4.74	0.71
1988	26.04	20.10	5.69	0.68
1989	19.99	20.39	3.25	0.38
1990	13.29	23.21	3.35	0.38
1991	11.30	24.31	2.55	0.33

The remaining output components (housing investment from Tables A9 and A10 and an aggregate of non-residential and other construction investment, plant, machinery and transport equipment investment, and changes in agricultural and non-agricultural inventories from Tables A12, A13, A14 and A17) and the variable input private sector labour (from Table A7) are already in producer prices and do not need to be further transformed.

Having derived all the components in terms of producer prices it was possible to calculate the profits of the private production sector as the sum of the 5 output values (motor vehicles, general consumption, housing investment, general investment and exports) less the value of the 2 variable inputs (imports and labour). The profit series is presented in Table A23.

Constant returns to scale were imposed necessitating the sum of the fixed input user costs to equal the value of profits. Fixed input user costs were specified for the 5 fixed input categories (non-residential and other construction stocks; plant, machinery and transport equipment stocks; non-agricultural inventories; agricultural inventories; and, land) of the following form:

(A11) $$UC_i = \left(d_i + t_i + R\right)P_iS_i \qquad i = 1,\dots, 5$$

where d_i is the economic depreciation rate for fixed input i, t_i is the property tax rate for fixed input i, R is the real pre-tax rate of return and P_i and S_i are the price and quantity of stock i. The economic depreciation rate was set at 2 per cent for non-residential and other construction

Table A23: **Profit, Tax Rates and Real Rates of Return**

Year Ending March	*Profit*	*Business Property Tax Rate*	*Capital Tax Rate on Assets*	*Real Pre-Tax Rate of Return*	*Real Post-Tax Rate of Return*
	$mil	%	%	%	%
1972	1 496	0.34	1.67	3.55	1.88
1973	2 016	0.32	1.60	4.71	3.11
1974	2 481	0.34	1.71	4.98	3.27
1975	1 335	0.34	1.47	0.56	-0.91
1976	1 778	0.33	1.16	0.57	-0.59
1977	2 223	0.33	1.32	1.01	-0.31
1978	2 268	0.33	1.38	0.73	-0.66
1979	3 264	0.34	1.08	1.88	0.79
1980	2 671	0.36	1.35	0.62	-0.73
1981	3 475	0.39	1.15	1.05	-0.10
1982	4 000	0.37	1.00	0.72	-0.28
1983	5 373	0.31	1.02	1.24	0.22
1984	8 624	0.30	0.92	3.23	2.30
1985	8 282	0.35	1.08	2.19	1.11
1986	10 516	0.35	1.19	2.75	1.56
1987	9 327	0.35	1.27	1.73	0.46
1988	10 006	0.24	1.67	1.95	0.28
1989	11 605	0.23	1.67	2.50	0.83
1990	12 902	0.32	2.12	2.74	0.62
1991	14 166	0.26	1.83	2.99	1.15

stocks and at 13 per cent for plant, machinery and transport equipment stocks. Non-agricultural inventories, agricultural inventories, and land were assumed not to be subject to depreciation. Business property and land taxes were assumed to be spread evenly between non-residential and other construction stocks and land. The property tax rate was thus zero for the other fixed inputs.

In order to make the sum of the fixed input user costs equal to profit, the post-tax rate of return, r, was endogenised. The following equation was solved for r:

$$\text{(A12)} \qquad PR = (1+r)\sum_{i=1}^{4}\left(d_i + t_i + r + t_K\right)P_iS_i - r\sum_{i=1}^{4} t_iP_iS_i + \left(d_5 + t_5 + r + t_K\right)P_5S_5$$

where PR is profits, t_K is the rate of capital taxation defined as the ratio of capital direct taxes to the total value of the five fixed input stocks and the fifth fixed input is land. The $(1 + r)$ term on the right hand side of equation (A12) reflects the fact that an installed capital input should be more valuable than a newly purchased investment good which only yields productive services in the following year.

