Development and Application of a New Zealand General Equilibrium Model

by

Adolf Hermanus Stroombergen, B.A. Hons.

A thesis
presented to Victoria University of Wellington
in fulfillment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Economics

June 1986

To Julianne

If my slight Muse do please these curious days,
The pain be mine, but thine shall be the praise.

(William Shakespeare, Sonnets)

ACKNOWLEDGEMENT

The completion of this work owes much to the zealous support and unfailing guidance of Professor Bryan Philpott. His penetrative questioning of model results over the course of countless hours spent in discussion (and argument), lead to many progressive refinements in model specification and design. Indeed those hours of debate advanced one's knowledge of economics as much as did the research and development of the model itself. Thus one has come to believe that the intellectual rewards of working on a doctoral thesis stem not only from the work on the thesis per se, but also from the increased insight that one gains from pursuing a subject beyond graduate level - both theoretically and practically. Without the enthusiasm and inspiration of Bryan Philpott, however, any such rewards would have been considerably diluted.

My gratitude also to Richard Wallace for his assistance with some of the initial data compilation and to the rest of the Economics Department staff for their encouragement and willingness to answer my questions.

Finally, my thanks to Verna and Elspeth for their assistance with the typing of the manuscript, to Steve for his contribution to its presentation, and to Anne and Moira for their assiduous proof-reading. Any remaining errors are naturally my responsibility.

ABSTRACT

Whether a country gains or loses from dismantling protection is a question which has received much attention in overseas studies; studies which deal both with the relevant theory and with actual measurement. The topic has not been well analysed in the New Zealand context. Discussion amongst economists and other interested parties has certainly occurred but this has been based more on philosophical and political considerations than on applied economic research.

Since questions of protection reform affect the whole economy it is inappropriate to study such problems in a partial or selective framework which cannot capture the interdependencies between each and every sector in the economy. A multi-sectoral general equilibrium model overcomes this deficiency. This thesis is concerned with the development and application of such a model.

The model (named JULIANNE) is a medium term policy model designed to answer 'what if' type questions, particularly questions about trade and structure. It is not a forecasting model. Its role is rather like that of a laboratory in the natural sciences, where experiments can be conducted in a situation where certain aspects of the (economic) environment can be controlled by the researcher so that it is possible to measure the relationships between the variables of interest. The closer the environment is to the 'real world' the easier it is to apply deductions from the experiment to reality. But even quite artificial experiments can yield useful insights.

The thesis comprises eleven chapters, the first three of which introduce and develop the model, examining some of the overseas general equilibrium models and assessing some of the problems which need to be addressed when constructing such a model for New Zealand; a model with an emphasis on trade and structure. The following three chapters present the JULIANNE model including its equations, a detailed explanation of its features and routines, and its method of solution, which for general equilibrium models is a most important consideration as it distinguishes the purely abstract Walrasian model from a model which is actually computable. Chapters 7 and 8 apply the model to various problems, especially to protection reform, but also to other interesting topics

such as export subsidisation, relative occupational wage rates and medium term projections. The issue of model validation (in a general sense) is also covered. In Chapter 9 the model is extended from a single period snapshot model into a multi-period dynamic model, essentially introducing another variable; time, that can be controlled by the experimenter. Some of the results from Chapters 7 and 8 are then reassessed with the extended model, as described in Chapter 10.

Results from the application of the model to questions about the effects of changes in protection enabled one to conclude that under flexible factor prices with fixed factor employment, the gains from freer trade vary directly with the values of the export price elasticities of demand, with the potential for economies of scale arising from specialization, and with the time horizon under consideration. They vary inversely with the values of the elasticities of substitution both between domestic and imported goods of a given type, and between goods of different types. Under a different labour market asumption, namely fixed real wage rates and flexible employment, the case for free trade is much stronger (that is, for a given set of parameter values).

The profile of protection across sectors can also be important with the not improbable chance that a low uniform level of protection is superior to complete free trade, again depending on parameter values and the characteristics of the labour market. In this connection the observed uniformity of the current protection regime is very dependent on the degree of sectoral disaggregation identified in the model. As the degree of disaggregation increases, the potential for specialization also increases, as does the potential for substitution between different commodity types. Just how important these issues are, is a question for future research.

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1

INTRODUCTION

CHAPTER 1

INTRODUCTION

This thesis is about the development and application of 'JULIANNE", a New Zealand computable general equilibrium (CGE) model, with an emphasis on trade and structure. In introducing the model it is convenient to split this chapter into five parts, the first four of which deal with: the object of the model, its significance, its evolution and its scope. The final part describes the layout of the thesis by presenting a brief outline of each of the remaining chapters.

Object

Two primary objectives underly the construction of the JULIANNE model:

1. To develop a general equilibrium (GE) model of the New Zealand economy that can be used to study questions of trade and structure.
2. To obtain some (indicative) answers to actual problems of trade and structure faced by New Zealand.

Thus the thesis is not exclusively theoretical nor exclusively practical. In grasping both of these areas one must necessarily compromise each to some degree. But economic literature all too often includes elaborate mathematical models based on plausible but essentially arbitrary assumptions with little or no data, let alone any empirical applications to real world issues. Conversely, to proceed directly into empirical work at an economy-wide multisectoral level requires the prior existence of a suitable theoretical framework, in this case a general equilibrium model. No such model existed when this project was conceived in 1979 although models by the Research Project on Economic Planning (RPEP) and by Gillion provided a useful starting point,[1] more by way of delineating what is required in a model intended for the analysis of trade and structural problems, than by providing elementary models as a basis for further development. Hence the dual objectives of this thesis.

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[1] See for example Philpott et al [72], Gillion [38], and Gillion & O'Neil [39].

Significance

When work on the model was begun it was intended that these two objectives would yield a model which would be of use in formulating New Zealand medium term economic policy, possibly in the context of indicative economic planning. In fact the model has been used not only by the New Zealand Planning Council as the central co-ordinating model in its National Sectoral Programme,[2] but also by numerous private organizations in assessing the role of particular sectors or industries in the total economy, in providing (conditional) projections of the medium term future for corporate planning, and in analysing the effects of changes in import protection and export incentives - both on particular sectors and in general; which is where the true strength of JULIANNE lies.[3] Thus the practical significance of the model is both evident and established.

It is worth noting, however, (to digress for a moment) that this fairly extensive use of GE models by private and quasi-government organizations, especially the former, is without precedent in New Zealand.[4] In the case of commercial applications the main reason for the lack of past use of economic models is undoubtedly ignorance although a poor example by governmental organizations can hardly have helped. Unfortunately, apart from the Planning Council and the limited use of the RPEP's 'VICTORIA' model[5] by the National Development Conference in the early 1970's, the attitudes of government officials to medium term policy planning have not really changed much since those noted a decade ago by Morgan [61, Ch.1, pp.47-52]. He quotes for instance from reports of the (now disbanded) Monetary and Economic Council:

> "Economic policies during 1976-77 must concentrate on the short-term issue of stability..."

and that by:

> "...contributing to the recovery of stability, these policies would also encourage a return to balanced growth in due course."

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[2] paper forthcoming

[3] See for example BERL [10].

[4] Their current relative popularity can be attributed in large part to the assiduous efforts of Professor B.P. Philpott, director of the Research Project on Economic Planning.

[5] Philpott, op. cit.

And from the Reserve Bank:

> "Considerations of medium and longer-term strategy have to be given a lower priority in the meantime."

> "It is the Bank's view that substantial progress towards meeting these two aims - a reduction in the rate of inflation and an expansion of output for export - are preconditions to the achievement of a satisfactory base for resumed growth and reduced unemployment."

Writing in 1979 Morgan expressed hope and some confidence that the future would see more soundly based medium term economic policy and that it would begin to be accorded priority over short term stabilization policy - a reversal of past emphasis. Whilst the then government placed great importance on its medium term oriented major projects programme, no systematic, that is general equilibrium analysis of the programme was ever requested. We can now see the results.[6] Furthermore, short term policies were still dominant right up to the change of government in 1984. The current government is also assuming much pride in the (ostensibly) medium term focus of its policies. But again no systematic analysis is evident - it is of course inconsistent with the revived laissez-faire philosophy! We have yet to see the results.

One has no desire personally to see widespread state control and intervention, or to see the state 'picking winners'. New Zealand's performance over the past decade has demonstrated the pitiful outcome of ad hoc short term policies and badly analysed medium term policies. One doubts whether a 'free' market will perform significantly better. This thesis is not broad enough to encompass an analysis of the role of models in economic planning, but it should be apparent from recent economic performance that GE models can and must have a role in medium term policy formulation. Of course the justification for a GE model does not depend on such a role, as the commercial applications of JULIANNE have shown.

From the model's practical significance then, we move on to its theoretical significance, which is probably less pronounced and certainly less evident, although the time and resources devoted to the development of the model are at least equal to that devoted to its applications. As with the applications, however, the theoretical

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[6] Gross cost over-runs, electricity subsidised by household consumers, overpriced petrol and government 'bail-outs' to name a few.

significance of JULIANNE depends upon such an assessment by others (via journal articles for example), the opportunities for which have yet to be pursued, although the structure and uses of the model have been published in numerous RPEP Occasional Papers such as those cited in the Bibliography.

An attempt has been made to advance the theoretical significance of JULIANNE in two areas. Firstly, the extensions of the standard model into the area of specialization and economies of scale may (one hopes) influence the way in which these phenomena might be modelled by others, since there is as yet not a great deal of published research in this field.[7] Secondly, the solution algorithm may also be a part of the model with the potential to contribute to the relevant field of economics, especially as regards the solution procedure for the dynamic version of the model. The existing literature on solution methods is far from conclusive as there is as yet no clear winner between Johansen type models, programming models, and nonlinear algorithm models. Presumably, however, the primary visible significance of JULIANNE is, or will be, practical rather than theoretical.

Evolution

The dominance of the practical side of JULIANNE over its theoretical side - in terms of impact, not in terms of allocated time and resources, is because (as stated before) no suitable New Zealand computable general equilibrium model existed when this thesis was commenced and thus questions relating to trade and structure had not been addressed in the manner to be presented here. World-wide, however, CGE models had existed since Johansen's [53] work in 1960, although their development did not gain much momentum until the work by the World Bank in the mid 1970's, followed soon after by Dixon et al [30] and Shoven and Whalley [81]. Hence the construction of JULIANNE from 1979 onwards was not really much behind the models of the leading proponents in the field, and in fact was about equal in the modelling of substitution between imported and domestic products and more lately in multiperiod dynamic modelling.

This approximate parity of development meant that the JULIANNE model could not simply be constructed as a New Zealand adaptation of some overseas model. Nevertheless the theoretical structure of JULIANNE is

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[7] Harris [46] is a notable exception here.

similar to other CGE models outside New Zealand, which have already been published in international journals and elsewhere. Indeed, because of this earlier publicity the theoretical advances of JULIANNE are now rendered less significant.

The World Bank (prototype) models of the mid 1970's provided the main source of information about CGE models. Those early models accomplished a great deal but as will become evident in Chapter 2, could still be much improved so as to enhance their capability to analyse issues of trade and structure - frequently their stated objective. Because of the entire chapter devoted to these and related models no more will be said here. The theoretical development of JULIANNE as a progression from these prior models emerges from Chapters 2 and 3, and from the presentation of the model itself in Chapters 4 and 6.

The development of JULIANNE as a progression from earlier structural New Zealand models, CGE or otherwise, is not discussed in other chapters as it was never a dominant theoretical link. However, as the models developed by both Philpott and Gillion were based at Victoria University and from personally working on the VICTORIA linear programming model, the need for something more comprehensive was readily apparent.

Linear programming (LP) models, whilst not usually thought of as GE models, do nonetheless solve a GE system.[8] The reason for the wide misinterpretation of LP models is that the solution contains no prices other than shadow prices. Nor of course does the associated input data contain prices, making it difficult to model relative price induced reactions by producers and consumers. To circumvent this problem the VICTORIA model, like many other LP models, incorporates numerous vectors of alternative production technologies and consumption good mixes, the shadow prices of which ensure that the activities chosen in the solution are those that would be chosen in an equivalent price-explict model. Such piecewise segmentation of nonlinear GE equations is a time consuming task even with the LP matrix generator packages that are now available. However, this disadvantage is (partially) offset by the major forte of LP models, notably their ease and speed of solution. No other form of model is as easy to solve including Johansen logarithmic differential models.[9] But as will be seen in Chapter 5, the algorithm

[8] Probably the most celebrated work in this area is that by Dorfman et al [31].

for the solution of JULIANNE (and doubtlessly other models also) is very comparable in terms of speed.

The explanation then for the recent demise of LP models in economics is that a model is much more easily specified in terms of equations (of virtually any form) than in terms of activity analyses. It is more flexible, more transparent, and more easily understood; and the unambiguous presence of prices and policy parameters (such as tariff rates) is the main factor underlying these advantages.

Prices and parameters can be incorporated into LP models but it is both messy and cumbersome - an observation from personal experience since the original conceptions of the JULIANNE model were as an LP model with prices. Such a model, although rudimentary, was actually tested at the 3-sector level. It certainly worked and there are extensions that one would still like to pursue. But it soon became obvious that extending it to even something approaching the sophistication of the JULIANNE model as described in this thesis would result in an extremely inefficient, inflexible, complicated and laborious model. That is, an LP model extended to include prices was not, and still is not the best means of examining problems of trade and structure with explicit policy variables. That the VICTORIA model has to this day had only limited application to questions of tariff reform, export subsidization and so forth, intimates that its comparative advantage does not lie in this area.

At the time (1979) the only other multisectoral medium term model in New Zealand of any note was that developed by Gillion [38] and by Gillion & O'Neil [39].[10] The former publication looks at the period 1954-74 whilst the latter looks at projections of 1986. However, the models in each case are almost exactly identical, (not that any pretence was made otherwise). Much of the effort expended by Gillion in constructing his model had to be allocated to the collection of a

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[9] Indeed, Wallace [97] discovered that the matrix for a large Johansen type model was easier and quicker to invert using an LP package than a matrix inversion package, even with a substantial amount of peripheral programming to firstly reduce the size of the matrix.

[10] Another model which was only underway at this time was Morgan's [61] econometric input-output model. A review of this extensive model is not possible here - the interested reader is referred to Wells et al [100]. As far as one can ascertain the model has not been touched since completion (in 1981) and has had no applied use by the Reserve Bank under whose patronage the model was developed, or commercially.

reasonable database.[11] This no doubt inhibited the degree of sophistication of his model, both because of the paucity of the data and because of the time required to compile it.

The objectives of the model were not unlike those of JULIANNE. Gillion's thesis [38] examines whether a better performance could have been achieved between 1954 and 1974,[12] and the 1986 projections in [39] contain a central projection plus variations in the terms of trade, balance of payments and labour force growth. But the model identified only six production sectors and only one import type, and the sectoral composition of both exports and investment was fixed. These limitations meant that it could not really be used in any reasonably detailed investigation of trade and structural problems. Admittedly one says this from a 1986 standpoint. At the time it was the only disaggregated model (apart from VICTORIA) that was anywhere near capable of studying these questions in a GE framework. Indeed Gillion's thesis contains some excellent discussion of the nature and limitations of GE models and on their application in a New Zealand context. Nevertheless, it is (now) evident that considerable scope existed for model improvement. Gillion was aware of this but again data and time limitations prevented him from any further model refinement. As will become evident in subsequent chapters the JULIANNE model incorporates improvements to each of the above mentioned shortcomings which renders it much more appropriate to the stated objectives.

Presumably in another five or ten years an even better model will exist. That is the nature of progress and at this stage one has every intention of continuous involvement in such advancement.

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[11] Basic model data such as standard input-output tables, are now much better and more readily available. But considerable personal research was still required for the assembly of additional model data such as the commodity by sector conversion matrices for exports and private consumption (and initially also for imports into investment), and the matrix of tariff equivalents.

[12] although there is no control type simulation which is necessary to properly distinguish between legitimate policy induced changes in economic activity and those that are merely due to a model's abstractions. See Chapters 7 and 10 for further elaboration.

Scope

Even with the substantial improvements over prior New Zealand GE models that exist in JULIANNE it is beyond the scope of this thesis to obtain absolutely definitive conclusions about the optimal trade policy stance for New Zealand. There are three reasons for this; uncertainty about some of the crucial parameter values, gaps in the database particularly as regards the existing profile of tariff and non-tariff protection, and the theoretical deficiencies of the model - its abstractions, simplifications and exclusions. Of course these problems can be claimed by any investigator, although presumably with progressively less validity as the body of knowledge about a given issue increases.

The scope of the objectives of the thesis (or rather of the model) does, however, definitely encompass the enlargement of the body of knowledge about New Zealand trade and structural policy as it affects economic efficiency and welfare in the medium term. The development of a New Zealand CGE model which advances theoretically on previous models, with the capability to address the stated issues, is itself a contribution to that body of knowledge. The application of the model including the prerequisite research and compilation of much of the data on the incidence and levels of both tariffs and tariff equivalents, is a further contribution to the topic. Thus the ambit of the thesis in including both theoretical work and applied work based on new data (not just new in time but also in coverage), is manifestly broad. Consequently it is unrealistic to also include the estimation of those trade and factor elasticities about which existing literature says little. (One has no reservations about using elasticity values that have been competently estimated by others.) Indeed the estimation of a GE model is a full research topic in itself.[13] Parameter estimation is therefore beyond the scope of this work.

Excluded also is the incorporation into the theoretical framework of the model of fiscal and monetary variables. It is a fundamental contention of medium term CGE models concerned with trade (as opposed to say tax models) that monetary and fiscal policies are appropriately accommodating. That is; numerous combinations of monetary and fiscal policies may be consistent with a given model outcome, that one does not

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[13] A claim which is backed up by Shoven and Whalley [81, p.1021].

wish to designate any particular policy as necessary and/or sufficient, that such policy is neutral across alternative scenarios relating to a given horizon year, and that the accommodation is net of any endogenous feedback effects.

Note that a dynamic model which solves for successive annual horizons, one which has no explicit overall medium term objectives, can still be considered as a medium term model if its theoretical structure is not concerned with policies which one can reasonably assume to be accommodating (in the above sense) and/or transient in their effects. This is not to deny the fact that taxation policies (say) can certainly affect model results.[14] That one has chosen not to model monetary and fiscal variables is because one sees greater importance (in a model concerned with trade) in the modelling of import-domestic substitution, in the extension of the JULIANNE snapshot model into a dynamic version, and in not just constructing a model but in actually using it. One does not wish to compromise those goals.

The lack of parameter estimation, or rather the uncertainty attached to some of the values adopted, together with data deficiencies, limit the applied ability of the model to yield definitive policy recommendations, as stated at the start of this section. There is also one further restriction on the range of applications of JULIANNE which should be noted, namely that its comparative advantage is in the modelling of alternative scenarios relating to the same time period rather than between time periods. That is, it is designed to be used for contemporaneous rather than intertemporal comparisons. This point will be repeated at various stages throughout the thesis as experience has shown that it is easily forgotten, particularly when (as in Chapters 7 and 10) the model is used to secure a 'control run' projection of some future year. In the context of counterfactual runs with the dynamic version of the model this means that they are best compared with each other rather than with actual known history. It is somewhat unfortunate that the applied use of the the model to date has been as much in projection work as in the investigation of alternative contemporaneous scenarios.

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[14] Some modelling of taxation flows and the fiscal deficit has been done with a modified version of JULIANNE although not in connection with this thesis. A forthcoming paper is planned.

All CGE models have this comparative advantage in contemporaneous as opposed to intertemporal investigation. The primary reason for this is simply that they do not include equations or variables for such phenomena as demographic changes, overseas events, weather patterns, capricious policy makers and so on, all of which change over time in ways that are generally without historical precedent. Thus they cannot be predicted even by econometric forecasting models, let alone GE models. But at a given point in time, whether in the past or in the future, one can reasonably assert that say the weather would be the same irrespective of the New Zealand economic situation. Likewise with overseas events and largely also with demographic characteristics. Government short term policy may not be so invariant but it is unreasonable to suggest that one cannot investigate alternative medium term structural policies because other (monetary and fiscal) policies may not be accommodating - in the sense asserted above.

The preceding argument and indeed the other points made about the model; its object, significance and evolution, will hopefully become clearer as the thesis is read. The remaining chapters then, are set out as follows:

Outline

Chapter 2 - Review of Major Computable General Equilibrium Models - surveys some of the more well known CGE models, particularly those that were designed to study trade and structural issues. The main focus of the discussion is on the modelling of factor substitution and domestic-import substitution in production, and on the modelling of investment. The models that are reviewed are not all representative of the 'state of the art'. Rather they provide a balanced cross section of model types and of the history of modelling progress, enabling one to identify some of the basic features that a 'good' CGE model should incorporate.

Chapter 3 - Issues in CGE Modelling - continues with the identification of the major issues and problems that arise in CGE modelling, some of which are more important in New Zealand than in other countries to which CGE models have been applied. The chapter is divided into two sections; one on general issues and one on trade related issues, with both sections encompassing both theoretical and practical issues. That they are divided into general and trade, rather than theoretical and practical, reflects the dual nature of this thesis in being a mixture of theoretical and practical work, frequently without a clear line of demarcation, but with a common focus on problems of trade and structure.

Chapter 4 - The JULIANE Snapshot Model - presents the snapshot version of the JULIANNE model, firstly in brief descriptive form so as to delineate the major divisions in the model, followed by the detailed equations with associated explanatory sections of text. All of the equations in the standard model are given, including all the options in areas where there is a choice of equations such as in the specification of production functions. Minor variations relating to the alternative endogenous/exogenous status of variables are not presented but they are noted in the definitions of the variables. Some experimental variations of the standard equations such as those explored in Chapter 8 are also not given here as they cannot be considered as part of the normal model. (Perhaps in the future they will become so.)

The final part of Chapter 4 collects most of the equations together and through substitution and elimination reduces them down to one rather complicated expression, designated the expanded income equation, which is analytically solvable for gross domestic expenditure minus investment. Although this reduction is technically part of the solution procedure (discussed in the next chapter) its critical dependence on the equation structure of the model means that it belongs more with a presentation of the model than with an analysis of the solution algorithm, which to a large extent is independent of the structure of the model.

Chapter 5 - The Solution Procedure - follows on from the last section of Chapter 4 into a full analysis of the solution procedure for the JULIANNE snapshot model, as regards both the logical strategy of solution and the mathematics of the algorithm. The economic interpretation of the mathematics is discussed in a brief essay at the end of this chapter - comparing the solution method with the Walrasian tatonnement process and with actual market adjustment.

Chapter 6 - JULIANNE Routines in Detail - describes the routines and features of the model in more depth than given in Chapter 4. Where appropriate it also returns to the issues raised in Chapter 3 so that the reader can judge how well they are answered in JULIANNE. Numerical examples are used in many instances to illustrate and reinforce the arguments. As in Chapter 3 the matters discussed are not separately enumerated, nor are they even split into general and trade related matters, since each is now important in its own right as a contribution to the entirety of the model, Similarly no overall summary is apposite.

Chapter 7 - Applications of JULIANNE Snapshot - consists of five distinct but not unrelated applications of JULIANNE, beginning with a set of sensitivity tests so as to instill an initial sense of proportion about the relative importance of various parameters and variables. One could argue that sensitivity tests should succeed, not precede, a 'proper' application of the model. Certainly this view has merit and in Chapter 8 the analysis is done in that order. But, given that even prior to proper model applications one should ascertain something about the validity and reliability of the model, the logic of presenting some initial sensitivity tests first, followed by the use of the model in an historical simulation mode, can be perceived. The former disaggregated approach complements and aids the latter more holistic approach to model familiarization.

The third section of the chapter presents a control projection of a future year and in the last two sections the model is used in genuine contemporaneous comparative analysis applications with empirical data.

Chapter 8 - Alternative Protection Regimes - presents the principal application of the JULIANNE (snapshot) model. The contemporaneous comparative analysis methodolgy of the last two sections of the previous chapter is maintained and enhanced in utilising JULIANNE to its full potential in terms of both the methodology and the topic - an extensive investigation of alternative protection regimes; their effects on sectoral performance, relative factor use, resource allocation, efficiency, welfare and so on; and the analysis of the sensitivity of results to changes in numerous parameters, elasticities and even whole equations. For the reasons outlined earlier it is unwise to recommend definitive policies but significant inferences which narrow the options and the range of uncertainty about quantitative gains are indubitably possible.

Chapter 9 - The JULIANNE Dynamic Model - extends the JULIANNE snapshot model into a multiperiod annual dynamic version, as a further refinement of the model's capability to address the stated objectives of analysing trade and structural issues, or indeed any issue to which the snapshot model can be applied. An incidental benefit is that it also improves the model's ability to be use in a projection mode. The underlying theory of the dynamic model is essentially unchanged although intertemporal consistency entails a few minor changes, mostly as regards the equations for production and investment. Where equations are completely unaltered from the snapshot model they are not repeated.

The solution procedure is not allocated a separate chapter as the strategy is very similar to that of the snapshot model solution procedure. It is described in section 9.5, and the final section presents the dynamic equivalent to the section in Chapter 5 on the parallels and differences between the solution procedure, tatonnement and actual market adjustment.

Chapter 10 - Applications of JULIANNE Dynamic - combines three dynamic model applications: a simulation of the period 1982-85, a control run projection to 1990 pursuant to this simulation, and a study of some alternative protection regimes for the 1986-90 period based on this projection. Thus this chapter is the dynamic equivalent of Chapters 7 and 8, although without as much depth since the methodology of the simulation and projection is basically identical to that used for the snapshot model. For the same reason these topics do not merit separate chapters. The section on alternative protection regimes is also not as extensive as Chapter 8 since one does not expect significantly different results from a fundamentally unchanged model. The primary point of interest is whether the gains and losses from changes in protection vary over time, since this question cannot be (rigorously) investigated with a snapshot model.

Chapter 11 - Summary, Conclusions and Recommendations - is self explanatory.

Data Appendix - presents the database for the latest and current 1981/82 based version of the JULIANNE model.

2

REVIEW OF MAJOR COMPUTABLE GENERAL EQUILIBRIUM MODELS

CHAPTER 2

REVIEW OF MAJOR COMPTUTABLE GENERAL EQUILIBRIUM MODELS

2.1 Introduction

In developing a computable general equilibrium (CGE) model for New Zealand, one which emphasises structural and trade related issues, it is naturally expedient to review some of the more noteworthy models which have been developed in recent years and which may in some cases, still be operational.

A cross-section of country specific models would yield much too large a number of models to review so a cross-section of model types is presented instead. This should expose the various strengths and weaknesses of CGE modelling, thereby providing a good indication about the sorts of features that could and/or should exist in a structural New Zealand CGE model, and ensuring that such a model does not represent a step backwards in the art (or science) of modelling.[1]

Most of the models which will be considered have progressed through many stages of elaboration and refinement with varying emphasis on neoclassical versus structural approaches to development policy, and frequent changes in the exogenous/endogenous variable mix and in the specification of particular equations so as to suit different applications. No model is ever considered final and indeed that is the correct attitude. But it implies that a review such as this cannot be too detailed since one should not become involved in meticulously evaluating temporary model idiosyncracies. For this reason the emphasis of each review will be on those aspects of the models which compare and contrast with the JULIANNE model, most particularly the investment routines, import-domestic substitution and factor substitution.

The accent on input and commodity substitution is both appropriate and fair, the former because of the focus of the JULIANNE model and the latter because many of the models were designed to study development planning type questions. Investment routines are always of interest

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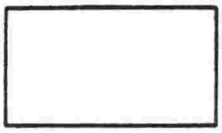
[1] Note that in assessing the models below, the simultaneous existence of the JULIANNE model is acknowledged. Although a vast amount of the current literature on CGE models naturally had to be read before the model could even be started, there is no pretence that this review was written prior to the development of JULIANNE.

since it is difficult to incorporate into equations the multitude of influences such as expectations, risk avoidance, and the imperfect workings of financial markets; which affect the level and allocation of investment. In a dynamic model the investment routines largely dictate the system's behaviour over time.

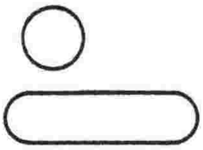
The major variables and linkages of the models are shown diagrammatically with a typical mix of exogenous/endogenous variables. The linkages represent both price and quantity flows but are not intended to show the directions of these flows or of causation. In general such direction is both ways and it will be apparent to the reader familiar with general equilibrium systems and models, which linkages are predominantly unidirectional. The diagrams are drawn with sufficient detail to take the place of repetitive lengthy discussion about characteristics common to virtually all CGE models. Consequently attention may be concentrated on model-particular attributes. The notation and symbols of the diagrams are given on the following pages.

Five models are reviewed and a summary completes the chapter.

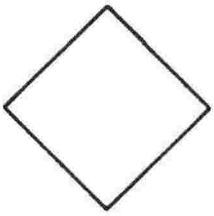
Symbols



All rectangles of whatever size represent endogenous variables in a given period.



All circles or elliptical shapes represent exogenous variables, although they may have been endogenous in a previous period.



A rhombus represents a relative price based mixing function for either factor inputs or domestic-imported inputs into production and final demand.

Where symbols are dashed the variable or function is non-existent. Naturally this applies only to variables or functions of relative significance.

Notation

i	a row of a matrix or origin of a good/factor flow.
j	a column of a matrix or destination of a good/factor flow.
	At times the distinction between i and j is irrelevant. This is usually indicated by i(j).
h	a household type, socioeconomic group, etc.
X(Y,Z)	denotes X is a function of Y and Z.
CD	Cobb-Douglas production function.
CES	Constant Elasticity of Substitution function.
AA	Activity Analysis vectors in a programming model.
MS	Monetary Sector, whether detailed or not.
Y	total income or GDP; a function of wage rates, profits, taxation, etc.
X	output or production.
L	labour input into production; $\bar{L}$ is the total labour force.
RUM	Rural-Urban Migration; generally occurs between periods.
K	capital input into production; $\bar{K}$ is total capital.
M	imports
I	investment
C	private consumption
G	government consumption

S	stock change
E	exports
F	net factor income
BoP	balance of payments
p or P	price of gross output or commodity price.
p^W	world price
v	net output price
w	wage rates, with an R super/sub script denoting real.
r	rates of profit or rental rates.
μ	supply price of capital in rate of profit equations.
t	tax, tariff or subsidy rates.
e	exchange rate
α	savings ratios - public and/or private
λ	stock-flow factor
Ω	investment matrix
Ξ	export matrix
Z	consumption matrix

Solution Method:	J	Johansen, conversion of equations into log-differential form and solved by matrix inversion.
Solution Method:	O	Optimization, (linear) programming methods.
Solution Method:	N	Non-linear algorithm designed specifically for the model concerned.

2.2 Review

The SIMLOG Model (see figure 1)

One of the world's major economic modelling institutions is the Development Research Centre of the World Bank. Since the early seventies numerous models and country specific versions of models have been designed, built and operated under the patronage of the Bank. For the reasons given earlier it is impractical to review each model variant separately so attention is here concentrated on the two major models, SIMLOG and PROLOG. These two reviews are not intended to be negative appraisals of models which are primarily developmental. The intention is to illustrate where traditional CGE models may be improved, particularly so as to make them suitable for studying trade related issues.

Of interest in the SIMLOG model are the international trade relations and the investment mechanisms. The former are purportedly designed to determine the general equilibrium responses of the economy to changes in the world prices of exports and imports, to calculate the resource allocation effects of adjustments in trade policy (such as in the exchange rate or in tariffs) and to analyse price determination in import competing sectors.[2]

Although imports are split into competitive and non-competitive categories the import substitution routine is very rudimentary since it entails the exogenous stipulation of the absolute amount of import substitution. That is:

$$M_i = [M_{i(t-1)}/X_{i(t-1)}]X_i - MS_i \qquad ([13], \text{Eqn.}24)$$

Imports of type i are equal to the previous year's import-domestic ratio multiplied by the current year's domestic supply, less some exogenous amount; a very simplistic routine which falls far short of the stated objectives, especially of the first two. Regarding the third objective, the analysis of price determination in import competing sectors, two pricing variants are proposed.

1. The price of an import competing commodity X is a weighted mean of the domestic production price of X and the domestic import price of X. Import substitution is via equation (24).

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[2] See Celasun and Caglarcan [13, p5].

2. The price of an import competing commodity X is equal to the domestic import price of X. Sectoral imports are exogenously specified such that the MS term in equation (24) is excluded.

Appropriate changes in the exogenous/endogenous mix of variables, typically tariffs or real wage rates, are asssociated with these two alternatives. Presumably the former alternative is an acknowledgement that unless one separately identifies thousands of commodities or homogeneous categories, imports of a given type and domestic goods of that same type are not perfect substitutes. Hence their prices need not and should not be equal.

Even though in the first case the price to the buyer of a good is appropriately weighted the underlying weights are virtually predetermined by equation (24) since the MS are exogenous. Furthermore the composite price is identical across buyers whereas the weights may not be, so that sectoral discrepancies can be expected to occur. Of course in the aggregate the discrepancy is zero. Therefore the only conclusions that could be inferred from a variety of runs with differing MS values, relate to aggregate magnitudes - the macro implications of different degrees of import substitution together with corresponding price changes which are 'correct in the aggregate'. Even then such conclusions would probably only be reliable to at most one order of magnitude due to the rather cavalier modelling at the micro level.

The investment mechanisms in the model are at times difficult to discern. In the text [13, p8] it is stated that:

> "The rates of return equations play a central role in allocating total investment amongst sectors."

Yet in the equations of the model given in appendix A of the paper, there is no indication of such a direct role. Rather the influence of rates of return on investment is more subtle. There is a standard equation for sectoral rates of return given by:

$$b_i r_i = [v_i X_i - w_i L_i - d_i \mu_i K_{i(t-1)}]/\mu_i K_i \qquad \text{([13], Eqn.18)}$$

The notation is described at the beginning of the chapter.

The relativities amongst these rates of return are exogenously stipulated (via the parameter b), with sectoral capital stocks being the corresponding adjustment variable, bearing in mind that all variables actually adjust simutaneously in this type of model. A standard capital updating equation then relates K(t) and K(t-1) to gross investment and depreciation, subject to total investment being exogenous.

The authors also state that investment is assumed to mature instantly since the incorporation of gestation lags generates intertemporal simultaneity which would require the stipulation of terminal conditions and hence a "much larger computational effort."[3] One infers that the reasoning behind this is as follows. If a gestation lag was introduced the model would have no reason to invest in the terminal year since the accumulation of capital for the years beyond the terminal year would serve no purpose. The need for terminal conditions then, is to ensure that the horizon year is not regarded by the model as the 'end of the world' but only as the 'end of the planning period'.

However, the terminal conditions problem should only surface in optimization models and in intertemporal equilibrium (IE) models. In the absence of a savings function most models incorporate a constraint which relates to total investment such as an investment-gdp ratio. This will circumvent the terminal conditions problem in the aggregate but in optimization and IE models it does not prevent the problem arising at the sectoral level. In optimization models where consumption is the maximand, the capital-output ratio in a given sector may be such that investment in that sector requires a greater sacrifice in consumption, than that which can eventually be regained from the investment. That is, some bias may occur in the trade-off between current (or terminal year) consumption and future (or post-terminal) consumption, the latter being represented by investment which is not usually part of the model's maximand. Consequently, one way to counter this would be to include the discounted future consumption value of horizon year investment in the objective function.[4] Similarly in intertemporal equilibrium models (about which more will be said later), the assumption of perfect foresight does not extend beyond the horizon year so it would be inefficient to invest for the post-terminal years, about which the model knows nothing. Hence the need for terminal conditions. The curious aspect about the possibility of this problem in the SIMLOG model is that it does not purport to be either an optimization model or an (IE) model.

[3] Celasun [12, p26]

[4] In this regard but with respect to snapshot models, see Tho [94].

The possibility of intertemporal simultaneity arises because the presence of gestation lags means that the capital stock used for the current year's production was installed in a previous year. It is then not possible to change the relativities in equation (18) above by altering investment in year t. Consequently K(t-1) may need to be adjusted and hence the emergence of intertemporal simultaneity.[5] Had sectoral investment in SIMLOG been made a direct function of rates of return without the relativities of the latter being exogenous, the anxiety over both intertemporal simultaneity and terminal conditions could have been avoided. Admittedly the inclusion of gestation lags would increase the computational effort but without the intertemporal simultaneity this increase should not be very much.

In general the SIMLOG model displays the expected characteristics of a CGE model, as may be seen in figure 1. (The solution method is the Johansen process of logarithmic differentiation and matrix inversion as described in Stroombergen [87]). Throughout the development of the model the authors' aim has been to create a flexible model framework by permitting a wide range of choice in the specification of equations and in the exogenous/endogenous mix of variables. Perhaps that framework is versatile enough to encompass vastly different and improved equations for import-domestic substitution. One would expect any further refinement of the SIMLOG model to be concentrated primarily in this area.

A final point which may be learnt from the SIMLOG model is that one should be very clear about the type of model one desires (whether optimization, forecasting and so on), when specifying the model's investment behaviour.

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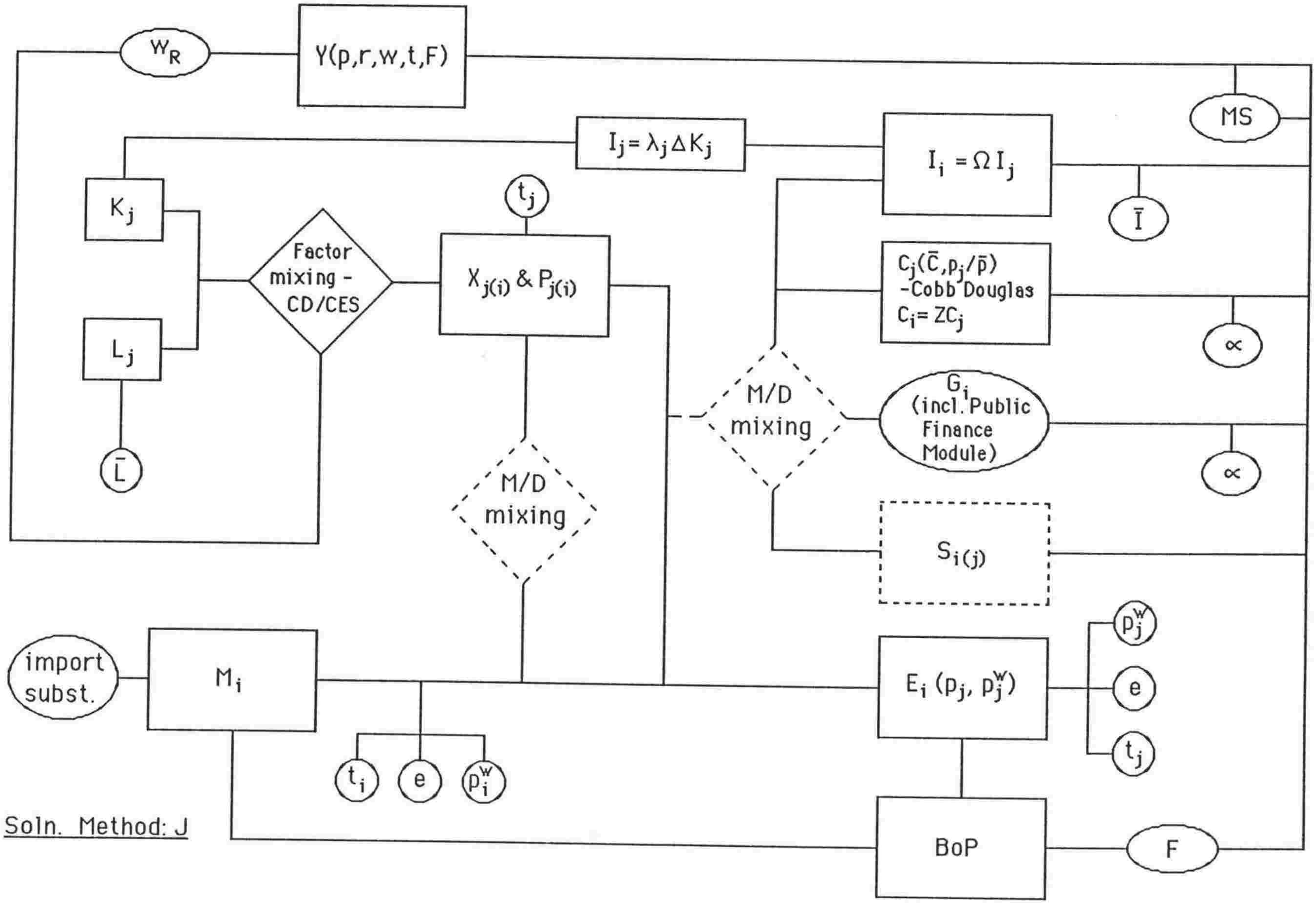
[5] A more detailed discussion of the processes involved in this adjustment is left to the section on the de Melo - Dervis dynamic models.