The resulting values of the pre-tax and post-tax real rates of return are presented in Table A23 along with the rate of business property tax and the capital tax rate on assets. Having obtained the user costs of the five fixed inputs, the four non-land inputs were aggregated using the user costs as weights.

A7 Data Input to the Econometric Models

The data input to the static consumer model are listed in Table A24. The four goods (motor vehicles, general consumption (excluding housing and transport), housing and leisure) are presented in consumer prices and their prices have been normalised to equal one in 1972.

The output and variable input price and quantity data input to the producer model are listed in Table A25. Fixed input user cost price and quantity data are listed in Table A26. All variables are in producer prices with values (the product of the price and quantity) in millions of New Zealand dollars. The prices of the 3 outputs and 2 variable inputs are normalised to equal one in 1972. For estimation purposes the two fixed inputs have been normalised so that their quantities equal one in 1972.

Although not used in this study directly, some of the variables in Tables A25 and A26 were constructed at a more disaggregated level. These more disaggregated series are listed in Tables A27 and A28 for future reference. In Table A27 the consumption and investment variable is broken down into a consumption component and five investment components. In Table A28 the capital variable is broken down into four components. In Tables A27 and A28 the same conventions regarding index basing and values are used as in Tables A25 and A26.

Table A24: Consumer Model Data

Year Ending March	*Motor Vehicle Consumption Price* Index	*General Consumption Price* Index	*Housing Consumption Price* Index	*Leisure Consumption Price* Index
1972	1.0000	1.0000	1.0000	1.0000
1973	1.1510	1.0455	1.5075	1.1116
1974	1.1986	1.0980	1.9506	1.2304
1975	1.0778	1.1815	0.4999	1.4032
1976	1.4419	1.3505	0.7283	1.6292
1977	1.6954	1.6309	0.9912	1.8088
1978	2.0768	1.9099	0.8705	1.9922
1979	2.5416	2.1248	1.8762	2.2343
1980	2.8516	2.5220	1.0128	2.6079
1981	3.1014	3.0179	1.6170	3.0254
1982	3.1424	3.4529	1.8477	3.5022
1983	4.4628	3.9171	2.9219	3.7627
1984	5.5525	4.0834	5.8933	3.9730
1985	5.8295	4.3836	4.8264	4.3630
1986	7.1761	4.9890	6.2794	4.8948
1987	7.4269	5.6257	5.1687	5.7457
1988	8.0397	6.2469	5.5710	6.8153
1989	7.6040	6.6630	7.4220	7.3896
1990	7.6958	7.1651	7.5230	7.8331
1991	8.2668	7.5696	9.6353	8.2354

Year Ending March	*Motor Vehicle Consumption Quantity* $1972thou/head	*General Consumption Quantity* $1972thou/head	*Housing Consumption Quantity* $1972thou/head	*Leisure Consumption Quantity* $1972thou/head
1972	0.1370	1.9795	0.1927	0.7756
1973	0.1393	2.0906	0.1935	0.8042
1974	0.1464	2.2105	0.1952	0.7846
1975	0.1430	2.2716	0.1981	0.7736
1976	0.1370	2.1660	0.2001	0.8075
1977	0.1324	2.0503	0.2033	0.8516
1978	0.1252	1.9457	0.2071	0.8625
1979	0.1224	2.0033	0.2092	0.7839
1980	0.1230	1.9816	0.2109	0.8072
1981	0.1277	1.9289	0.2107	0.8111
1982	0.1378	1.9254	0.2105	0.7936
1983	0.1353	1.9106	0.2100	0.8087
1984	0.1337	1.9383	0.2080	0.8873
1985	0.1370	1.9802	0.2080	0.9147
1986	0.1376	2.0023	0.2095	0.9190
1987	0.1358	2.0826	0.2113	0.9140
1988	0.1347	2.1067	0.2113	0.9603
1989	0.1368	2.1117	0.2123	1.0351
1990	0.1521	2.0528	0.2133	1.1271
1991	0.1649	1.9803	0.2145	1.1902