Figure 1

SIMLOG Model



Soln. Method: J

The PROLOG Model (see figure 2)

One of the most interesting features of the PROLOG optimization model is its solution method. This is so for three reasons.

1. The maximand is the difference between the value of expenditure on goods and the economic rents to fixed resources.[6] The optimum value of the maximand is thus equal to zero so as to preserve the income-expenditure identity in the general equilibrium system.

   An alternative along the same lines is to maximise the sum of consumer and producer surpluses as in the version of PROLOG described in Norton [65, p41].[7]
2. Some of the functions in the model are segmented. That is, they undergo a piecewise linear transformation before entering the linear programming tableau.
3. The LP tableau consists of level form equations as well as (Johansen type) logarithmic differential equations. If a variable X occurs in both sorts of equations, a connecting equation is also required. Such an equation has the form:

   $$X(1/X_{t-1}) - d(LnX) = 1$$

   where d(LnX) is the Johansen growth rate. This combination of growth rate and level form equations permits for example, the specification of sectoral production relationships which are Cobb-Douglas in some factors and Leontieff in others. The annual updating of the tableau is required since the model is dynamic but such updating also helps to reduce the extent of the linearization errors which accompany Johansen type models.[8]

The segmentation technique as well as being used for consumer demand functions is also used for import supply and export demand equations. The former is upward sloping, so the price (to importers) rises with demand. Similarly, the greater the exported quantity the lower the price received. In a CGE model endogenous import prices are rather unusual but as Norton [65, p32] points out:

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[6] See Norton & Scandizzo [66, p2].

[7] Note that this form of the objective function is not new, going back at least as far as Samuelson's [77] 'net social pay-off' function.

[8] See Stroombergen [87] for a description of such errors.

> "An upward sloping import supply function...(means)...it becomes progressively more costly to carry out import substitution."

However, this statement needs some elucidation. Presumably a programme of import substitution would correspond to a movement down the supply curve and as this continues one would be displacing progressively cheaper imports necessitating therefore, progressively better cost competitiveness on the part of domestic producers. The 'cost' is in terms of opportunity foregone in that it may be highly inefficient to attempt to displace relatively cheap imports. In a CGE model it would be better to model import substitution via an import demand function with relative prices featuring explicitly and with exogenous world prices, at least for a small country. Of this there is no sign in PROLOG as reported in [65] and [66].

The modelling of import substitution/encouragement in PROLOG is thus not much better than in SIMLOG, although it is admitted that the authors of PROLOG nowhere state an intention to model this. However, Norton [65, p2] does aim to:

> "...set out model structures...in the hope of providing a more flexible tool of analysis to the economist studying national development strategies and

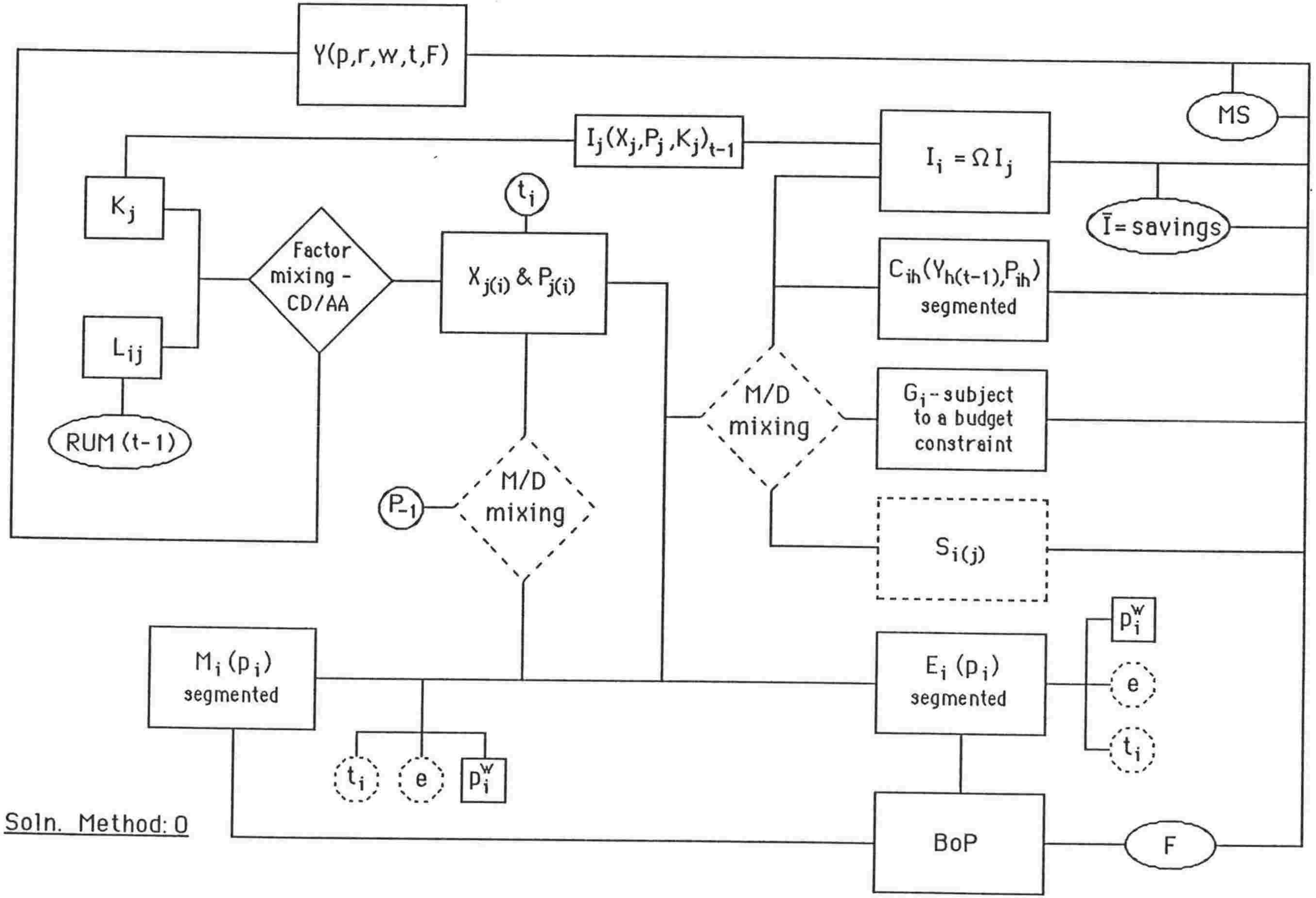
One would expect therefore, greater emphasis in the model on trade relations.

Sectoral investment allocation in the PROLOG model is a function of such variables as lagged output, lagged prices, and the previous year's capital stock. At the same time some sectoral investments may be specified exogenously. The choice of functional form is considered to be primarily an empirical question. As long as the lagged nature of the function is retained, since it is the presence of lagged explanatory variables which obviates the need for terminal conditions, the exact specification of the function is almost immaterial because the updating of capital stocks actually occurs between periods. Norton makes a most valid point (in [65, p28]) in stating that in an intertemporal model the allocation of investment should be on the basis of marginal productivities. But these must be known 'ex ante' which requires the assumption of perfect foresight. Since PROLOG is not that type of model such a tendentious assumption is not required. Instead investment functions may be specified which better approximate observed reality. To further improve the capital section of the model, gestation lags are explicit and a distinction is made between installed capacity and utilized capacity.

Overall then the investment-capital routines in the model are commendable and considerably more flexible than those in the SIMLOG model, but the trade relations could still be markedly improved. Other aspects of PROLOG which deserve a mention are the disaggregation of consumers into household classes, the specification of a public finance sector, and labour migration. However these aspects are not directly relevant to the modelling of trade and structural issues in New Zealand. In any case they contain no special features except that as with investment allocation, labour migration occurs between periods so again the precise choice of equation is vitually unlimited. In other respects the model embodies most of the usual features of a CGE model as may be seen in figure 2. Note that the compartments for the exchange rate (e) and for tariffs and subsidies (t) in the import and export sections of the diagram are drawn with broken borders to indicate that changes in e and t cannot be directly modelled. Rather the segmentation parameters of the supply/demand functions must be exogenously altered.

Figure 2

PROLOG Model



Soln. Method: 0

The dMR Model (see figure 4)

Probably the most well known CGE models are those designed by Robinson, Dervis, and de Melo. The earlier statements about the World Bank models having numerous versions and specifications apply here also, so we will examine a typical snapshot model constructed by de Melo and Robinson in 1978/79 whilst the latter was at the World Bank. This model was not described before as a World Bank model because it is felt that the contribution by the above authors to CGE modelling merits a separate introduction. That a connection with the Bank does exist should remind us that no model is completely unique.

Unfortunately this model as described in de Melo and Robinson [19] does not appear to have a name. For convenience then it is designated the dMR model to distinguish it from similar models which are alluded to in the discussion below, by the same set (or subset) of authors.

The basic model structure is given in figure 4. Its most noticeable differences from figures 1 and 2 are the non-empty rombi. Robinson and de Melo are very aware of the need to allow for imperfect substitution between domestic and imported goods. They state that:

> "From an empirical point of view, the traded - nontraded - goods dichotomy is too coarse." And "price differentials between domestic and foreign prices persist for a long time (with) significant two way trade existing even at a disaggregated level", ([19, pp7,8]).

Hence it seems rather crass to describe the assumption of imperfect substitution as an "arbitrary" means of alleviating the tendency toward specialization inherent in most (CGE) models - as done by Bell and Srinivasan [5, p11].

Substitution between imported and domestically sourced goods is via CES functions. That is, under the assumption of cost minimization a composite good is a CES function of its domestic and imported components and the price of that good is a CES function of its component prices. (This concept is studied in detail in Chapter 6). The same elasticity is used irrespective of where the substitution occurs - intermediate demand or final demand. Presumably this is due to the nature of the CES function although from one's own experience with nonlinear algorithms it should not involve too much extra effort to specify different CES functions for different end uses, but for the same category of good.

The CES function is also used for the input of primary factors into production where different labour types are combined at one CES level with aggregate labour and capital then combining via another CES function. Intermediate inputs are used in fixed composite proportions.

The other side of international trade, exports, are specified thus:

$$E_i/X_i = f[p_i/p_i^W(1+t)e] \qquad ([19], \text{Eqn.4})$$

The ratio of exports of good i to total domestic output of good i is a decreasing function of the ratio of the domestic price of i to the world price of i, allowing for the exchange rate and any subsidies which may exist.

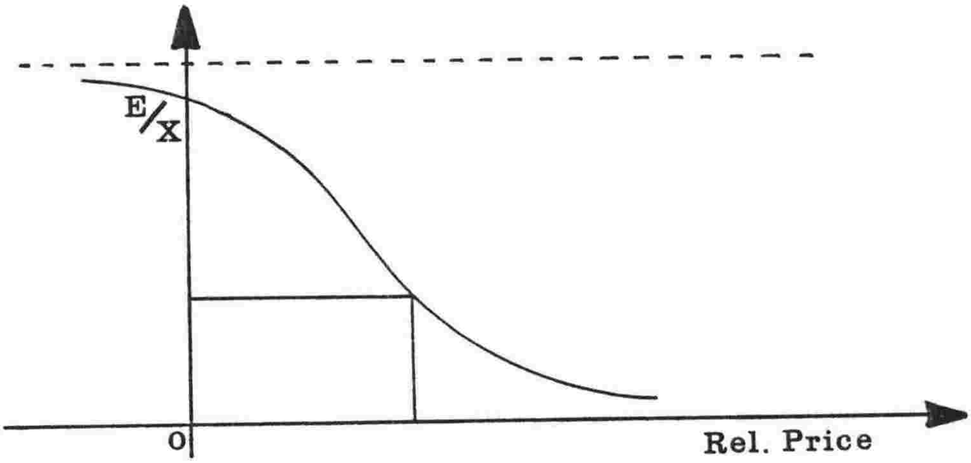


Figure 3: Export Supply Function

The function is illustrated in figure 3 where the point of inflexion is at the base year export-output ratio. (Further detail is given in appendix A.) It may be justified on three criteria.

1. With a fairly high degree of sector aggregation it is unlikely that exports of a given type will either fall to zero or usurp all production.
2. As the export-output ratio moves further away from the base year ratio, in either direction, the elasticity of transformation between the two products becomes less, reflecting the fact that exported goods from a sector i may not be the same as domestically consumed goods from sector i.
3. If there were virtually no export sales in the base year, a point on the right-hand end of the curve, (that is not at the point of inflexion as previously stated), one could argue that

> a substantial increase in exports requires either a large drop in the domestic price or a large rise in the world price, to offset initial market penetration costs. Once a foothold in the world market has been secured further expansion is relatively easy but beyond some saturation point it would again become relatively costly.

The given export function is of course a supply function where the subsidy is a positive magnitude, not a negative one as is the case in a demand function. The removal of a subsidy lowers the price received by exporters and thus reduces some of the incentive to export. A demand function would have captured the quantity reduction via the increase in the market price which results from removing the subsidy.

Whether the logistic supply function is better than a (regular) demand function is an empirical question. However, given the rather complicated nature of the logistic curve (as may be seen in appendix A) it is not surprising that most CGE modellers opt instead for a demand function. In another paper de Melo and Robinson [20] actually set the export-output ratios exogenously.

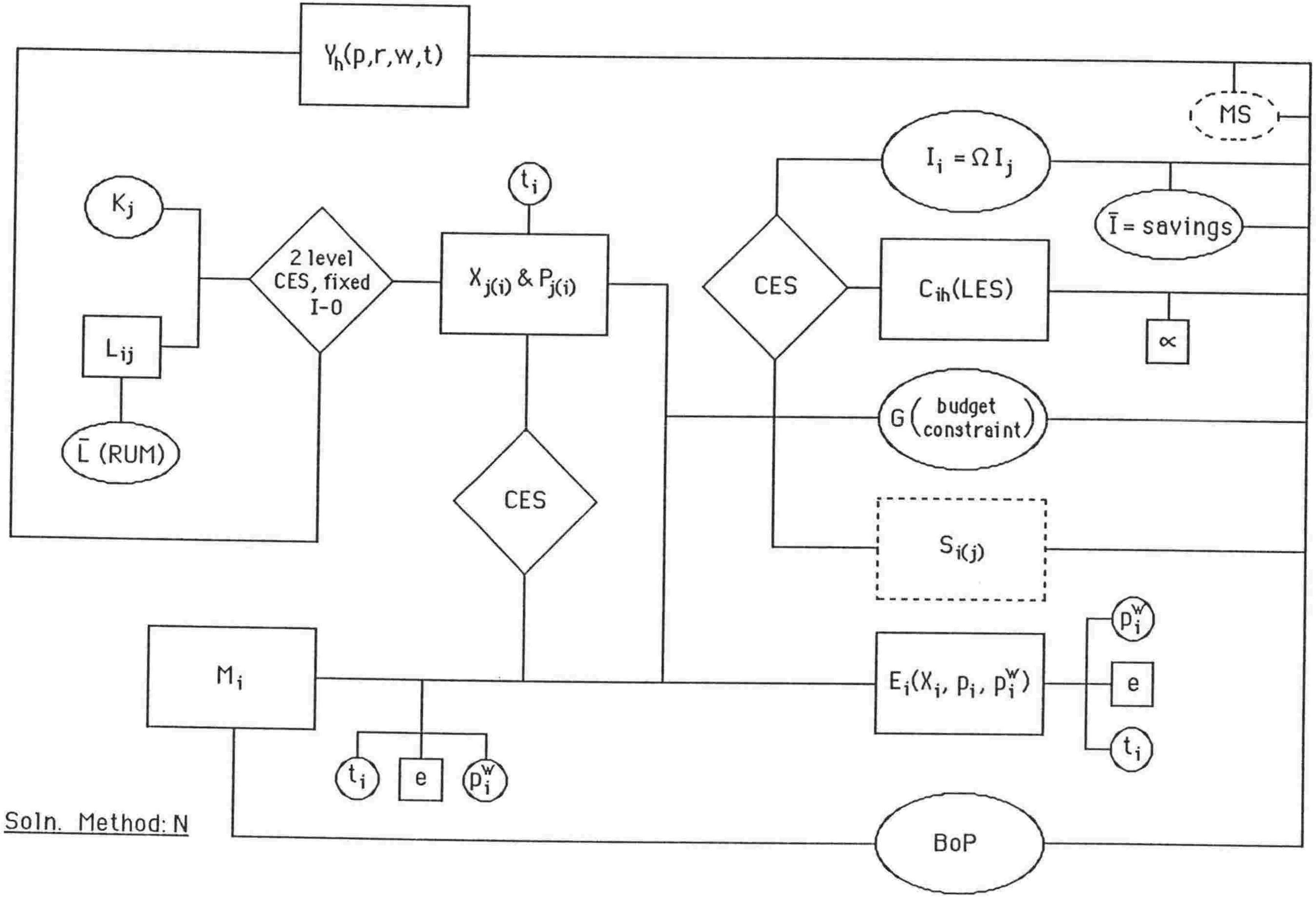
The model's investment routines are nowhere described. All that is stated is that capital stock in each sector is assumed to be fixed during a given period which implies that horizon year investment has no effect on the level of horizon year capital stock. In an earlier model described by de Melo in [17], investment by sector of origin is exogenously stipulated, this being justified by claiming that it simplifies "the interpretation of the comparative static experiments with respect to the welfare costs of protection", (p213). In two subsequent publications [20] and [25], the former of which describes a model almost exactly identical to the one presented here, investment by sector of destination is exogenously set as an absolute amount and in the latter as an exogenous share of endogenous total investment. A capital matrix is used to convert investment by sector of destination to sector of origin.

One assumes therefore that sectoral investment (by destination sector) is not endogenous in the dMR model. In general one infers that de Melo et al favour a fixed mix of sectoral investment, either absolutely or proportionately, in snapshot models dealing with trade issues. As was stated above this certainly simplifies the analysis of alternative trade policy scenarios since it divorces the effect of investment on growth from the effect of trade policy 'per se' on growth. That is, the trade policy to investment to growth link is nullified. The analysis may well be easier but whether it is empirically valid must depend on whether investment patterns can be considered as being independent of trade policy. If this is not the case then any gains or losses associated with particular policies could be seriously understated.

The major features of the dMR model are the treatment of international trade and the determination of the distribution of income. The former has been discussed above whilst the latter, as with certain aspects of the SIMLOG and PROLOG models, is not directly relevant to modelling New Zealand exports and imports. It is acknowledged that the issue is important in developing countries where trade-offs between growth and distribution can be significant.

This completes the discussion of the dMR model. It has the edge on the SIMLOG and PROLOG models in the specification of trade routines but its investment routines are seemingly elementary. In these respects it is typical of de Melo - Robinson - Dervis models. However we should not forget that the dMR model is a snapshot model. Better investment routines may be expected in a dynamic model.

Figure 4 dMR Model



Soln. Method: N

Dervis - de Melo Dynamic Models (see figures 5 & 6)

This section focusses on two dynamic models by Dervis [24] ,and de Melo and Dervis [18]. The models are very similar with regard to their equations but at the same time are readily distinguished by the fact that the former is an intertemporal equilibrium (IE) model and the latter like JULIANNE, is a sequential equilibrium (SE) model. The discussion below will be concentrated initially on this major difference.