Table A25: Producer Model Data - Outputs and Variable Inputs

Year Ending March	*Motor Vehicle Price*	*Consumption and Investment Price*	*Exports Price*	*Import Price*	*Labour Price*
	Index	Index	Index	Index	Index
1972	1.0000	1.0000	1.0000	1.0000	1.0000
1973	0.9688	1.0627	1.2087	1.0394	1.1197
1974	1.0954	1.1289	1.4252	1.1354	1.2653
1975	1.1755	1.2850	1.4501	1.4091	1.4714
1976	1.5761	1.5014	1.6003	1.8117	1.6938
1977	1.7669	1.7048	1.9403	2.1765	1.9289
1978	2.0883	1.9443	2.1687	2.3659	2.2051
1979	2.3021	2.1366	2.4117	2.5430	2.4332
1980	3.7478	2.4425	2.8359	2.9360	2.8547
1981	3.9019	2.8707	3.2580	3.6072	3.3683
1982	3.9589	3.3468	3.7049	4.1678	3.9675
1983	5.5177	3.7502	4.0433	4.6209	4.3171
1984	5.8542	3.8693	4.3467	5.0919	4.5217
1985	6.8192	4.1875	4.8756	5.7475	4.9418
1986	8.4582	4.7370	5.2324	6.0489	5.7779
1987	8.4736	5.0723	5.3432	5.8724	6.7796
1988	10.2156	5.3608	5.6560	5.6341	7.7557
1989	10.0614	5.5675	5.9657	5.5225	8.5960
1990	11.1990	5.7417	6.4759	5.8555	9.2382
1991	11.8686	5.9023	6.3408	5.8893	9.6332
Year Ending March	*Motor Vehicle Quantity*	*Consumption and Investment Quantity*	*Exports Quantity*	*Import Quantity*	*Labour Quantity*
	$1972mil	$1972mil	$1972mil	$1972mil	$1972mil
1972	142.23	4,661.31	1,581.30	1,592.46	3,296.78
1973	147.31	5,203.78	1,548.43	1,747.98	3,314.33
1974	173.28	5,977.99	1,626.19	2,146.26	3,428.70
1975	151.74	5,782.07	1,612.61	2,401.34	3,553.24
1976	130.00	5,564.08	1,734.38	1,967.64	3,537.20
1977	119.52	5,439.52	1,937.56	1,952.41	3,510.52
1978	99.94	5,192.53	1,961.32	1,944.54	3,487.06
1979	104.38	5,554.02	2,015.19	1,934.10	3,610.17
1980	118.65	5,234.38	2,132.06	2,166.93	3,588.20
1981	145.36	5,410.74	2,212.30	2,157.36	3,577.65
1982	182.16	5,580.34	2,279.74	2,241.88	3,654.79
1983	156.06	5,767.28	2,344.36	2,311.04	3,686.85
1984	150.61	6,404.36	2,505.64	2,288.19	3,600.09
1985	167.36	6,422.13	2,658.44	2,563.00	3,638.75
1986	162.29	6,640.56	2,815.54	2,620.77	3,667.77
1987	150.35	6,716.47	2,827.16	2,770.52	3,665.66
1988	151.26	6,874.06	2,932.65	3,009.00	3,613.26
1989	163.85	6,971.27	3,018.17	3,086.87	3,468.39
1990	230.72	7,190.67	2,992.61	3,444.54	3,266.78
1991	261.23	7,051.51	3,209.10	3,498.00	3,145.61

Table A26: **Producer Model Data — Fixed Inputs**

March Year	*Capital User Cost* Index	*Land User Cost* Index	*Capital Quantity* Index	*Land Quantity* Index
1972	1 176.0	320.7	1.0000	1.0000
1973	1 478.6	447.8	1.0621	1.0000
1974	1 650.3	621.1	1.1286	1.0000
1975	984.9	152.7	1.1996	1.0000
1976	1 286.3	177.3	1.2440	1.0000
1977	1 498.7	296.9	1.2848	1.0000
1978	1 536.9	254.2	1.3098	1.0000
1979	2 003.0	575.4	1.3430	1.0000
1980	1 731.5	283.3	1.3783	1.0000
1981	2 115.0	494.0	1.4092	1.0000
1982	2 354.5	507.2	1.4830	1.0000
1983	2 833.7	930.3	1.5679	1.0000
1984	3 931.2	2 164.1	1.6451	1.0000
1985	3 806.1	1 704.9	1.7293	1.0000
1986	4 570.3	2 246.6	1.8109	1.0000
1987	4 135.0	1 605.6	1.8679	1.0000
1988	4 177.2	1 846.4	1.9537	1.0000
1989	4 546.0	2 302.2	2.0472	1.0000
1990	4 764.4	2 670.9	2.1480	1.0000
1991	4 924.9	3 091.0	2.2499	1.0000

A8 Productivity and Price Ratios

Various performance measures for the market sector of the New Zealand economy are reported in Chapter 3. The main performance measure reported is total factor productivity (TFP). TFP is an index of the ratio of the aggregate output quantity index to the aggregate input quantity index. The total output quantity, total input quantity and TFP indexes are presented in Table A29 along with the overall prices received index, the prices paid index and the index of the prices received to prices paid ratio.

A9 Tax Rates in Terms of Producer Prices

In the model of deadweight losses constructed, tax rates enter in terms of producer prices. The six principal tax rates in terms of producer prices are presented in Table A30. The capital tax rate is the ratio of direct capital taxes to profit.

Table A27: **Producer Consumption and Investment Data**

Year Ending March	Consumption of Goods and Services Price Index	Investment: Residential Housing Price Index	Investment: Non-residential & Other Construction Price Index	Investment: Machinery & Equipment Price Index	Investment: Non-Agricultural Inventories Price Index	Investment: Agricultural Inventories Price Index
1972	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1973	1.0506	1.0950	1.0905	1.0480	1.0690	1.3728
1974	1.1128	1.2839	1.2770	1.0342	1.2051	1.4200
1975	1.2294	1.6054	1.5844	1.2518	1.3026	0.8141
1976	1.3969	1.7766	1.7881	1.7610	1.4756	1.1715
1977	1.6369	1.9436	1.8446	1.9178	1.8056	1.4942
1978	1.9151	2.1712	1.8956	2.1245	2.1023	1.4297
1979	2.1422	2.3507	1.8850	2.3268	2.3448	2.3198
1980	2.5133	2.5491	1.9951	2.5029	2.7604	2.6551
1981	3.0096	2.9196	2.1368	2.8683	3.3918	2.6089
1982	3.4626	3.5313	2.8139	3.2390	3.9637	2.6098
1983	3.8950	4.0605	3.1666	3.5448	4.5624	2.8931
1984	4.0131	4.1944	3.2552	3.6832	4.8109	3.1272
1985	4.2756	4.5586	3.4747	4.1703	5.1546	4.3854
1986	4.8612	5.2327	3.9014	4.6513	5.9453	3.8237
1987	5.3051	5.0597	4.3447	4.7032	6.2866	4.0328
1988	5.5604	7.1538	4.7372	4.3946	6.7854	3.8064
1989	5.9067	6.9413	5.3098	4.0658	7.1409	4.1291
1990	6.1211	7.5375	5.3209	4.0833	7.6457	5.3025
1991	6.3595	7.8570	5.5035	3.9850	8.0000	4.7158