Some of the essential differences between IE and SE models are discussed in Chapter 3 where the JULIANNE model is compared to intertemporal optimization models. The Dervis IE model does not incorporate an explicit optimization routine or maximand but this is not required to achieve intertemporal equilibrium. However, whilst both IE models and optimization IE models ignore the historical actuality of the base year (for reasons outlined in Chapter 3), the absence or presence of a maximand has implications for the specification of other relationhips in the model. The philosophy underlying the IE model is that proper development policy should explicitly consider long run intertemporal efficiency. If a maximand is excluded there is a danger that the most efficient growth strategy for a defined set of social goals will not be discovered, even though the model solution should itself be efficient within the confines of its equations. The advantage of excluding a maximand, which means discarding the optimization framework is that it is then easier to specify certain types of exogenous constraints and behaviour which are cumbersome to include in a programming problem, such as price determined import demands. The relevant question is: How far should one go in trading off potential efficiency gains from maximum variable endogenization against incorporating immutable economic or political relationships? Is the propensity to import truly fixed? Over what period of time? If an optimization model showed a particular pattern and level of imports to have a favourable effect on growth, could that import profile actually be realised or is it futile even attempting to realise it? Answers to these questions should depend on the particular attributes and rigidities of the economy, on the issue under consideration, on the time span to which the question relates and on who is asking the questions - whether private company or government.

The Dervis model is a step away from the optimization philosophy but is still very much at the optimization end of the spectrum with SE models closer to the other end; characterised in the extreme by short term forecasting models which take all economic relationships as given.

The major flows in each model are drawn in figures 5 and 6 with the IE-SE distinction being marked by the presence of a compartment labelled 'perfect foresight' for the former and an explicit link between the rates of return (r) and sectoral investment (I) blocks for the SE model.

Production in the IE model is a Cobb-Douglas function of the current labour input and capital installed in the previous period. Hence, as discussed with regard to the SIMLOG model, there is no demand for capital in the horizon year so terminal conditions are required. These take the form of equating the growth in sectoral capital stocks between the terminal year (T) and the previous year (T-1) to the growth between (T-1) and (T-2).

In other years the change in sectoral capital stocks, that is the allocation of investment, is based on the implicit assumption of perfect foresight, manifested by the equalization of sectoral rates of return where these are given by:

$$r_i = \frac{v_i X_i - w_i L_i}{\mu_{i(t-1)} K_{i(t-1)}} + \frac{\mu_i - \mu_{i(t-1)}}{\mu_{i(t-1)}} - \frac{d\mu_i}{\mu_{i(t-1)}} \qquad \text{([24], Eqn.10)}$$

The three terms on the right-hand side are the rental rate, rate of capital gains and rate of financial loss due to depreciation. The price of net output is denoted by v, μ is the price of capital and d is the physical rate of depreciation. Other notation is as defined at the beginning of the chapter.

There is no equation which explicitly links investment allocation to rates of return or to anything else, as would be required in a sequential equilibrium model. In an IE model, or at least in the Dervis IE model, capital and investment adjust so as to achieve rate of return equalization in each year. In principle this adjustment occurs simultaneously for all years but some idea of the way in which the model actually solves might be as follows.

Assume that we know K(t-1) for any year, ignoring for the moment how it was calculated. If the model is then solved for year (t) there is no guarantee that the rates of return (r) would be equal. That is, the rental rates may not differ in the 'correct' way so as to exactly counteract natural differences in rates of capital gain and depreciation. Since all predetermined variables for the year (t) are either exogenous or calculated from the previous year's solution by a known equation, the alignment of the rates of return must be induced via the K(t-1). One therefore needs to go back to year (t-1) and reallocate investment in order to yield equal rates of return in year (t). But in year (t-1) a different allocation of investment will generate a different mix of sectoral outputs and prices, and thus different rates of return also. Enter the same problem in year (t-1) as in year (t); namely unequal rates of return. Hence the solution for any one year (except the end points) is affected by and itself affects, the solution to preceding and succeeding years. The outcome of this plexiform process is an intertemporal equilibrium growth path where all expectations are fulfilled.

The end point years receive special attention with the horizon year requiring the imposition of terminal conditions (as described above) and the base year being detached from the actual base year by allowing the endogenous distribution of capital subject only to the actual aggregate supply constraint. In fact the growth rate of the total capital supply is exogenous throughout the entire model period.

Dervis does not explain the solution algorithm actually used which is understandable given the space limitations on journal articles. He describes it as a combination of Walrasian tatonnement and Gauss-Seidel iterations. Judging from one's own experience with such algorithms, one presumes that the tatonnement procedure is used primarily for the intratemporal part of the solution and the Gauss-Seidel technique primarily for the intertemporal part of the solution, although the two parts are naturally not completely independent in an IE model.

In the de Melo-Dervis SE model the allocation of investment is explicitly linked to sectoral rates of return:

$$I_j = \theta_j \bar{I} \qquad \text{([18], Eqn.11)}$$

$$\theta_j = \pi_{j(t-1)} + \lambda \pi_{j(t-1)} \frac{[r_{i(t-1)} - \bar{r}_{(t-1)}]}{\bar{r}_{(t-1)}} \qquad \text{([18], Eqn.12)}$$

where π_j is sector j's share of total profits and λ is an investment mobility parameter.

Note that the mean rate of profit ($\bar{r}$) could be any of three alternatives:

1. A simple unweighted mean; $\Sigma r_j/n$
2. A profit weighted mean; $\Sigma r_j \pi_j$
3. The economy-wide rate; that is a capital stock weighted mean.

Dervis and de Melo state that for any value of λ it will be true that $\Sigma\pi=1$ as long as $\Sigma\theta=1$. However, this is only correct if the mean rate of return is given by the second of the above definitions, which is not necessarily always the obvious choice. What is also not stated is that if in the base year the distribution of investment bears little correspondence to profit shares, there will be a drastic reallocation of investment in the first 'proper' solution year of the model; a reallocation which may be quite absurd. Perhaps de Melo and Dervis did not encounter this problem.

Total investment in the SE model is either exogenous or is set equal to total savings using either a classical or a neoclassical savings function.

International trade in the IE and SE models is rather crudely specified. In the former sectoral exports are exogenous and imports are divided into competitive imports, the demand for which is based on fixed coefficients, and noncompetitive imports which are fixed in absolute amount. In the SE model sectors are classified as tradable or nontradable with prices in the latter adjusting to equate supply and demand, whilst for tradable sectors prices are determined by world prices with quantities traded clearing the domestic market. Hence a good of a given type cannot be simultaneously imported and exported. As in the IE model some imports are completely noncompetitive but fortunately they are not fixed in absolute amounts.

One might expect the assumption of perfect substitution to cause extreme specialization in production but by using previously installed capital as an argument in sectoral production functions this tendency is effectively curtailed since installed capital is sector specific implying at least as many factors as goods[9]

The SE model permits three specifications of labour market behaviour.

1. Exogenous full employment with endogenous wage rates, equal across sectors.
2. Exogenous changes in real wage rates whilst preserving a fixed urban-rural wage differential. (This is also the specification in the Dervis IE model).
3. Rural-urban migration (RUM) of the Harris-Todaro type; a function of relative wage rates with a fixed wage rate in the urban sector and a flexible rate in the rural sector which adjusts to clear the rural labour market. If full employment is attained in the urban sector the urban wage rate becomes endogenous.

The significance of the labour market specification when analysing trade strategies with respect to developing countries is adequately demonstrated by de Melo and Dervis in [18]. Their results are too detailed to present here but their general conclusion is that in terms of discounted utility, when labour is mobile across sectors free trade is usually superior to protection since reverse migration back to the agricultural exporting sector generates a net increase in employment. But if such migration is limited as under the Harris-Todaro specification, the protected path will probably dominate since free trade lowers urban employment without the concomitant rise in rural employment.

Concerning the savings assumptions; the neoclassical variant generally reinforces the case for free trade whilst the classical savings function tends to promote protection.

The importance accorded to the labour market and savings specifications in the SE model is matched by the importance in the IE model of the exogenous growth rates in the real wage and in the total stock of capital. These parameters are considered to be the "two major social decision variables" with their values reflecting an "economic, social and historical balance",[10] but which may nonetheless be

[9] See Chapter 3 for a discussion of this problem.

[10] Dervis [24, p84]

consciously changed. The nature of the solution, especially the degree of labour-capital substitution, is very much affected by these variables. In this connection an elementary but most valid point made by de Melo and Dervis in [18, p170] is that the comparison of various trade strategies and policy alternatives will not usually lead to knowledge of the optimal strategy. This point returns us to the difference between (optimization) IE models and SE models.

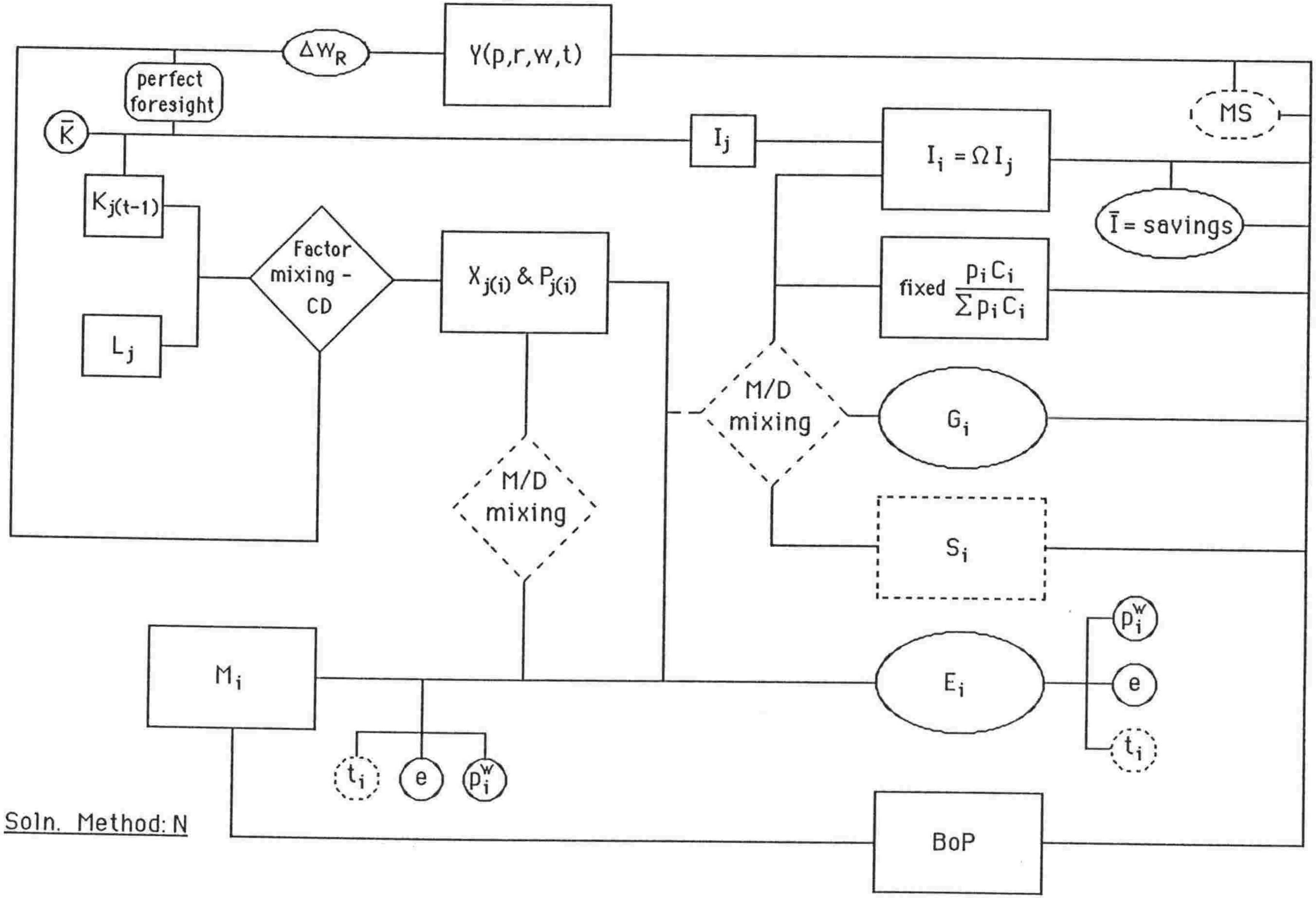
It may well be that the most viable means of reconciling the desire for optimal growth with the necessity to take into account the existing or base year situation (which is usually not on a long run optimal growth path) together with some reasonably stable economic parameters and interdependencies, is via a fairly formal interface between an optimizing IE model and a short to medium term 'forecasting-SE' model. The latter would certainly need rather more emphasis on known short term behavioural relationships than exists in most SE models. Such a combination could well trace out von Neumann turnpike style growth paths.

However, standard SE models such as the one described here by de Melo and Dervis and such as JULIANNE, are essentially a compromise between IE and forecasting models and could thus be an alternative to the type of interface just delineated, particularly if the modelling is done by non-governmental organizations who may nevertheless have some influence in the setting of economic policy in the medium term. Such organizations will usually have neither the expertise to determine long run social goals nor the power to pursue them, so an IE model would be of little use. On the other hand an SE model could be a valuable aid in the analysis of medium term issues such as protection and taxation which may directly affect the organization concerned. The SE model may be used to assess the effects of possible changes in government policy or be used more actively to promote particular policies which can be demonstrated to be socially advantageous as well as of direct benefit to the interested party.

In conclusion then, the comparison of the Dervis and de Melo IE and SE models reinforces the view expressed earlier that the choice of model is as much governed by who is asking the questions as by the nature of the questions. These two models illustrate well the differences between IE and SE type models, highlighting the contrasting specifications of investment in each model type but nonetheless incorporating many mutually similar equations. Both models contain rather weak and archaic assumptions about the treatment of imports but are better in other areas, notably the specification of labour markets. In deference to the authors' modelling dexterity it is generally quite impractical, if not impossible to build super models which 'do everything'. One assumes therefore that Dervis and de Melo designed and tuned their models to suit the particular objectives they had in mind.

Figure 5

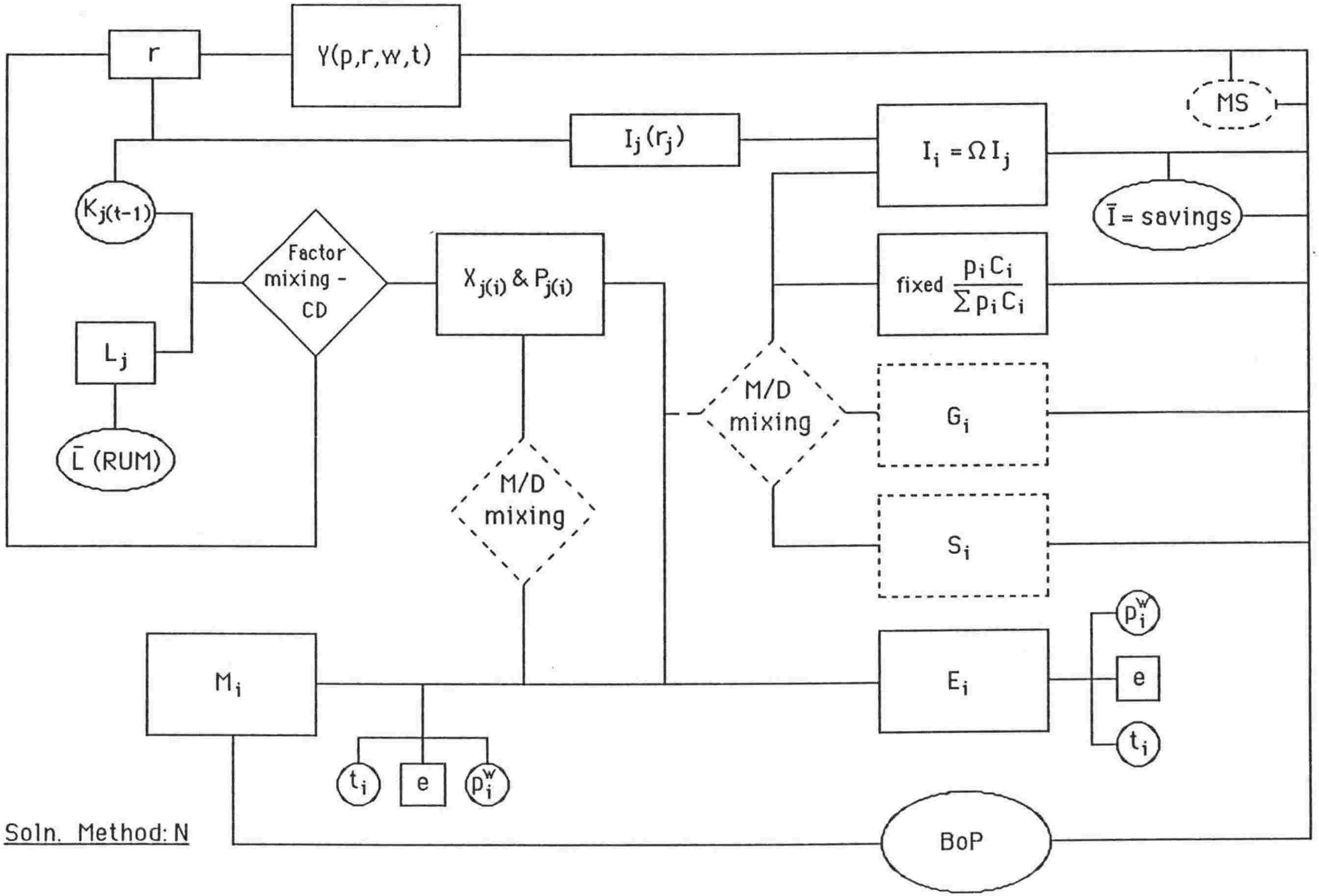
IE Model



Soln. Method: N

Figure 6

SE Model



Soln. Method: N

2.3 Summary

By studying and comparing a collection of some fairly well known CGE models of varying complexity and elaboration we have been able to ascertain the qualities that can be and should be present in a (New Zealand) general equilibrium model which stresses international trade and structural problems. The five models which have been reviewed here provide a good cross-section of recent CGE models, with the latter models representing the current 'state of the art' in dynamic modelling. The ORANI model of the Australian Impact Project is (at the time of writing) probably the largest, most sophisticated and well known snapshot CGE model, especially out of those solved by the Johansen method. It is described in Dixon et al [30] and reviewed by Wallace [97]. An example of very recent advances in snapshot CGE modelling is given by Harris [46] who attempts to deal with non-competitive pricing and economies of scale.

Rapid advances during the last decade in computer technology have freed designers of large economic models from having to use linear programming methods, as Evans used in 1972. (See Evans [35]). The more recent models by de Melo et al utilize nonlinear algorithms which although not generally as inherently mathematically efficient as programming techniques for a given number of sectors, compare much more favourably when one is seeking to include substitution possibilities in production or consumption in a model. Pricing circuits also are usually easier to include in nonlinear algorithm based models than in programming models. Consequently those models which are of the former type allow the modeller more flexibility in the specification of equations and behavioural linkages,[11] so one should expect such models to be better abstractions of reality.

Bearing in mind that the requisite qualities of a model will depend on the issues to which a model is to be addressed as well on the exact type of model in which one is interested; in the first instance whether snapshot, intertemporal equilibrium (IE), or sequential equilibrium (SE) as discussed elsewhere in the text, what are the features for which one should be looking in a 'good' CGE model? The following points emerge from this review.

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[11] We will not debate here the relative merits of nonlinear algorithms versus Johansen type matrix inversion. The reader is referred to Chapter 5 and to Stroombergen [87].

Substitution between domestic and imported products in both intermediate and final demand: Only the dMR model embodies a satisfactory routine for this by treating imported and domestic products of a given type as imperfect substitutes. Without fairly comprehensive routines for capturing import-domestic substitution in relation to relative prices, the applicability of a model to trade and protection issues is severely limited. Certainly a model of the New Zealand economy should be able to handle these issues.