Year Ending March	Consumption of Goods and Services Quantity $1972mil	Investment: Residential Housing Quantity $1972mil	Investment: Non-residential & Other Construction Quantity $1972mil	Investment: Machinery & Equipment Quantity $1972mil	Investment: Non-Agricultural Inventories Quantity $1972mil	Investment: Agricultural Inventories Quantity $1972mil
1972	3260.70	306.00	428.00	649.00	-60.55	78.16
1973	3531.08	379.91	440.15	770.02	116.78	-5.55
1974	3799.50	437.72	444.01	854.78	386.71	29.27
1975	4045.57	425.43	458.21	849.18	-8.08	-6.51
1976	3960.83	432.84	490.46	743.34	-76.76	-17.76
1977	3813.03	439.90	520.97	745.65	-114.38	-5.14
1978	3688.27	311.35	587.69	678.76	-84.92	-14.62
1979	3814.94	304.59	601.60	724.16	100.97	-33.36
1980	3783.07	286.77	578.43	735.16	-204.67	44.07
1981	3730.78	301.75	627.59	750.27	-16.81	-4.87
1982	3775.54	334.15	660.65	972.23	-141.41	-9.36
1983	3824.87	322.86	675.18	1085.26	-105.42	-29.29
1984	3985.85	372.40	699.49	1121.86	156.17	20.08
1985	4161.59	391.13	701.65	1156.99	-5.30	18.37
1986	4235.67	393.10	743.57	1221.38	2.54	55.39
1987	4410.55	477.49	776.81	1105.41	-30.66	-31.60
1988	4518.72	385.67	778.32	1317.97	-87.63	21.33
1989	4569.19	389.99	701.91	1449.92	-50.59	-34.87
1990	4497.21	403.45	794.41	1625.65	-37.49	26.32
1991	4418.18	389.59	764.96	1672.01	-53.24	3.17

Table A28: Disaggregated Capital User Cost Data

Year Ending March	*Non-Residential & Other Construction Price* Index	*Plant, Machinery and Equipment Price* Index	*Non-Agricultural Inventories Price* Index	*Agricultural Inventories Price* Index
1972	531.63	541.13	59.62	43.65
1973	700.76	614.22	85.60	80.49
1974	855.28	616.23	102.12	88.11
1975	403.89	539.96	11.97	5.48
1976	457.60	762.62	13.84	8.05
1977	545.45	859.85	30.04	18.21
1978	510.81	929.88	25.02	12.46
1979	709.48	1119.77	73.08	52.94
1980	523.36	1085.84	27.84	19.60
1981	651.76	1292.40	58.78	33.11
1982	770.15	1422.84	47.20	22.75
1983	999.77	1623.75	93.48	43.40
1984	1632.27	1962.51	261.89	124.64
1985	1415.14	2056.41	188.53	117.44
1986	1789.51	2387.37	273.40	128.75
1987	1579.83	2234.08	180.31	84.69
1988	1767.87	2115.32	219.22	90.04
1989	2248.05	2039.75	296.98	125.73
1990	2402.44	2075.42	347.31	176.37
1991	2589.32	2068.29	398.43	171.97
Year Ending March	*Non-Residential & Other Construction Quantity* Index	*Plant, Machinery and Equipment Quantity* Index	*Non-Agricultural Inventories Quantity* Index	*Agricultural Inventories Quantity* Index
1972	1.0000	1.0000	1.0000	1.0000
1973	1.0283	1.1099	0.9633	1.0647
1974	1.0573	1.2319	1.0341	1.0601
1975	1.0863	1.3363	1.2686	1.0844
1976	1.1162	1.3942	1.2637	1.0790
1977	1.1492	1.4453	1.2172	1.0643
1978	1.1850	1.4688	1.1478	1.0600
1979	1.2275	1.5035	1.0963	1.0479
1980	1.2708	1.5371	1.1575	1.0203
1981	1.3106	1.5710	1.0334	1.0568
1982	1.3552	1.6697	1.0232	1.0528
1983	1.4026	1.7907	0.9375	1.0450
1984	1.4507	1.9075	0.8735	1.0207
1985	1.5006	2.0200	0.9682	1.0374
1986	1.5497	2.1379	0.9650	1.0526
1987	1.6025	2.2044	0.9666	1.0985
1988	1.6581	2.3284	0.9480	1.0723
1989	1.7127	2.4774	0.8948	1.0900
1990	1.7576	2.6618	0.8642	1.0611
1991	1.8120	2.8367	0.8414	1.0829

Table A29: Productivity and Price Ratio Indexes

Year Ending March	*Total Output Quantity*	*Total Input Quantity*	*Total Factor Productivity*	*Prices Received*	*Prices Paid*	*Output/ Input Price Ratio*
	Index	Index	Index	Index	Index	Index
1972	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.073	1.019	1.053	1.114	1.173	0.950
1974	1.171	1.059	1.105	1.216	1.344	0.905
1975	1.070	1.102	0.971	1.280	1.243	1.030
1976	1.155	1.106	1.045	1.403	1.466	0.957
1977	1.179	1.107	1.065	1.592	1.695	0.939
1978	1.128	1.106	1.020	1.842	1.879	0.981
1979	1.224	1.141	1.073	2.054	2.204	0.932
1980	1.128	1.142	0.988	2.389	2.360	1.012
1981	1.197	1.144	1.047	2.706	2.832	0.956
1982	1.239	1.174	1.055	3.116	3.287	0.948
1983	1.269	1.195	1.062	3.500	3.716	0.942
1984	1.458	1.189	1.226	3.565	4.372	0.816
1985	1.424	1.213	1.174	3.850	4.519	0.852
1986	1.494	1.234	1.211	4.430	5.363	0.826
1987	1.468	1.242	1.182	4.857	5.739	0.846
1988	1.470	1.242	1.184	5.399	6.390	0.845
1989	1.497	1.218	1.229	5.774	7.097	0.814
1990	1.488	1.180	1.261	6.040	7.617	0.793
1991	1.509	1.163	1.298	6.148	7.980	0.770

Table A30: Tax Rates on Producer Prices

Year Ending March	*Motor Vehicles Tax Rate*	*General Consumption Tax Rate*	*Housing Property Tax Rate*	*Import Duty Rate*	*Labour Tax Rate*	*Capital Profit Tax Rate*
	%	%	%	%	%	%
1972	54.42	11.44	0.63	5.13	20.22	25.94
1973	70.14	11.19	0.70	5.08	20.80	20.71
1974	55.21	10.70	0.62	5.17	22.43	21.76
1975	72.10	8.89	0.50	4.39	23.92	45.69
1976	67.55	10.84	0.53	3.62	23.27	32.56
1977	72.12	11.55	0.62	3.59	25.19	32.97
1978	83.04	11.67	0.64	3.37	27.93	36.43
1979	83.07	12.18	0.72	3.49	26.74	21.49
1980	40.86	12.38	0.79	3.45	27.12	36.50
1981	40.38	12.19	0.81	3.06	28.35	27.40
1982	42.02	12.58	0.81	3.73	29.58	26.92
1983	39.59	13.69	0.85	3.45	30.47	24.74
1984	42.59	14.29	0.89	3.96	29.90	14.63
1985	38.73	14.55	0.85	4.42	29.57	20.09
1986	33.73	13.87	0.86	3.63	32.42	19.51
1987	48.74	17.94	1.03	4.74	32.39	25.58
1988	35.21	24.99	0.88	5.69	29.90	33.70
1989	24.99	25.52	1.07	3.25	31.42	30.63
1990	15.33	30.11	1.06	3.35	32.36	36.58
1991	12.74	32.01	1.08	2.55	31.80	30.70