Substitution between factor inputs into production: Most of the models surveyed embody some form of factor mixing function and again the dMR model is probably the best with its two-level CES function. Few models exist which include more sophisticated factor mixing functions such as the translog or CRESH specifications.

The fact that all of the models allow some substitution amongst factors, is indicative of the sort of questions to which CGE models are frequently applied; namely development options. Here the crucial issues are generally to do with labour intensive versus capital intensive growth strategies, or with ascertaining whether enough skilled labour is available to meet specific growth targets. In this connection it is worth noting that the CRESH and translog functions are really only required when many factors of production are distinguished. Their sophistication is superfluous when only one or two types of labour (often rural and urban) and capital constitute a satisfactory degree of disaggregation. In such cases a CES or even a Cobb-Douglas specification is quite adequate. Just how many factor inputs should be identified depends on the nature of the questions being asked.

Investment: The allocation of investment amongst sectors and the way in which new investment is converted into productive capacity is very much a function of model type, more so in fact than is any other component of model structure. It is also one of the most difficult issues to handle, no matter what the model type. In IE models and in optimization models there is generally the added complication of terminal conditions as well.

In medium term snapshot models which yield virtually no information about the time period between the base year and the horizon year, the foremost concern of the modeller should be to ensure that the profile of capital stocks in the horizon year is at least feasible, given the base year mix. And similarly to ensure that the profile of horizon year investment is not inconsistent with the accumulation of each sector's horizon year capital stock.

Satisfaction of these two conditions usually entails setting horizon year sectoral investment equal to the mean rate of capital accumulation between the base year and the horizon year. Including profit considerations and expectations as determinants of investment in a snapshot model entails the risk of failing to fulfil the given conditions. This risk is obviated in Johansen type models since the results are expressed as percentage changes on what would otherwise have been the case and they do not generally relate to a specific snapshot year, so the time span between it and the base year is not fixed.

The other common method of determining investment in snapshot models is via an exogenous stock-flow factor which converts the horizon year demand for increased capital (in a sector) into the amount of that increase which is supplied from horizon year investment. Computationally this method is simpler than the former method of calculating the mean rate of capital accumulation throughout the model period, but the two alternatives are similar theoretically.

In dynamic models the investment routines are far more significant than in snapshot models since the changes in capital stocks between periods generally provide the dominant intertemporal connections. Numerous different routines exist but theoretically they fit into one of two categories, as illustrated by the de Melo - Dervis IE and SE models. In IE models perfect foresight is assumed on the part of investors which implies equal rates of return whereas this is not assumed in SE models (such as JULIANNE). Different rates of return are allowed in the latter and investors respond to these differences as well as to expectations based only on past events, about future profits. In both types of model the routines may be complicated by gestation lags or in the case of SE models only, by a distinction between installed capacity and utilized capacity. The expectations function may also be rather complex but this should not alter the essential IE-SE distinction. The SIMLOG model is rather an oddity in this regard. Its investment routines rule it out of the SE class but the lack of rate of return equalization means it is not really an IE model either, even though the computation of sectoral investment levels is based on IE type methods. This hybrid approach reminds us that no classification of models is ever absolute but it also clouds both the understanding of the model and its realm of applicability.

There are of course other features that one might wish to see in a CGE model. The ones listed above form a nucleus which should exist in all CGE models, especially those which purport to study trade and development issues. Chapter 3 describes some of these other features; those which a trade related New Zealand CGE model should contain. As a concluding thought to this chapter, however, it is suggested that perhaps the greatest attribute of any model is flexibility. If new routines and equations can be easily added and old ones modified or replaced as the topic demands, the power of the model is substantially enhanced. The flexibility of the above models is fairly high but the concept is difficult to define quantitatively. However, through reviewing a collection of representative models a good qualitative understanding has been gained about what a CGE model should be capable of doing without requiring time-consuming alterations to the model's structure or solution technique.

Appendix A

The de Melo - Robinson Export Function

The authors in [19, p9] loosely describe their export supply function as an asymmetric logistic function with asymptotes at the points $y=0$ and $y=1$, and a point of inflexion at the base year export ratio.

The general form of such a function may be given by:

$$y = a[1-(1+e^{b+cx})^{-d}] \qquad \text{(i)}$$

where: a is the upper asymptote => $a=1$ in this case

$c<0$

$d>0$ (If $d=1$ the function is symmetric.)

The point of inflexion is at: $x = [\mathrm{Ln}(d)-b]/c$ (ii)

which has a y value of: $y = a[1-(1+d)^{-d}]$ (iii)

The elasticity of the export-output ratio with respect to relative price, namely $(dy/y)/(dx/x)$, is given by:

$$\epsilon = \frac{dce^{b+cx}x}{[1+e^{b+cx}][(1+e^{b+cx})^{d}-1]} \qquad \text{(iv)}$$

The function in (i) is rather complicated and would require non-linear estimation to be quantified. However, the parameters can be determined if certain prior information is available on:

1. The base year price relativity (x)
2. The base year export ratio (y)
3. The elasticity (ϵ)

Since $a=1$, d is calculated by inserting y and a into equation (iii), c can be expressed as a function of b from equation (ii) since x and now d are known, and b can then be determined from equation (iv).

3

ISSUES IN CGE MODELLING

CHAPTER 3

ISSUES IN CGE MODELLING

3.1 Introduction

This chapter outlines the issues and problems which need to be addressed when designing a general equilibrium model, some of which are fairly specific to New Zealand. It is divided into two sections which identify these as general or trade related, although the latter group is really a subset of the former. The intention is not to offer universal solutions to the various issues raised. However, particular (JULIANNE model) solutions will sometimes be suggested with the details being left to subsequent chapters, especially Chapter 6.

3.2 General Issues

Macroeconomic Closure

Superficially the closure of a model defines the set of information, translated into values of the exogenous variables, required to obtain a solution. More subtly, closure involves considerations about the time span of the model (that is whether short term or long term), the importance of financial and money markets, and the links between the microeconomy and the macroeconomy. Thus the way in which a model is closed is intimately connected with the choice of equations.

The input-output coefficients, factor demand equations, relative prices and the composition of the components of final demand, form the microeconomic base of a CGE model. Their mutual closure is virtually automatic. Closure at the macroeconomic level, however, presents more options. For most CGE models one can identify four areas that require rules of closure, three of which arise from the absence of a money and finance dimension.[1]

It is a fundamental proposition of the JULIANNE model and many other CGE models that the impacts of financial markets and monetary policy are transient phenomena which therefore have no place in a medium term model. Indeed even in the Reserve Bank's econometric forecasting model money is rather passive. Spencer [83, p336] writes:

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[1] A good discussion of the effects of different macroeconomic closure rules is presented in Taylor et al [93].

> "Thus it is clear that in the 'long run' money is essentially a neutral force in the RBNZ model", but that: "...a monetary impulse can continue to have a significant effect on the real sector for several years."

Should the medium-long term influence of money ever not be neutral (at least as a first approximation), whether by assumption or from empirical observation, it follows both logically and necessarily that in a CGE model, real variables would need to be exogenously adjusted. In particular it is generally true that the overall level of prices and the money supply are not endogenous. Consequently one element of macroeconomic closure involves the assignment of a price level by stipulating the value of a numeraire variable such as the exchange rate or the GDP price index.

Another aspect of macroeconomic closure concerns the external balance of trade. In a model which does not endogenously calculate foreign capital inflows (which is another variable in the money and finance dimension), a balance of trade constraint must be included to render the system determinate, although an alternative is to fix domestic absorption as is frequently done in the ORANI model. (See Dixon et al [30].)

Some form of constraint is also required to determine total investment, unless savings behaviour is comprehensively modelled which again entails a monetary sector including a complete portfolio subsector and equations which link the demand for investment funds to the various sources of supply. The usual choice of closure rules consists of either setting total investment exogenously, thereby imparting a Keynesian flavour to the model and implicitly relying on Robinson's "animal spirits"; assuming classical savings behaviour where investment is equated to profit income; or assuming neoclassical behaviour which links investment to savings as a proportion of total income.

The fourth element of macroeconomic closure stems not from the lack of a monetary sector but from the absence of what may loosely be described as institutional factors, that determine the extent to which wage setting procedures channel possible employment increases into real wage increases. In association with this there is also the extent to which wage rates respond to price increases. The choice here is usually between exogenously stipulating (real) wage rates with total employment endogenous, or vice versa; fixing total employment with wage rates endogenous.

The above closure rules may convey the impression that too many important variables are exogenous and therefore at the capricious discretion of the modeller. However, intelligent choices are not limitless and in many cases it is possible to set the values of exogenous variables using information from other studies, notably macro (forecasting) models. An informal interface of this sort between the JULIANNE model and a simple macroeconomic projection model forms the basis of most applications of JULIANNE. (The procedure is described in Chapter 7). There is also some benefit in being able to control the model's macro environment. It may aid the interpretation of model results, particularly in assessing the impact of the macro environment on micro activity and, if one believes that governments have policy instruments which can neutralise undesirable macro effects caused by microeconomic changes (such as relative price shifts), it is obviously advantageous to be able to model such reactions.

Whether it is better to develop CGE models in the true Walrasian spirit and link them (formally or informally) to conventional macroeconomic and macroeconometric analyses, rather than extend the CGE model to incorporate a complete money and finance dimension, is a question which is rather beyond the scope of this thesis. Indeed the applied use of CGE models to date has not suggested an answer.

The Pricing Equation

Debate still exists within the economics profession about the form of the pricing equation, with the debate being essentially polarised into those who believe in neoclassical zero pure profits pricing and those who countenance (Keynesian) cost-plus markup pricing. Except for a few polemics however, most participants would agree that the form of the pricing equation is sector specific and also depends on the time span under consideration. The greater the market forces of supply and demand and the longer the time horizon involved, the greater is the chance that neoclassical pricing will prevail. Accordingly in traded sectors such as agriculture markup pricing is rare whereas in the more protected manufacturing industries it is quite common.

A preliminary (unpublished) investigation of cost-plus pricing by the author in 1979 confirms this contention. It showed that with the economy grouped into 13 sectors, a fixed percentage markup hypothesis explained price movements well for only one sector; Construction, very much a nontraded sector. A fair degree of explanation was obtained for the Primary Products Processing, Manufacturing and Trade sectors, whilst for the remaining 9 sectors[2] the hypothesis performed poorly or very poorly. The study covered the years 1959/60 to 1975/76 using as benchmarks the four input-output tables given in Choo [14]. For all sectors a better fit was obtained if variable markups were allowed, particularly in the inflationary latter years when most markups appeared to fall.

However, if over time, markups are more flexible than in the short run, as monopolistic and protected industries are forced to submit to (some) market pressure or as capital earns its marginal product, the distinction between neoclassical pricing and cost-plus pricing becomes less pronounced. That is, pricing behaviour which is describable by a variable markup equation could probably also be explained by a neoclassical pricing equation.

For modelling purposes the question is really; which hypothesis provides the better approximation to observed pricing behaviour over time? In the case of medium term CGE models such as JULIANNE the neoclassical hypothesis is in general likely to be better although certain sectors such as Housing may require an alternative specification.

As a concluding thought on pricing behaviour consider: If the incidence of administered pricing varies directly with the degree of border protection, there is a strong argument in favour of altering the form of a model's pricing equations when protection is reduced, if administered pricing is originally fairly widespread. This could be expected to increase the benefits from free trade beyond the direct (or pure) welfare gains,[3] frequently estimated at less than 2% and even less than 0.5%. See for example Boadway & Treddinick [8], de Melo [17] and Dixon [29, pp.68 & 71]. Grubel & Lloyd [43, p124] discuss the effects of free trade on price setting and Staelin [84] examines the effects of tariff changes under various types of administered pricing.

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[2] Agriculture, Mining, Forestry, Forestry Products Processing, Energy & Utilities, Transport, Private Services, Government Services, and Housing.

[3] That is excluding gains due to improvements in 'X-efficiency' etc. - See Chapter 8 for further elaboration.

Staelin obtains different results from different non-competitive pricing assumptions and thence concludes that competitive pricing structures would also yield different results. However, his model cannot be used to directly compare competitive pricing with noncompetitive pricing since if the former is implemented the model becomes indeterminate. If one then introduces say, sector specific capital the model versions would no longer be comparable. Hence one either needs to incorporate sector specific capital in the original noncompetitive model versions or abolish the assumption of perfect substitutability between imported and domestic products. Indeed this assumption may be more crucial to the model's results than the pricing assumption, a subject which will be pursued in the section on trade issues.

Non-constant Returns

Under the heading of non-constant returns are included economies of scale, decreasing returns to scale and decreasing returns to all but one factor of production where that factor is in fixed supply. All are phenomena which prevail in the real world but are often ignored in CGE models, as exemplified by those surveyed in Chapter 2. In the New Zealand context the assumption of constant returns to scale is probably quite reasonable for most sectors given the degree of disaggregation with which one is dealing. Recent studies by Evans & Low [36] and Wallace [98] have, however, indicated that non-constant returns to scale probably exist within the agricultural sector. Associated with this is the possibility of decreasing returns to factors when one factor, notably land or management, is in (approximate) fixed supply. Again see Wallace [98]. If non-constant returns are widespread and significant (and there is still much scope for the empirical testing of this), it is important that they be adequately modelled. In particular the response of agricultural exports to changes in either world selling prices or input prices could be seriously overstated. Conversely if increasing returns exist in manufacturing industries, possibly as a result of intra-industry specialization, the gains from the removal of protection could be seriously understated. See for example Dixon [29].

There are numerous ways of modelling non-constant returns such as via the technological change parameter in the sectoral production functions or by respecifying the production functions to include inputs measured in effective units. The first option is probably best suited to capturing the changes in returns to scale which might occur over time - that is between the base year and the horizon year, whilst the second is more appropriate to modelling decreasing returns (to a fixed factor) in a given year, namely the horizon year. These possibilities are examined in Chapter 6.

Investment

In the previous chapter numerous methods of handling investment were observed and it became evident that the specification of investment is of paramount importance in all CGE models, especially dynamic ones. In deciding on an appropriate investment specification the following interdependent matters should be considered.

1. Steady state growth
2. Terminal conditions
3. Expectations
4. Intertemporal consistency
5. The allocation of investment
6. The total level of investment (already discussed under macroeconomic closure)
7. Capital mobility
8. Depreciation and capital vintages

The first question one must answer is: Does one desire a CGE model which is concerned with what should happen (in an optimal sense) or with what would happen in the medium term future, given certain events or policies and assuming other variables unchanged? Note that the latter option is certainly not equivalent to the definition of a forecasting model, which relates to a much shorter time span and does not usually involve ceterus paribus assumptions.

If a model is a snapshot version of the 'what would happen' type, questions of steady state growth are not directly addressed but are nonetheless not irrelevant, as will become evident below. In a dynamic version of this model type, whilst steady growth is not forced into the solution path, such growth may still be generated if the model's equations portray intertemporally consistent and efficient behaviour, and if the model is not subjected to continual exogenous shocks. By contrast, steady growth should be automatic in optimization and intertemporal equilibrium (IE) models. However, as elaborated in the previous chapter, such models require terminal conditions to force investment in the horizon year so as to provide for post-horizon consumption. Because a model cannot cover an infinite period of time over which all investment could be seen to eventually yield consumption, the model's time period must be truncated. In so doing, however, the agents represented in the model cannot perceive the benefits of investing in the horizon year (or earlier depending on the lags involved) since nothing is then known about future consumption. Hence the need for a formula to induce horizon year investment. Unfortunately such a formula may bias results,[4] a problem which some modellers deal with by running the model for more periods than is required and then ignoring the surplus periods' solutions, the justification being that most of the bias would occur around the terminal year.

Underlying these sorts of models is the assumption of perfect foresight since steady growth can only occur if everybody's expectations are both stable and fully realised. Once this assumption is abandoned it is legitimate to specify investment as a function solely of past events (as in the PROLOG model), thereby eschewing the terminal conditions problem.

In snapshot models the inclusion of such lagged behaviour is not possible, unless it relates to the base year. However, precisely because the interregnum periods are not modelled, it is essential to ensure that the allocation and level of investment in the horizon year is consistent with the implicit path of capital accumulation implied by the level and distribution of the horizon year capital stock, and with the maintenance of that path in the immediate post-horizon years. If this is not done the model may yield results that in reality have no chance of eventuating, and/or which undermine post-horizon year activity. The consistency requirement generally entails the implicit assumption of steady growth between the base year and the horizon year. Thus even though a snapshot 'what would happen if' type model is not an optimization model, some aspects of the latter cannot be avoided.

Lest one should gain the impression that horizon year capital stocks are completely endogenous in snapshot models, it is worth pointing out that limitations on capital mobility should prevent a sector's capital

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[4] The extent of such bias is investigated in Chapter 6.

from decumulating faster than its rate of depreciation. This does not proscribe, however, the existence of substantial differences in the sectoral allocation of horizon year capital stocks between alternative scenarios of a given target year. As long as the decumulation rule is obeyed such differences do not imply shiftable capital since the only capital which is immutably installed in each and every target year scenario is the base year level of capital, less that which has depreciated. This point is perhaps rather elementary but from one's experience with the presentation of snapshot models, incorrect inferences are common about what model results imply as regards capital movements.

One speaks of depreciation as if it is precisely measurable and quantifiable by a simple coefficient, namely the depreciation ratio. But there are difficulties with depreciation that are both theoretical and operational. Since worn-out capital is usually replaced with new capital which is also better (due perhaps to embedded technological change), such as when an automobile is replaced, the true increment to the stock of capital cannot be unambiguously ascertained. Thus the distinction between net and gross investment is often far from precise. Unfortunately in models which purport to study capital accumulation or which link output to capital input, such a distinction is essential and so depreciation must be quantified. But even if the theoretical difficulty is overcome, a simple rate of depreciation coefficient is a crude measure of the rate of decay of a whole conglomerate of items of capital of varying vintages, with depreciation rates that are age specific.

One could of course incorporate capital vintages into a dynamic model but in a snapshot model this would be rather sophistic. In either case the procedure is cumbersome and it is highly doubtful whether New Zealand capital data would be comprehensive enough to support such a move. Probably a compromise is possible which would be to define the rate of depreciation as a function of past rates of technological change, or of the rate of output growth, the assumption regarding the latter being that firms may scrap plant and equipment at different rates between downturns and upturns.

Major Projects

Virtually absent in the literature on CGE models is any discussion of the effects that large industrial or agricultural projects such as petrochemical plants and hydro-electric power stations, can have on the economy. Such projects have not usually been included in CGE models. One can think of three possible reasons for this.

1. Such projects have not existed in countries where CGE models have been developed or applied. In fact many models have only been applied to hypothetical economies.
2. In large economies their effects may not be particularly significant, and thus not worthy of special treatment.
3. Modelling them may be difficult in terms of data availability or may be 'uncomfortable' since it implies a break with the marginalist principles of many CGE models. A further difficulty may arise when the model is of the Johansen type if the major projects cause significant differences, in terms of model coefficients, between the documented base year and the undocumented ceterus paribus base to which J-type model results apply.

The New Zealand economy is judged to be small in this regard, as the major energy based developments have had and will continue to have significant and discrete (as opposed to marginal) effects on the entire economy. Their effects are felt firstly, chronologically speaking, on the demand for investment goods and subsequently as they begin yielding output, on exports and import substitution. For example the import substitution effects of the synthetic petrol plant and the Marsden Point refinery expansion cannot be endogenously modelled by standard equations based on elasticities and price differences. Model coefficients must be exogenously adjusted if one wishes to obtain reasonable projections of some future year. Admittedly it could be argued that model coefficients should be left unaltered to indicate which sectors exhibit the greatest potential for expansion under various future scenarios. Certainly this approach has considerable merit as it is one of the principal strengths of CGE models to do just that sort of comparative analysis. However, if a certain project is declared a 'fait accompli' it is usually best to treat it as such.