APPENDIX B: DATA USED IN THE EXCESS BURDEN MODEL

Table B.1: Fitted consumer data

Year	P_1	P_2	P_3	P_4	C_1	C_2	C_3	C_4
1972	0.704	1.090	1.000	0.798	0.194	1.757	0.208	1.034
1973	0.849	1.155	1.507	0.887	0.192	1.845	0.204	1.049
1974	0.798	1.219	1.951	0.981	0.222	1.923	0.200	1.056
1975	0.998	1.355	0.500	1.119	0.153	1.913	0.207	1.049
1976	1.272	1.589	0.728	1.300	0.153	1.853	0.208	0.996
1977	1.513	1.857	0.991	1.443	0.152	1.819	0.208	1.037
1978	2.008	2.119	0.871	1.589	0.135	1.778	0.211	1.039
1979	2.252	2.321	1.876	1.783	0.146	1.808	0.209	1.007
1980	2.019	2.684	1.013	2.081	0.180	1.839	0.212	1.034
1981	2.112	3.161	1.617	2.413	0.193	1.823	0.211	1.036
1982	2.199	3.669	1.848	2.794	0.193	1.793	0.210	1.023
1983	2.963	4.135	2.922	3.002	0.196	1.783	0.212	1.057
1984	3.461	4.317	5.893	3.170	0.213	1.855	0.208	1.085
1985	3.673	4.705	4.826	3.481	0.210	1.872	0.209	1.116
1986	4.177	5.340	6.279	3.905	0.226	1.889	0.209	1.139
1987	5.348	5.936	5.169	4.584	0.186	1.970	0.209	1.156
1988	5.044	6.649	5.571	5.437	0.218	2.010	0.209	1.165
1989	4.004	6.958	7.422	5.895	0.282	2.003	0.211	1.307
1990	3.347	7.437	7.523	6.249	0.354	1.963	0.215	1.426
1991	3.313	7.761	9.635	6.570	0.390	1.980	0.214	1.447

Notes:

1. Good 1 is the services of the motor vehicle stock.
2. Good 2 is general consumption.
3. Good 3 is the services of the housing stock.
4. Good 4 is leisure.
5. The consumer prices P_i listed above are identical to the consumer prices listed in Appendix C (except for normalising constants). The units are in thousands of 1972 New Zealand dollars.
6. The per capita consumer quantities C_i listed above are the predicted values generated by the consumer model described in Chapter 6 (up to normalising constants).

Table B.2: Fitted producer data

Year	Y_1	Y_2	Y_3	Y_4	Y_5
1972	0.076	2.897	0.858	-1.044	-1.948
1973	0.078	2.928	0.897	-1.067	-1.949
1974	0.078	2.929	0.928	-1.076	-1.928
1975	0.074	2.900	0.931	-1.058	-1.873
1976	0.070	2.862	0.943	-1.034	-1.841
1977	0.068	2.857	0.977	-1.028	-1.841
1978	0.070	2.868	0.999	-1.052	-1.817
1979	0.072	2.903	1.035	-1.079	-1.818
1980	0.074	2.900	1.063	-1.102	-1.787
1981	0.071	2.871	1.079	-1.088	-1.758
1982	0.071	2.919	1.118	-1.115	-1.760
1983	0.073	2.993	1.172	-1.158	-1.785
1984	0.071	2.991	1.210	-1.156	-1.778
1985	0.070	3.021	1.260	-1.173	-1.786
1986	0.075	3.080	1.299	-1.240	-1.756
1987	0.080	3.061	1.302	-1.295	-1.659
1988	0.086	3.065	1.323	-1.370	-1.585
1989	0.090	3.079	1.356	-1.430	-1.536
1990	0.092	3.109	1.413	-1.474	-1.521
1991	0.094	3.145	1.457	-1.531	-1.494

Notes:

1. Good 1 is new motor vehicles produced or imported during the year.
2. Good 2 is general consumption output plus investment plus government consumption of goods.
3. Good 3 is exports of goods and services.
4. Good 4 is (minus) imports of goods and services.
5. Good 5 is (minus) market sector labour input.
6. The Y_i listed above are the predicted net outputs generated by the producer model described in Chapter 5 above, divided by the working age population.
7. Units are in thousands of 1972 New Zealand dollars.

Table B.3: **Tax and subsidy rates**

Year	t_1	t_2	t_3^*	t_4	t_5	t_6	s_2 *and* s_3
1972	0.544	0.114	0.006	0.051	0.202	0.259	0.022
1973	0.701	0.112	0.007	0.051	0.208	0.207	0.023
1974	0.552	0.107	0.006	0.052	0.224	0.218	0.025
1975	0.721	0.089	0.005	0.044	0.239	0.457	0.033
1976	0.676	0.108	0.005	0.036	0.233	0.326	0.047
1977	0.721	0.116	0.006	0.036	0.252	0.330	0.024
1978	0.830	0.117	0.006	0.034	0.279	0.364	0.025
1979	0.831	0.122	0.007	0.035	0.267	0.215	0.033
1980	0.409	0.124	0.008	0.035	0.271	0.365	0.023
1981	0.404	0.123	0.008	0.031	0.284	0.274	0.019
1982	0.420	0.126	0.008	0.037	0.296	0.269	0.027
1983	0.396	0.137	0.009	0.035	0.305	0.247	0.031
1984	0.426	0.143	0.009	0.040	0.299	0.146	0.024
1985	0.387	0.146	0.009	0.044	0.296	0.201	0.019
1986	0.337	0.139	0.009	0.036	0.324	0.195	0.010
1987	0.487	0.179	0.010	0.047	0.324	0.256	0.008
1988	0.352	0.250	0.009	0.057	0.299	0.337	0.008
1989	0.250	0.255	0.011	0.033	0.314	0.306	0.004
1990	0.153	0.301	0.011	0.034	0.324	0.366	0.005
1991	0.127	0.320	0.011	0.026	0.318	0.307	0.004

Notes:

1. t_1 is the tax rate on motor vehicles.
2. t_2 is the tax rate on general consumption.
3. t_3^* is the tax rate on housing, expressed as a percentage of the stock price rather than the rental price.
4. t_4 is the tariff and indirect tax rate on imports.
5. t_5 is the tax rate on labour earnings.
6. t_6 is the tax rate on gross profits.
7. s_2 *and* s_3 is the subsidy rate on general consumption and exports.

Table B.4: Additional data used in the excess burden model

Year	*Pop*	*G*	L_G	*D*	*B*	*R*	*r*
1972	1.722	0.086	0.328	-0.517	-0.154	1.054	0.0188
1973	1.759	0.101	0.312	-0.522	0.005	0.982	0.0311
1974	1.806	0.093	0.325	-0.563	0.130	0.913	0.0327
1975	1.855	0.117	0.388	-0.581	-0.120	0.869	-0.0091
1976	1.897	0.119	0.474	-0.323	-0.366	0.890	-0.0059
1977	1.924	0.111	0.432	-0.525	-0.309	0.927	-0.0031
1978	1.941	0.128	0.454	-0.608	-0.293	0.962	-0.0066
1979	1.945	0.137	0.485	-0.435	-0.233	0.958	0.0079
1980	1.966	0.127	0.488	-0.610	-0.179	0.934	-0.0073
1981	1.989	0.133	0.516	-0.504	-0.358	0.915	-0.0010
1982	2.009	0.144	0.527	-0.499	-0.445	0.982	-0.0028
1983	2.042	0.150	0.468	-0.596	-0.574	1.061	0.0022
1984	2.084	0.163	0.447	-0.553	-0.526	0.973	0.0023
1985	2.115	0.174	0.408	-0.656	-0.431	0.975	0.0111
1986	2.133	0.172	0.414	-0.744	-0.510	1.018	0.0156
1987	2.149	0.177	0.495	-0.840	-0.360	0.913	0.0046
1988	2.179	0.178	0.560	-0.921	0.118	0.877	0.0028
1989	2.198	0.187	0.467	-1.009	0.406	0.890	0.0083
1990	2.215	0.191	0.362	-1.291	0.756	0.955	0.0062
1991	2.236	0.201	0.369	-1.231	0.414	0.964	0.0115

Notes:

1. *Pop* is the working population of New Zealand in millions.
2. *G* is per working age expenditures by government on goods in thousands of 1972 New Zealand dollars.
3. L_G is fitted per working age expenditures by government on labour in thousands of 1972 New Zealand dollars.
4. *D* is the fitted per working age real government deficit (minus real transfers if *D* is negative) in thousands of 1972 New Zealand dollars.
5. *B* is the fitted per working age balance of trade surplus (deficit if negative) in thousands of New Zealand dollars.
6. *I* is per working age fitted real investment in thousands of New Zealand dollars.
7. *r* is the ex post real after tax rate of return to capital.