In this regard one sounds a warning which will be repeated elsewhere, that the power of the JULIANNE snapshot model is less in modelling the differences between the base year and some horizon year than in modelling the differences between alternative horizon year scenarios. That is, contemporaneous comparisons are more reliable than intertemporal comparisons. Whilst this means that the inclusion of major projects is not always an absolute necessity - for example the effects of removing agricultural export subsidies are probably largely independent of whether or not an aluminium smelter exists; it is naturally expedient to secure as good a control scenario as is practical. One could never be quite sure about the degree of influence major projects might have on even contemporaneous alternatives. The presence of an aluminium smelter would naturally affect the predicted outcome of a reduction in import barriers against foreign supplies of aluminium.

An example of the inclusion of major projects in the JULIANNE model is given in Chapter 7.

Labour Disaggregation

Few CGE models currently in existence distinguish more than one or two (usually rural and urban) categories of labour and thus there is little scope for studying substitution amongst different labour types. When the rural/urban distinction is included, rural/urban migration of the Harris-Todaro kind is frequently allowed, such as in the Dervis-de Melo 'sequential equilibrium' model reviewed in the last chapter. Since many general equilibrium models have been constructed for application to less developed countries, the prevalence in (these) models of this degree of labour disaggregation and this form of substitution is understandable.

In the developed countries interest is likely to be focussed more on the substitution possibilities between and within various blue collar and white collar occupations, and on the potential growth of each occupation under alternative policy options. With respect to New Zealand a question of obvious interest is which occupations will gain and lose from the dismantling of protection and the consolidation of new trading links. To obtain some answers to this sort of question entails distinguishing rather more labour types and permitting different degrees of substitution between them. Cobb-Douglas and CES production functions will thus not suffice, so one must turn to more sophisticated specifications such as the translog or CRESH functions.[5]

The possibility would also exist to model the effects of alternative assumptions about occupational wage rate relativities and to examine the implications of shortages of particular labour types. A recent study by Grimes [42] suggests that New Zealand occupational wage relativities have been fairly rigid (over the period 1960-1980) and that this rigidity may have contributed to the imbalances of some labour types. Hence fixed wage rate relativities could be a major obstacle to the success of policies aimed at freer trade (such as CER) if changes in trading patterns alter the occupational profile of labour demand.[6]

Depending then on what one believes, or can ascertain, about the flexibility of the supply of various labour types and about the rigidities of wage rate relativities over the medium term, there may be a case for the incorporation into a CGE model of disaggregated labour types and a production specification which can do this justice. In many cases it may, however, suffice to exogenise sectoral wage rate relativities as a proxy for variations in the occupational structure between sectors, given basically fixed occupational wage rate relativities.

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[5] Transcendental logarithmic and Constant Ratio Elasticities of Substitution, Homothetic.

A function is transcendental if it is not a solution to a polynomial with integer coefficients. The translog function in particular is a second order approximation to any arbitrary (polynomial) production function.

A function f(x) is homothetic if it can be expressed as a monotonic transformation of a linearly homogenous function: $f(x)=g(h(x))$. For example a homothetic production function could exhibit increasing returns to scale but its expansion path would still be linear.

[6] For an example of this kind of analysis with a CRESH production structure see Higgs et al [50].

3.3 Trade Related Issues

Indeterminacy

For thirty years since Samuelson's 1953 article "Prices of Factors and Goods in General Equilibrium" [78], there has been debate about the indeterminacy in the composition of output in a general equilibrium system when production functions are homogeneous of degree one. The various aspects of this issue have been well documented in economic literature, with notable writers on the subject including Melvin [59] and Travis [95] whose articles will be alluded to below. One's purpose here is not to indulge in elaborate and redundant repetition of the arguments but to provide a broad overview of the problem in order to be able to comprehend its essential relevance to CGE models. It will become apparent that without solving the indeterminacy problem one does not have a model.

In his leading article on the subject Samuelson states that:

> Under "a constant returns to scale or homogenous production function of the first order.....the composition of industry output among firms becomes indeterminate and of no importance."

It is also assumed [78, p3] that factors are perfectly mobile between industries.

We can see this firstly for the case where the number of goods (n) exceeds the number of factors (r). Let n=3, r=2. (This diagrammatic representation is from Melvin [59, pp1250-1253]).

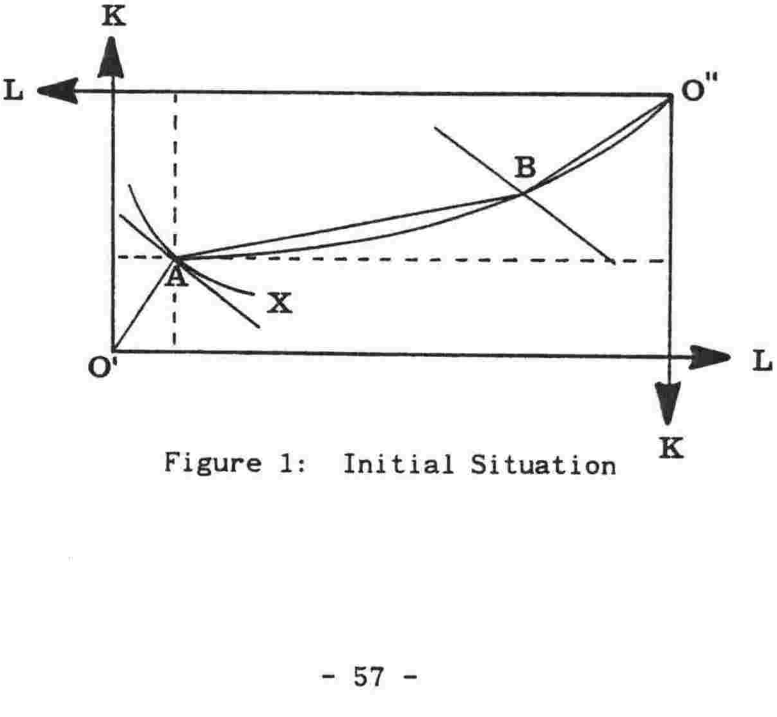

Figure 1: Initial Situation

With reference to figure 1: Output of good 1 is at the point A on the isoquant X. Consider A as the origin for the production of good 2 and 0" as the origin for good 3. Let AB0" be the efficiency locus. The slope of the isoquant at A is equal to w/r. For goods 2 and 3 to be produced there must exist a point B such that w/r at B equals w/r at A. Note that B will be unique as w/r is monotonic increasing and continous along the efficiency locus from A to 0".

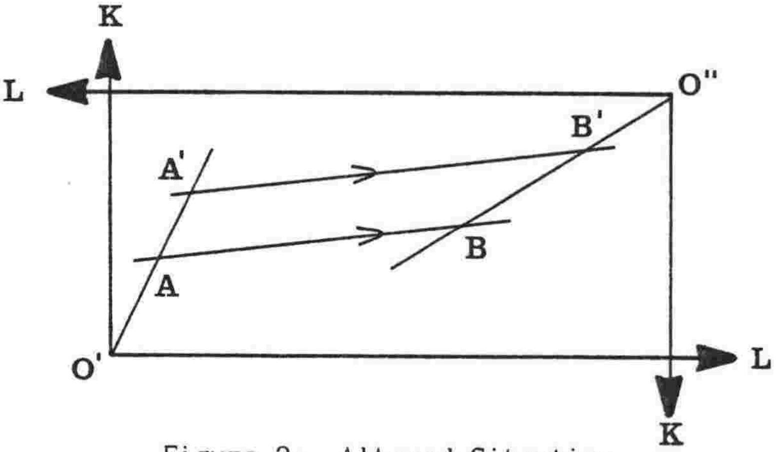

Figure 2: Altered Situation

In figure 2 suppose that the output of good 1 rises to A′. Naturally w/r at A′ equals w/r at A. If a point B′ exists it will lie on the ray 0"B and furthermore AB must therefore be parallel to A′B′. Assuming that the output composition given by A and B is on the production possibility surface, then A′ and B′ must also be on that surface. Output price ratios will not change as the marginal conditions have not changed. Hence there are an infinite number of output configurations consistent with the same set of factor (and product) price ratios.

Samuelson (p6) goes on to say that if more than r commodity prices are arbitrarily given some industries will shut down as a result of complete specialization. If commodity prices are determined by international trade then it is likely that something of at least r goods will be produced and if factor prices are equivalent in the trading countries then something of every good can be produced; the scale of production depending (obviously) on factor endowments. However, the indeterminacy of the pattern of production will not disappear as long as there are zero transport costs since there will be a considerable "zone of indifference" as to how the production of different goods is distributed between the countries.

In the case where n=r, the uniqueness of a solution cannot be guaranteed without examining the quality of the equations. Samuelson's "overly strong sufficiency conditions" ([78, pp9-10]) state that a unique equilibrium will exist if one can recognise a situation where good X_1 is in some sense relatively Y_1 intensive, X_2 is relatively Y_2 intensive and so on. One says "in some sense" because the conditions are actually stated mathematically and are not open to ready verbal interpretation for n,r>2.

In the case of n<r factor prices will not usually be equalised. To use Samuelson's [78, p8] example:

> "If more capital in America made both labour and land twice as productive in the food and clothing industries as in the corresponding industries in Europe, the same food-clothing price ratio would prevail in the two regions but with a lower American interest rate and a higher wage and rent level."

The system will generally be determinate with given international goods prices by requiring full employment of factors. Nevertheless singular cases of indeterminacy may still arise if inelastic factor supplies co-exist with inelastic demands and fixed input-output coefficients.

Another implicit assumption in the above and in Samuelson's article is that all goods are traded. If this is not the case the indeterminacy will generally disappear. With reference to figure 2, the point A say would then be determined since each country would produce exactly what it required. Hence the output of the other two goods is also established. The difficulty arises in deciding what are nontradable goods since a good that is currently nontraded "does not imply that it is inherently nontradable."[7]

The relevance of the above arguments to higher dimensions is perspicuously reinforced by Travis [95]. However, one is forced to contemplate on the relevance of the arguments to observed economic reality. Both Melvin and Travis take care to point out the implications of the indeterminacy problem for the theory of international trade and protection. At one stage Travis concludes:[8]

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[7] Melvin [59, p1267]

[8] Travis [95, pp. 96 & 98]

> "It can be seen.....that the exact output of any product is indeterminate under normally observed conditions".

However, only two pages further on he states:

> "Either the assumption of a factor specific to each product or the assumption of decreasing returns to scale would be required to rule it (indeterminacy) out."

Add to this the assumptions of a sharp distinction between traded and nontraded goods, of zero transport costs and of factor price equalization; and the virtual irrelevance of the indeterminacy problem to many real world situations is evident. Indeed we should note Samuelson's conclusion to his original article:[9]

> "I need scarcely add the caution that the above description is of a very idealised, statical, competitive situation, where monetary considerations scarcely raise their ugly heads."

Of course many CGE models represent idealised, statical, competitive situations; embodying the above assumptions to some degree. Models solved by linear programming are well known examples where the indeterminacy is revealed by the existence of non-unique optima and the 'flip-flop' tendency. More complicated models must of course be made uniquely determinate to get any solution at all, so one or more of the above assumptions is discarded. But the choice should not be arbitrary since the effect on model behaviour can not be expected to be neutral. That is, a model which is characterised by decreasing returns and perfect substitution between foreign and domestic goods would almost certainly yield different answers to one characterised by constant returns and imperfect foreign-domestic substitution. The choice of how a model is rendered determinate should be made on empirical grounds - and there is plenty of evidence to refute the offending assumptions.

Import Substitution

Traditionally imports have been divided into those which compete with domestically produce goods and those for which there is no domestic equivalent. Accordingly the elasticity of substitution between imported and domestic goods is either zero or infinity.

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[9] Samuelson [78, p14]

New Zealand trade statistics identify over 5000 commodities and at this level of disaggregation the assumption of elasticities of zero or infinity are frequently not unrealistic. For example the commodity 'matches' is a very precisely defined category and obviously highly substitutable with the local product. The substitution elasticity is probably as close to infinity as is ever likely to be empirically observed. (The fact that there are any imports at all of this commodity is probably attributable to perceived differences in quality.) Conversly a Boeing 747 or particular chemical compounds can be classified as completely non-competitive.

However, CGE models contain nothing like this degree of disaggregation. Typically the number of import categories is between ten and fifty. Thus each category is not only far from homogeneous in composition, it is also likely to be different in composition from its corresponding domestic sector category. That is, although an import category and a domestic category may be identically defined, the actual products 'made' in each case will be different. For example imports of Wood Products may be mostly teak furniture whilst the output of the domestic Wood Products sector may be concentrated in sawn timber.

When both an import category and its corresponding domestic sector category are known to embody numerous different commodities, it becomes apparent that substitution elasticities of zero or infinity between between foreign and domestic sources of supply, will be very rare. It is essential therefore that imperfect substitutability be permitted in CGE models where the composition of sectors and import categories is heterogeneous. Certainly this is generally true for 30 or 40 sectors and import types. Failure to model imperfect substitution could yield absurd results where for example, entire sectors close down in response to fractionally cheaper imports. Absurd, because the price difference applies to the mean price of goods from each source. Individual commodities within the general sectoral/import classification are unlikely to have identical price differences, even assuming price comparisons can be made, since in some cases there may only be one source of supply. Then no price comparison is possible.

The removal of tariffs on say imported radios may be sufficient to reduce the mean price of imported electronic equipment to below that of domestic electronic equipment but this is hardly likely to cause the closure of the entire electronics sector. Even if all protection on the sector was removed it would still not close completely as long as some of its products never had any protection or embodied certain characteristics (real or imagined) which rendered them superior, or simply different in some sense from the foreign competition. Of course the significance of this superiority diminishes with the extent of the price difference, such that if the latter were large enough the demand for the domestic good would fall to zero and the domestic industry would cease operation. Substitution elasticities between zero and infinity are needed to properly capture such reactions.

Import Protection

The same aggregation problem which dictates that substitution elasticities are not restricted to values of zero or infinity, is also present in modelling import protection. In New Zealand the incidence of import licences and tariffs increases markedly over the range of goods; investment - intermediate - consumption. For example cosmetics incur high tariffs whilst superphosphate fertiliser is duty free. Both goods are part of the Chemical Products category and thus one can ascertain the mean tariff on chemical imports. However, knowledge of this tariff is of very limited use since under a policy of tariff removal the model would show the price of chemical imports to consumers (namely cosmetics) falling by the same amount as the price of chemical imports to the farming sector (namely fertilser). In fact of course the former would fall by more and the latter not at all.

Theoretically each buyer of a product faces the same tariff rate, but when a product is no longer defined as a distinct homogeneous commodity buyers may face different rates on that broad product grouping. Hence the tariff needs to be distinguished both by product type (with the product groups classified identically to the domestic sectoral groups) and by destination, as a proxy for a finer import group classification. This can be accomplished by compiling a whole tariff matrix, rather than a vector, which associates a particular tariff rate with each import flow, in each cell. Whilst the imports in each cell are not completely homogeneous and thus probably not subject to the same tariff, at least the much more important differences between intermediate, investment and consumer imports and the various degrees of duty thereon, would be adequately taken care of.

Such a matrix of tariffs actually needs to be converted to a matrix of tariff equivalents, where the tariff equivalents reflect the cost difference between foreign and domestic goods caused by both tariffs and import licences. In New Zealand the latter are usually of greater significance.

One is aware that tariff equivalents are difficult to evaluate and that the concept has deficiencies that would not arise if import quotas were modelled directly. Whilst the latter should be computationally feasible in a CGE model, the problem again is heterogeneity, this time of the licences. These are generally so specific that that even cell by cell quotas would not provide a fine enough level of disaggregation. Naturally the intrinsic degree of heterogeneity does not disappear with the conversion of the licences into tariff equivalents, but at least the latter can be added or averaged with some degree of meaning whereas for two goods in the same general import category, one of which is licensed and one of which is not, it is not possible to calculate an average licence.

Exports

Having devoted numerous pages to discussing the modelling of imports and import substitution, one could be forgiven for thinking that the modelling of exports presents no problems. However, the general lack of any detailed discussion of exports in most CGE models as exemplified by those reviewed in Chapter 2, (the dMR model excepted), indicates that the modelling of exports is not a straightforward affair. The two main difficulties in modelling exports are:

1. The aggregation problem - as with imports.
2. The fact that the demand for exports is largely determined by events external to the economy being modelled.

The aggregation problem surfaces mainly on the supply side where exports from a given sector may not be composed of the same bundle of goods as output from that sector which is destined for the domestic market. For example exports of energy may be mostly coal whilst domestic consumption of energy might be concentrated in electricity. Thus rapid changes in the composition of energy output in response to changes in relative price are not possible. In fact one cannot readily export electricity unless it is sold to foreign companies operating in New Zealand and paying in foreign currency.

On the demand side the same sort of situation occurs where, on the world market, exports of a New Zealand commodity may not be a perfect substitute for exports with the same general classification from another country. A commodity such as butter undoubtedly has a high elasticity of substitution with butter from other countries, whereas the elasticity for 'exports' of foreign tourism is probably much lower.

Even these sorts of comparison entail the implicit assumption that all competing exports from other countries can be lumped together in a single bundle with a specific mean price. But without developing a world model or something close to it, one has no choice. Indeed, such an assumption is central to the identification of world demand curves for a single country's (New Zealand's) exports. The corresponding demand function should include not only a relative price term but also a variable which represents movements of the curve arising out of changes in world real income, the removal of trade barriers against our exports, the development of new markets as a result of the promotional efforts of exporters and so on.

Overall then, five parameters are relevant to the modelling of exports.

1. The world price elasticity of demand.
2. The elasticity of substitution between domestic and other exports on the world market.
3. The domestic share of the world market, which in combination with items (1) and (2) will yield the elasticity of demand for N.Z. exports.
4. A curve shift parameter, to reflect world income elasticities, new markets etc.
5. The domestic supply elasticity.

This collection represents a staggering informational requirement, especially when one recalls that each parameter value is likely to be commodity specific. The commodity mix of New Zealand exports covers the whole range of parameter values, from products such as butter with low income and price elasticities of demand and supply, and a significant share of the world market, to manufacturing goods with higher elasticities and small world market shares. Consequently, in all practicality some retreat from the above ideal may be unavoidable, provided however, that this would not result in the model showing rapid, biologically impossible increases in agricultural and foresty exports over short periods of time. The danger of this should be small as long as the horizon year of the model is maintained at least five years out, although even then one would need to check model projections of forestry output.

The Marshall-Lerner Conditions

In applications of a model to trade policy one must be confident that its results do not contradict (well) established economic theory However, in many circumstances a theory is not sufficient to supply definitive answers to particular problems. A devaluation for example, may alleviate a balance of payments deficit or it may not. Quantification of theory is required. An economic model fulfils this need but one must acsertain whether it is the quantification of some accepted theory or whether the model contains an embedded, possibly faulty theory of its own which, because of the interaction amongst the many equations and parameters may be difficult to educe. This is not to say that a model must conform to a set theory or a particular paradigm. An advantage of using economic models is their amenability to an eclectic approach, provided that the underlying theoretical structure is decipherable and 'acceptable'.

The elaborate import substitution routines and export equations that have been described above, require a multitude of commodity specific paramater values. So care must be taken to ensure that these values do not interact in such a way as to yield ostensibly plausible but misleading or even incorrect results. Of use in this regard are the well known Marshall-Lerner conditions which provide a framework within which the economy-wide averages of all the sectoral trade related elasticities can be combined into one equation. This can then be used to help predict whether a change in the exchange rate will worsen or improve the balance of trade thereby assessing the model's (trade) parameter values and equation structure against accepted theory.

Naturally the M-L conditions do not provide an exhaustive test of the sensibility of the model's parameter values. This must be augmented by other procedures as demonstrated in Chapter 7. Nor do they provide an exhaustive prediction of the effects of an exchange rate change since factors apart from the magnitudes of the trade elasticities also have an effect. In the model such factors may include a shift in the distribution of income following the change, an income effect, supply conditions, and the time period under consideration. (In the real world one must also consider the effects of speculation leading up to the exchange rate change and a money demand effect.)[10] However, it is generally not too difficult to make allowances for these effects a priori, something which cannot easily be done with respect to the interaction of the model's disaggregated trade elasticities.

For completeness and without showing its derivation, which can be found in Vanek [96] or Cooper [15], the (extended) Marshall-Lerner equation is:

$$dB = \frac{dr[X\epsilon_x(1+\eta_x) - M\eta_m(1-\epsilon_m)]}{[(\epsilon_x+\eta_x) - (\eta_m+\epsilon_m)]}$$

where: X M B are exports, imports and the trade balance in local prices

dr is the change in the exchange rate

ϵ_x and ϵ_m are the price elasticities of demand

η_x and η_m are the price elasticities of supply

More simply, when the supply elasticities equal infinity:

$$dB = dr[X\epsilon_x - M(1-\epsilon_m)]$$

which is the simple M-L equation.

Hence for X=M and dr>0, dB>0 as $|\epsilon_x|+|\epsilon_m|>1$.

How the JULIANNE model conforms with the M-L conditions is explored at the end of Chapter 8.

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[10] Further elaboration of the income effect is given in Vanek [96, pp. 127-129]; the income distribution effect is well exemplified by the 1959 Argentinian devaluation as analysed in Diaz-Alejandro [27]; Johnson [54] covers the monetary effects and the effects of supply constraints; and an excellent non-mathematical discussion of the M-L conditions is given in Robinson [76].

4

THE 'JULIANNE' SNAPSHOT MODEL

CHAPTER 4

THE 'JULIANNE' SHAPSHOT MODEL

4.1 Introduction

This chapter presents the JULIANNE model. A general outline is first given followed by the full set of equations. A brief description of the solution procedure is also provided since this is as much a part of the model as its equations, but the details are left until Chapter 5.

4.2 General Outline

The equation structure of the model is set out in the form of numerous equation blocks; with one equation for each sector, commodity, factor etc.

Production Functions

Three alternative specifications are available:

(1) Cobb-Douglas with one labour input and one capital input,
(2) Reduced from CES with one of each input type,
(3) Constant Ratio of Elasticity of Substitution, Homothetic (CRESH) with ten labour types and one capital type.

Capital and Labour Demand

The production functions together with profit maximization / cost minimization conditions lead to factor demand as a function of relative factor prices. Under constant returns the level of output is irrelevant.

Intermediate Demand

A composite commodity is defined which is made up of a domestic and an imported component. The share of each of these components is determined by the elasticity of substitution between them and by relative prices. No substitution involving non-competitive imports is permitted.

Substitution with unitary elasticity between composite inputs is sometimes allowed but generally zero substitutability is assumed.

Price Determination

The price of sectoral output is determined by the cost of factor inputs, domestic and imported intermediate inputs, and tax payments. World import prices are exogenous but New Zealand export prices are determined by the cost of manufacture although it is also possible to set them exogenously, usually via endogenous subsidy rates.

Consumption Expenditure

This is divided into government consumption and private consumption. For the latter, eight Household Expenditure Survey commodity categories are identified and spending on these is modelled with a linear expenditure system. A sector by commodity conversion matrix translates the demand for commodities into sectoral output requirements and also allows import-domestic substitution.

Government consumption is usually either a fixed proportion of GDP or is set exogenously.

Stocks

The ratio of stock change to GDP is assumed constant although variation is permitted in the import-domestic composition of stocks.

Investment

Sectoral investment is related to the rate of capital accumulation over the model's planning period as revealed by sectoral demand for capital in the horizon year. Allowance is made for depreciation, and rental rates also have an indirect effect on capital formation. Investment by sector of demand (or destination) is converted into investment by sector of origin using a capital input-output table. Again import-domestic substitution is possible between sources of supply.

Exports

These are determined from overseas export demand functions in relation to world prices and domestic prices inclusive of export subsidies, adjusted by the exchange rate. It is also possible to set export quantities exogenously.

Supply-Demand Identities

Supply-demand balances are required to clear all product markets. Domestic output must equate to the demand stemming from consumption, investment, stocks, exports and intermediate requirements.

Balance of Payments

Receipts from exports plus net capital inflows (or borrowing) must be equal to payments for imports; each item being measured in domestic currency net of subsidies or tariffs.

Factor Market Balance

In cases where total employment of a factor is exogenous, factor price relativities are usually fixed so that all factor prices adjust equiproportionally to achieve the set target.

Income-Expenditure Identity

Total expenditure on domestically consumed final demand must be equal to the income generated by labour, capital, taxation, tariffs, and net capital inflows.

4.3 The Model's Equations

In the notation and equations below, the following apply:

(i) A subscript i refers to a row of an input-output table or matrix.

(ii) A subscript j refers to a column of an input-output table or matrix. The context of an equation will make it clear whether j refers to sectors, final demand, or both.

Hence X_{ij} represents a flow of X from origin i to destination j.

(iii) A superscript D refers to the domestic component of a variable and M refers to the imported component of a variable.

Where no superscript is given either the total (D+M) is implied or the distinction is not relevant. Again the context will make this clear.

(iv) A superscript C refers to the competitive component of an import and NC refers to the non-competitive component.

(v) X(0) refers to the base year level of a variable X.

(vi) t denotes time but unless otherwise indicated all variables pertain to the horizon year.

As far as is convenient, parameters are denoted by lower case Greek letters and commodity-sector conversion matrices are denoted by upper case Greek letters. Upper case English letters represent vectors or matrices of dollar flows, both real and nominal, whether exogenous or endogenous; and lower case English letters represent coefficients or prices. Some symbols are used more than once but this should not cause any confusion.

The classification of variables as endogenous or exogenous and the distinction between exogenous variables and parameters, are not always unique, depending largely on the issue under study. Thus in the equations below no definitive classification is attempted. In most cases the nature of a variable is self evident but where this is not so an indication is given of the usual status of the variable.

Production Functions

The Cobb-Douglas specification is given by:

$$X_j = e^{\nu t}\theta_j L_j^{\alpha} K_j^{\beta} = A_{ij}/a_{ij} \tag{1.1}$$

Output in sector j is a function of two factors, labour and capital, augmented by technological progress. It is related by input-output coefficients to non-factor inputs.

The Constant Ratio of Elasticity of Substitution, Homothetic (CRESH) specification is given by:

$$\sum_{i=1}^{11} \Gamma_{ij}\left(F_{ij}/X_j\right)^{\gamma} - 1 = 0 \tag{1.2}$$

Output is a function of eleven separately identified inputs; ten labour types and one capital type. A technological change parameter is not shown but is easily incorporated into the Γ or X term depending on the bias.

Note that the parameters α and β are of course sector specific and that the γ is both input specific and sector specific. That is, i and/or j subscripts are implicit.

The reduced form CES specification does not actually feature as a production function precisely because it is in reduced form. Only the factor demand functions are relevant, as given in the next section.

X	gross output
L	labour employed
K	capital stock
F	factor input of any type, in CRESH case
A	intermediate input with domestic and imported components
a	input-output coefficient = A/X
α	labour share in value added, (compensation of employees)
β	capital share in value added, (operating surplus + depreciation)
θ	a constant
γ	CRESH parameter related to elasticity of substitution
Γ	" " " " "
$e^{\nu t}$	efficiency growth at a rate ν per annum over t years

Factor Demand

Profit maximization or cost minimization of the production functions yields the factor-output ratios. For the Cobb-Douglas case:

(2.1.1) $$l_j \equiv L_j/X_j = e^{\nu t}\theta_j^{-1}(\alpha_j/w_j)^{1-\alpha}(r_j/\beta_j)^{\beta}$$

(2.1.2) $$k_j \equiv K_j/X_j = e^{\nu t}\theta_j^{-1}(\beta_j/r_j)^{1-\beta}(w_j/\alpha_j)^{\alpha}$$

For the CRESH case:

(2.2.1) $$Ln(f_{ij}) \equiv Ln(F_{ij}/X_j) = (g_{ij}/g_{1j})Ln(f_{1j}) - g_{ij}Ln(w_i/w_1) + G_{ij}$$

where $g = 1/(1-\gamma)$

and $G_{ij} = g_{ij}Ln(\Gamma_{ij}\gamma_{ij}/\Gamma_{1j}\gamma_{1j})$ (i=2...11)

(2.2.2) $$\partial f_{1j}/f_{1j} = \sum_i \eta_{1i}\partial w_i/w_i$$

A detailed derivation of the factor demand equations for the CRESH case is set out in appendix A of this chapter.

The reduced-form factor demand equations are given by:

(2.3.1) $$\partial l_j/l_j = \sigma_j\beta_j(\partial r_j/r_j - \partial w_j/w_j)$$

(2.3.2) $$\partial k_j/k_j = \sigma_j\alpha_j(\partial w_j/w_j - \partial r_j/r_j)$$

Equations (2.3) relate the change in per unit factor demand to the relative change in factor prices via the elasticity of factor substitution σ. When this equals unity equations (2.3) are equivalent to (2.1), provided of course that the linearization errors that are inherent in (2.3) are removed. This is accomplished for all elasticity values by using the 'Richardson deferred approach to the limit', more detail of which is given in Chapter 5 and in Stroombergen [87]. The same approach is used to solve equation (2.2.2).

l	labour-output ratio
k	capital-output ratio
f	factor-output ratio in CRESH case for either labour or capital
w	wage rate of labour in a sector, or any factor price in CRESH case
r	rental rate of capital in a sector

Factor prices are usually endogenous whenever total demand for a factor is set equal to an exogenous factor supply.

η	cross price elasticity between factor 1 and factors 2...11
σ	elasticity of substitution between labour and capital

Intermediate Input Demand

(3) $$m_{ij} = h_{ij} m^{C}_{ij} + m^{NC}_{ij}$$

(4.1) $$h_{ij} = \varepsilon_{ij}\big((p_i/q_{ij})/(p(0)_i/q(0)_{ij}) - 1\big) + 1$$

(4.2) $$= \varepsilon_{ij}(p_i/q_{ij} - 1) + 1 \quad \text{as } p(0)=q(0)=1 \text{ by definition}$$

(5) $$m^{C}_{ij} = m(0)_{ij}\pi_j S_{ij} \qquad \text{where } m(0) = m^{NC} + m^{C}$$

m	imported part of input-output coefficient (a) defined above, measured in constant purchasers' prices
p	price of gross output
q	domestic import price (inclusive of tariff)

h	a parameter/variable
ε	relative price elasticity of demand
S	maximum potential degree of import displacement, $0 \leqslant S \leqslant 1$
π	proportion of S allowed, given model's time horizon, $0 \leqslant \pi \leqslant 1$

The above three equations define the intermediate import coefficients in the horizon year to be equal to the competitive portion as defined in the base year, plus whatever import substitution (or expansion) may be desired on the basis of relative prices, plus the non-competitive portion. In chapter 6 it is shown that equations (3) to (6) are equivalent to the more general expression:

$$\partial m/m = \eta\partial(p/q)/(p/q) \qquad \text{where } \eta = \varepsilon\pi S$$

(6.1) $$\rho_{ij}a_{ij} = q_{ij}m_{ij} + p_i d_{ij} = p_j\alpha_{ij}$$

(6.2.1) $$d_{ij} = (p_j\alpha_{ij} - q_{ij}m_{ij})/p_i$$

(6.2.2) $$d_{ij} = a_{ij} - m_{ij}$$

d	domestic part of (a)
ρ	composite price of (a), a weighted average of p and q
α	(a) in value terms, as opposed to volume terms

Equation (6.1) equates the sum of the value of payments to domestic and imported intermediate inputs to: (1) the total composite volume coefficient multiplied by the composite price, and (2) the total value coefficient times the sectoral output price. That is:

$$\alpha_{ij} = \rho_{ij}a_{ij}/p_j$$

In the base year $\alpha = a$ but the distinction is important in the horizon year. If the α_{ij} are assumed fixed the a_{ij} become variable such that the composite inputs are substitutable with unitary elasticity and the domestic component is then given by equation (6.2.1). Note that such substitution is over and above any domestic-imported substitution <u>within</u> the composite commodity. If the a_{ij} are fixed the domestic component is given by equation (6.2.2) and zero substitution prevails between composite inputs. This is the more usual assumption.

Naturally the condition $m,d,a,>0$ must be obeyed at all times and the solution algorithm includes constraints to ensure this. However, the condition does imply that the fixed share (unitary elasticity) assumption cannot always be applied, such as when a composite input contains no domestic component and a completely non-competitive imported component.

The details of the above equations, their relationship to the conventional elasticity of substitution between two goods, and an example of how they work are given in Chapter 6.

Commodity Prices

(7) $$p_j = \sum_i \rho_{ij} a_{ij} + w_j l_j + r_j k_j + p_j v_j$$

$$= \left(\sum \alpha_{ij} + v_j\right) p_j + w_j l_j + r_j k_j$$

The price of output of a sector j is neoclassically determined as the sum of payments to primary and intermediate inputs plus (ad valorem) taxes. Zero pure profit exists. In the CRESH case the terms in w and r are replaced with $\sum_i w_i f_{ij}$ where i denotes a factor type.

(8) $$q_{ij} = e p_i^w (1+t_{ij})/(1+t(0)_{ij})$$

The domestic price of imports is given by the product of the exogenous world price, the exchange rate and (one plus) the ad valorem rate of tariff, relative to the base year tariff. This denominator in equation (8) may appear curious. Its presence is due to the normalization procedure which will be explained in Chapter 6.

v	exogenous ad valorem tax on gross output
e	exchange rate, (the price of a unit of foreign currency)
p^w	exogenous world price
t	exogenous tariff rate

Private Consumption

Private consumption expenditure is divided into eight (Household Expenditure Survey) commodity categories and is modelled by a linear expenditure function based on utility maximization subject to a budget constraint. The share of total income (or GDE) devoted to consumption is usually exogenous although a more suitable savings function is easily incorporated.

(9) $$p_j C_j = p_j T_j + \mu_j (C - \sum_j p_j T_j)$$

(10) $$C \equiv \sum_j p_j C_j = \phi Y$$

(11) $$\underset{\sim}{C}_i = \Theta \underset{\sim}{C}_j$$

(12.1) $$C_{ij} = (\theta_{ij} p_j C_j)/\rho_{ij}$$

(12.2) $$C_{ij} = \theta_{ij} C_j$$

(13) $$\theta_{ij} = f(\theta^D_{ij}, \theta^M_{ij})$$

- where f() has the same form as the intermediate domestic-import substitution functions given by equations (3) - (5).

C_j	private consumption of commodity j
C	total value of the j commodities
Y	nominal income, (horizon year prices)
C_{ij}	output from sector i going to commodity j

T_j	committed consumption of commodity j
μ_j	discretionary consumption of commodity j
Θ	sector-commodity conversion matrix
θ_{ij}	item in row i, column j of Θ

Consumption by supplying sector is obtained from consumption by commodity through a commodity-sector conversion matrix which may consist either of fixed value coefficients or fixed volume coeficients. Equations (12.1) and (12.2) respectively correspond to these options. The former allows substitution with unitary elasticity between composite inputs within a given commodity, whilst the latter allows no such substitution. In both cases domestic-import substitution is permitted within each composite input according to the same rules as applied to intermediate inputs.

Some model variants have also included an alternative demand specification given by:

$$\partial C_j/C_j = \varepsilon \partial p_j/p_j + \sigma \partial C/C \tag{14}$$

This is a reduced form specification similar to the Rotterdam model which relates the change in the consumption of good j to the change in its price and to the change in total expenditure, via standard price and expenditure elasticities. Equation (14) has not been frequently used as there is no guarantee that its results will satisfy the budget constraint, since the elasticities are point elasticities which are being applied to changes in prices and expenditure that are not infinitesimal. The usual answer has been to uniformly scale the expenditure elasticities, endogenously within the solution procedure.

Obviously then, there is some loss in virtue as regards using equation (14). It is best used only in cases where there is clear advantage in doing so, such as when the number of commodities distinguished is too large to support the assumption of additivity. Since nothing is ever said about the utility function corresponding to equation (14) the assumption of a utility function based on additive preferences is not required whereas it is for the utility function from which the LES is derived.[1]

Government Consumption and Stock Change

$$G_i^D = \zeta_i^D \phi^G Y/p_i \tag{15.1}$$

$$G_i^M = \zeta_i^M \phi^G Y/q_i \tag{15.2}$$

$$S_i^D = \zeta_i^D \phi^S Y/p_i \tag{16.1}$$

$$S_i^M = \zeta_i^M \phi^S Y/q_i \tag{16.2}$$

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[1] See Deaton and Muellbauer [16, pp. 137-142] for a full discussion on additivity.

Government consumption and investment in stocks are of the same functional form. Both are expressed as a fixed proportion of income (Y), and expenditure across each constituent commodity is composed of a domestic component and an imported component. Quantity substitution with unitary elasticity can be seen to occur both between and within commodities.

On some occasions it is desirable to stipulate government consumption exogenously. In that case the parameters ϕ^S and ϕ (in equation 10) need to be redefined as fractions of Y-G.

G_i^D	government consumption of domestically produced good i
G_i^M	government consumption of imported good i
S_i^D	stocks of good i supplied domestically
S_i^M	stocks of imported good i
ϕ^G	share of Y allocated to government consumption
ϕ^S	share of Y allocated to stock change
ζ_i	share of government consumption / stocks devoted to good i

Note that $\sum_i(\zeta_i^D + \zeta_i^M) = 1$ for each of G and S

Investment

(17.1) $$I_j = (\lambda_j + \delta_j)K_j$$

(18.1) $$\lambda_j = \left(K_j/K_j(0)\right)^{1/T} - 1$$

or an alternative specification:

(17.2) $$I_j = \lambda_j(K_{j(t)} - K_{j(t-1)}) + \delta_j K_j \quad \text{where } t \; \varepsilon \; \{1....T\}$$

(18.2) λ_j = an exogenous parameter

Equations (17.1) and (18.1) set net investment in the model's terminal year equal to the mean rate of capital accumulation throughout the model period. Adding on replacement investment which is an exogenously specified proportion of each sector's capital stock, yields gross investment.

The rationale underlying equations (17.2) and (18.2) is essentially short run. In such situations it is perhaps more reasonable to relate a sector's investment in the terminal year to its investment in some earlier year. These two equations are typically used when the model's base year, (usually the year of the latest input-output table) is some years back and the terminal year is only a few years hence. One should then have some knowledge about the rate of investment between the base year and the current year from which values for the λ_j in equation (18.2) could probably be obtained.

Neither of the above investment specifications purports to accurately portray the process of investment. The justification for their adoption is fully explained in Chapter 6.

Investment by sector of origin, that is by supplying sector, is derived from investment by sector of destination via a capital input-output table (or investment matrix).

(19) $$\underset{\sim}{I}_i = \Omega \underset{\sim}{I}_j$$

(20.1) $$I_i^D = \omega_i \rho_i I_i / p_i$$

(20.2) $$I_i^M = (1-\omega_i)\rho_i I_i / q_i$$

The imported/domestic share of the nominal value of each of the components I_i of $\underset{\sim}{I}_i$ is fixed, implying unitary elasticity of substitution between imported and domestic capital goods of the same type. Ideally such substitution should occur within the investment matrix possibly using a routine similar to that used for intermediate inputs and private consumption. However, due to modern and reliable data having only recently become available, this degree of sophistication is not yet included.

I_j investment by sector of destination

I_i investment by supplying sector with domestic component I_i^D and imported component I_i^M

λ	mean rate of capital accumulation during the model period
δ	physical rate of depreciation
ω	domestic share of I_i
Ω	investment conversion matrix

Exports

(21) $$E_j = E_j(0)\psi_j\big(p_j(1-s_j)/ep_j^w\big)^{\eta} \qquad \{\eta \text{ differs across } j\}$$

(22) $$\underset{\sim}{E}_i = \Xi\underset{\sim}{E}_j$$

Exports of a particular commodity type are determined by a world export demand curve, the argument of which is the local price relative to the world price. The position of the curve is related to world income growth, the establishment of new markets etc, as discussed more fully in Chapter 6. As with consumption and investment, the vector of export commodities is transformed into a vector of exports by supplying sector via a commodity-sector conversion matrix.

A wide choice is possible with respect to the mix of endogenous and exogenous variables in equation (21).

E_j	exports of commodity j
E_i	exports from sector i
s	subsidy on commodity exports (usually exogenous)
ψ	demand curve shift factor (usually exogenous)
η	(relative) price elasticity of demand
Ξ	sector-commodity conversion matrix

Domestic Market Balance

(23) $$X_i = \sum_j d_{ij}X_j + C_i^D + G_i^D + S_i^D + I_i^D + E_i$$

Ouput from sector i must be equal to the demand for its products for intermediate use, private and government consumption, stocks, investment and exports.

External Balance

(24) $$\sum_j p_j(1-s_j)E_j + N - \sum_i p_i^w e \sum_j \left(M_{ij}/(1+t_{ij}^0)\right) = 0$$

where:

(25) $$M_i = \left(m_{ij}X_j \;\S\; C_i^M \;\S\; G_i^M \;\S\; S_i^M \;\S\; I_i^M\right)$$

and the symbol $\S$ denotes horizontal concatenation such that the columns of M comprise the sectors and the four local final demand categories.

Thus the subscript j in equation (25) applies to sectors <u>and</u> final demand categories. The presence of the base year tariff t^0 (abbreviated notation for t(0)) is again due to the normalization procedure. It ensures that imports are measured at c.i.f. prices for balance of payments purposes.

Equation (24) states that income from exports plus net factor income or borrowing (N) to cover any trade imbalance, must equal c.i.f. import payments.

Factor Market Clearance

In cases where the total level of employment of a factor is exogenous and the factor price is endogenous, the following must hold (using the CRESH function notation):

(26) $$\sum_i f_{ij}X_j = F \equiv \sum_i F_i$$

where F is the total exogenous supply of factor i.

In the CRESH case a given factor market is cleared simply by the endogenous determination of the corresponding factor price. If the total labour market is to clear, relative occupational wage rates are fixed and all rates move equiproportionally to achieve the given target.

(27.1) $$w_i = \beta_i w_k \qquad \text{where } k \in \{i=1 \ldots 10\} \text{ and } \beta_k = 1$$

In the Cobb-Douglas case it is sectoral factor price relativities that are assumed fixed. These can of course be exogenously altered and become endogenous if sectoral employment (labour or capital) targets are specified.

(27.2.1) $$w_j = \beta_j w_k$$

(27.2.2) $$r_j = \gamma_j r_k \qquad \text{where} \quad k \,\varepsilon\, \{j=1\ldots n\} \text{ and } \beta_k = \gamma_k = 1$$

w_i	wage rate of labour of type i, CRESH case only
w_j	wage rate of labour in sector j
r_j	rental rate of capital in sector j

β_i	wage rate relativity between occupations i and k
β_j	wage rate relativity between sectors j and k
γ_j	rental rate relativity between sectors j and k

Note that occupation k or sector k is arbitrarily chosen and that the parameters β and γ have nothing to do with the production function exponents of equation (1).

Income - Expenditure Identity

(28)
$$Y = \sum_j w_j L_j + \sum_j r_j K_j + \sum_{ij}\sum t^*_{ij} q_{ij} M_{ij} + \sum_j p_j v_j X_j + N - \sum_j s_j p_j E_j$$
$$= \sum_j p_j C_j + \sum_i \rho_i I_i + \sum_i \rho_i S_i + \sum_i \rho_i G_i$$
$$\text{where } t^* = 1/(1+t)$$

National income is defined as the sum of payments to factors of production, (labour and capital in the Cobb-Douglas notation), tariff and tax revenue, net capital inflows, less export subsidies. It must also be equal to expenditure on the four domestic components of final demand.

In more conventional terms equation (28) may be expressed as

(29) $$Y - N = GDP = EGDP = Y + (E - M)$$

where GDP is gross domestic product
EGDP is expenditure on GDP
E & M are nominal exports and imports
so Y = GDE, is gross domestic expenditure

4.4 Solution Procedure

The nonlinear equation system is solved by an iterative procedure which progressively converges to an equilibrium. The required number of iterations and the length of each iteration depend on which version of the model is being used (for example whether it has Cobb-Douglas or CRESH production functions) and on the mix of endogenous/exogenous variables. Typically, however, four to six iterations suffice to achieve convergence to within 0.001% of whichever variables are given target values at the start of the algorithm.

Existence of a solution is confirmed by the fact that such has been obtained for every run of the model. Whilst one cannot categorically assert that each solution is unique, numerous experiments with widely differing initial values failed to suggest any multiple equilibria. Economically absurd solutions containing say negative quantities might well exist if variables were not otherwise constrained, but again none have been discovered. Because there is only one household sector the equilibrium should be unique, according to Arrow and Hahn [3].

The solution algorithm centres around solving the income-expenditure identity given by equation (28). The relevant manipulation of the equations is given below with the details being left until Chapter 5 which is devoted entirely to the solution procedure. For the sake of clarity the following algebra does not show the distinction between vector and matrix, nor the transpose of these, nor the distinction between normal matrix multiplication and element by element multiplication. The accompanying description of the equations provides or implies all such information.

An expanded form of equation (28) is derived in eight stages - as presented on the following page.

(i) All variables here are in real terms. Investment by sector of destination is converted to investment by sector of origin. To prevent the proliferation of subscripts the former is denoted by (J) and the latter by (I).

(ii) Again all the variables are in real terms. The matrix of d_{ij} coefficients is denoted by D and the supply of output (X) equals the sum of demands for that output from equation (23). The symbol ω^* is used

The Solution Equation

(i) $$I = \Omega J$$
$$= \Omega(\lambda+\delta)K$$
$$= \Omega(\lambda+\delta)kX$$

(ii) $$X = DX + C^D + I^D + G^D + S^D + E$$
$$= DX + C^D + \omega^* \Omega(\lambda+\delta)kX + G^D + S^D + E$$
$$= \left(1-D-\omega^*\Omega(\lambda+\delta)k\right)^{-1}\left(C^D + G^D + S^D + E\right)$$

(iii) Using the equations for C^D, G^D, S^D (as given in the text):
$$I = \Omega(\lambda+\delta)k\left(1-D-\omega^*\Omega(\lambda+\delta)k\right)^{-1}\left\{\left(\sigma^D+ \theta^D\mu\phi\right)\left(Y-I\right) + E + \theta^D T\right\}$$

(iv) $$\text{Nominal } I = \rho\Omega(\lambda+\delta)kH^{-1}\left(\sigma^D+ \theta^D\mu\phi\right)\left(Y-I\right) + \rho\Omega(\lambda+\delta)kH^{-1}(E+\theta^D T)$$

where $H = \left(1-D-\omega^*\Omega(\lambda+\delta)k\right)$ and $\rho = pq/[q\omega+p(1-\omega)]$

(v) $$Y = wL + rK + T + tqM - spE + N$$
$$=(wl+rk+pv+tqm)X + tq\left(\sigma^M+\theta^M\mu\phi\right)\left(Y-I\right) + tq\theta^M T + t(1-\omega)I - spE + N$$

=> $Y-I$ = as above with $(t(1-\omega)-1)I$ replacing $t(1-\omega)I$

(vi) Substitute $X = H^{-1}\left\{\left(\sigma^D+ \theta^D\mu\phi\right)\left(Y-I\right) + E + \theta^D T\right\}$

and let $Z = (wl + rk + pv + tqm)$ in (v)

(vii) $$\Rightarrow \left\{1 - tq\left(\sigma^M+ \theta^M\mu\phi\right) - ZH^{-1}\left(\sigma^D+ \theta^D\mu\phi\right)\right\}\left(Y-I\right)$$
$$= ZH^{-1}\left(E + \theta^D T\right) + tq\theta^M T - spE + N + \left(t(1-\omega)-1\right)I$$

(viii) Thus:
$$(Y-I) = \frac{ZH^{-1}(E+\theta^D T) + tq\theta^M T - spE + N + \left(t(1-\omega)-1\right)\left(\rho\Omega(\lambda+\delta)kH^{-1}(E+\theta^D T)\right)}{\left\{1-tq(\sigma^M+\theta^M\mu\phi) - ZH^{-1}(\sigma^D+\theta^D\mu\phi) - \left(t(1-\omega)-1\right)\left(\rho\Omega(\lambda+\delta)kH^{-1}(\sigma^D+\theta^D\mu\phi)\right)\right\}}$$

to denote ω in 'real terms' where the latter is the domestic share of investment in nominal terms from equation (20). It is derived thus:

$$\text{Given} \quad \omega = pI^D/(pI^D + qI^M)$$

$$\text{then} \quad \omega^* = I^D/(I^D + I^M)$$

To express ω^* without reference to I^D and I^M:

$$\omega(pI^D + qI^M) = pI^D$$

$$\Rightarrow I^M = pI^D(1-\omega)/q\omega$$

$$\text{So} \quad \omega^* = I^D/\left(I^D + pI^D(1-\omega)/q\omega\right)$$

$$= q\omega/[q\omega + p(1-\omega)]$$

(iii) From equations (9) - (13):

$$C_j = T_j + \mu_j\left(\phi(Y-I)/p_j - \sum_j (p_jT_j)/p_j\right)$$

and

$$C^D \equiv \underset{\sim}{C}{}_i^D = \theta^D \underset{\sim}{C}{}_j$$

$$= \theta^D\left(T_j - \sum(p_jT_j)/p_j\right) + \theta^D\mu_j\phi(Y-I)/p_j$$

which for convenience is abbreviated to:

$$\theta^D T + \theta^D\mu\phi(Y-I)$$

Similarly $\quad C^M \equiv \theta^M T + \theta^M\mu\phi(Y-I)$

and ϕ is redefined to be a proportion of (Y-I) rather than of Y, for the sake of computational convenience. Also:

$$\underset{\sim}{G}{}_i^D + \underset{\sim}{S}{}_i^D \equiv \sigma^D(Y-I)/p$$

$$\underset{\sim}{G}{}_i^M + \underset{\sim}{S}{}_i^M \equiv \sigma^M(Y-I)/q$$

where σ is an amalgamation of the previous ζ and ϕ parameters and, as with private consumption, relates to (Y-I) instead Y.

Stage (iii) then, substitutes out the domestic components of C, G and S by expressing them as functions of (Y-I), in the equation for X from stage (i). Then this equation is substituted into the equation for I from stage (ii).

(iv) The equation for I in (iii) is in real terms. To convert this into nominal terms entails multiplying it through by a mean price vector ρ where:

$$\begin{aligned}\rho &= \omega^{*}p + q(1-\omega^{*}) \\ &= pq/[q\omega + p(1-\omega)]\end{aligned}$$

Also for convenience, from here on H is substituted for:

$$\left(1-D-\omega^{*}\Omega(\lambda+\delta)k\right)$$

(v) Equation (28) expresses income (in nominal terms naturally) as wage payments, plus returns to capital, plus tax and tariff revenue, less export subsidies, plus net capital inflows. (The tariff rate t is the previously defined t^{*}).

Tariff revenue is split into revenue arising from imports of intermediate goods (tqmX); from C, G and S as per stage (iii) above, and from imports of investment goods $[t(1-\omega)I]$, where I is nominal investment from (iv). Subtracting I from both sides so as to get (Y-I) as the subject of the equation, yields the last expression in stage (v).

(vi) From stages (ii) and (iii) one has the equation shown for X. Hereafter Z is used as a replacement for:

$$(wl + rk + pv + tqm)$$

(vii) The equation here is obtained by substituting the expressions from (vi) into the last expression in stage (v), and moving all terms involving (Y-I) to the left side.

(viii) Taking the equation from (vii) and substituting for I the equation from (iv) gives the final equation for (Y-I).

As already stated the exact method of solution depends on model specification but the equation in stage (viii), perhaps with some minor modifications, is always used. As an example assume that given exogenous amounts of total labour and capital are to be employed. The exchange rate is selected as the numeraire so wage rates and rental rates are endogenous (with fixed relativities).

Initial values for w_k and r_k will yield all wage rates and rental rates. These determine factor-output ratios which then yield prices, from which exports and the various other magnitudes which enter into equation (viii) can be ascertained. Solution of this enables the calculation of final demand expenditures which, together with exports, determine the demand for sectoral output, which in turn requires the use of labour and capital in production. Hence total factor usage is calculated and compared with the given exogenous amounts. If they are not equal the initial w and r values are altered and the process is repeated until convergence is achieved.

It can be seen then, that the logic underlying the solution procedure is the progressive elimination of excess demand. Of course the targets of this elimination process depend on the exact mix of endogenous / exogenous variables.

The above is a very simplified description since the procedure is complicated by various sub-routines and sub-loops which operate within the iterative process. Nevertheless it serves as an outline of the JULIANNE model solution method without recourse to the mathematical detail of the algorithm. And, more importantly, because the solution procedure can (now) be seen to be very dependent on the structure of the model (in contrast to say Johansen logarithmic differential models) it is appropriate that such an outline be included in the chapter which presents the model proper. However, this aspect of the model is also deserving of a separate chapter, to which we now turn.

Appendix A

Derivation of CRESH Factor Demand Functions

Given the CRESH function:

$$\sum_{i=1}^{11} \Gamma_{ij}(F_{ij}/X_j)^{\gamma} - 1 = 0$$

To minimise cost (C):

$$C = \sum_i w_i F_i - \lambda\left(\sum_i \Gamma_i (F_i/X)^{\gamma} - 1\right) \qquad \text{\{dispensing with the j subscript\}}$$

$$\Rightarrow \partial C/\partial F_i = w_i - \lambda\gamma_i\Gamma_i F_i^{\gamma-1}X^{-\gamma}$$

$$\Rightarrow \quad w_i = \lambda\gamma_i\Gamma_i F_i^{\gamma-1}X^{-\gamma} \qquad \text{for minimum cost} \qquad \text{(A1)}$$

$$\text{Let } i=1, \Rightarrow \quad \lambda = w_1/\gamma_1\Gamma_1 F_1^{\gamma-1}X^{-\gamma} \qquad \text{(A2)}$$

Converting to logs and substituting A2 into A1 yields:

$$\mathrm{Ln}(w_i) = \mathrm{Ln}(w_1) + \mathrm{Ln}(\gamma_i\Gamma_i/\gamma_1\Gamma_1) + (\gamma_i-1)\mathrm{Ln}(F_i) - (\gamma_1-1)\mathrm{Ln}(F_1) + (\gamma_1-\gamma_i)\mathrm{Ln}(X)$$

$$\Rightarrow \mathrm{Ln}(F_i) = \frac{\left(\mathrm{Ln}(w_i/w_1) - \mathrm{Ln}(\gamma_i\Gamma_i/\gamma_1\Gamma_1) + (\gamma_1-1)\mathrm{Ln}(F_1) + (\gamma_i-\gamma_1)\mathrm{Ln}(X)\right)}{(\gamma_i - 1)}$$

$$\text{Let } g_i = 1/(1-\gamma_i) \quad \text{and} \quad G_i = g_i\mathrm{Ln}(\gamma_i\Gamma_i/\gamma_1\Gamma_1)$$

$$\Rightarrow \mathrm{Ln}(F_i) = -g_i\mathrm{Ln}(w_i/w_1) + G_i + (g_i/g_1)\mathrm{Ln}(F_1) + (1-g_i/g_1)\mathrm{Ln}(X)$$

$$\Leftrightarrow \mathrm{Ln}(f_i) = (g_i/g_1)\mathrm{Ln}(f_1) - g_i\mathrm{Ln}(w_i/w_1) + G_i \qquad \text{where } f_i = F_i/X$$

- which is equation (2.2.1) as given in the main text (without the j subscripts).

This equation determines all the f_i except for f_1 as functions of f_1 and relative factor prices. Naturally then, f_1 must first be determined and for this purpose equation (2.2.2) is used. Since the application of point elasticities to discrete (non-infinitesimal) changes will yield linearization errors, equation (2.2.2) is solved by utilising the Euler technique for solving differential equations, augmented by the 'Richardson deferred approach to the limit'. This method enables the reduction of linearization errors to within any desired tolerance margin.

That equation (2.2.2) needs to be used at all is because it has not been possible to derive functions of the form of the Cobb-Douglas factor demand equations, from the CRESH function; that is equations which include only factor prices and the parameters of the production function on the right hand side. (Any assistance in this regard would be most appreciated.)

Note that the choice of factor for equation (2.2.2) is of course mathematically arbitrary. But it is convenient if the same factor is used for all sectors (except Ownership of Dwellings which has only one input and thus does not have a CRESH production specification). This criterion rules out only two factors; occupation No.9 - Armed Services, and Capital. The former does not feature in the Government Services sector whilst the latter features only in that sector. The sole reason for selecting occupation No.1 - Professional White Collar, was that of computational simplicity.

5

THE SOLUTION PROCEDURE

CHAPTER 5

THE SOLUTION PROCEDURE

This chapter is divided into six sections, the first five of which provide a detailed, frequently mathematical description of the model's solution procedure. They are set out as follows:

1. Introduction
2. The Solution Strategy
3. Background to the Solution Algorithm
4. The Solution Algorithm
5. Alternative Solution Methods

The final section, section 6, is an essay type discussion of the model's solution procedure, which focusses on the economic interpretation of the various mathematical conditions (as given in the first five sections of the chapter) needed for the attainment of a solution or equilibrium. This is done in the context of the parallels which exist between the model's solution method and the well known Walrasian tatonnement method of market adjustment. Both of these methods are also compared to actual market adjustment processes.

5.1 Introduction

Following Adelman and Robinson [1], a solution procedure is easier to comprehend if one thinks of it as comprising two parts; a solution strategy and a solution algorithm. The former sets up the problem, in particular, the set of excess demand equations to be solved and the order in which the various equations are tackled by the algorithm. The exact nature of that algorithm is a separate part of the solution procedure. It is generally functionally independent, although not choice independent, of a given solution strategy. That is, the logical structure of a given solution strategy does not usually imply that any particular algorithm must be used to solve it. However, a particular class of algorithms may well be more suitable than others.

The last section of Chapter 4 outlined the solution strategy with only scant reference to the solution algorithm. That emphasis was appropriate within a general description of a nonlinear model since the strategy is (and was seen to be) closely related to model stucture, as will become even more evident.[1] Further elaboration of the solution strategy is now given before proceeding with an in-depth description of the solution algorithm.

5.2 The Solution Strategy

The choice of a strategy is essentially the choice of an ordering for the adjustment of prices and/or quantities in the various sets of excess demand equations. Again following Adelman and Robinson, the solution strategy for the JULIANNE model can be classified as a factor market strategy as opposed to a product market strategy, in the sense that the major or outermost loop generates the excess demand for factors whilst within this loop, subsidiary loops generate excess demands for goods. Loops are required whenever an excess demand equation is not solvable analytically.

The solution algorithm refers to the way in which prices or quantities are adjusted in response to excess demands. An own-price tatonnement, for example, is a particularly simple solution algorithm. As will be elucidated later, efficiency considerations lead to the use

[1] See also Stroombergen [87] in this regard.

of algorithms for the solution of JULIANNE which involve variants of a gradient method.

The strategy adopted then, is illustrated in figure 1. (The dashed lines should be ignored in the meantime.) An initial set of factor prices is selected which, in conjunction with the factor input demand functions (derived from the production functions) given by equation (2),[2] yields the factor-output ratios, which when inserted into equation (7) yield sectoral prices. These together with world prices determine: domestic and imported input-output coefficients via equations (3)-(6); final demand coefficients via equations (9)-(13), (15), (16), (19) and (20); and the demand for exports via equations (21) and (22). With the demand for investment from equations (17) and (18), this information is substituted into the domestic balance equation (23) which in turn is substituted into the income identity equation (28) along with the calculated factor-output ratios and the balance of trade constraint given by equation (24). With the algebraic manipulation as given in Chapter 4 this yields the important expanded income equation given by equation (viii), which is analytically solvable for gross domestic expenditure less gross investment. Back substitution then yields the magnitudes and values mentioned above in reverse order finishing with factor demands. If these do not equal the given factor supplies the algorithm determines a new set of factor prices and the whole process is repeated.

The fact that this process constitutes the outermost loop justifies one's use of the term 'factor market strategy'. The reason for this choice of strategy is that the structure of the JULIANNE model, as reflected in the weak separability between the various blocks of equations such as income, production, consumption, and so on; implies a certain pattern of (semi) recursiveness which happens to be more suited to a factor market strategy than a product market strategy, as was shown by the algebra at the end of the last chapter.[3]

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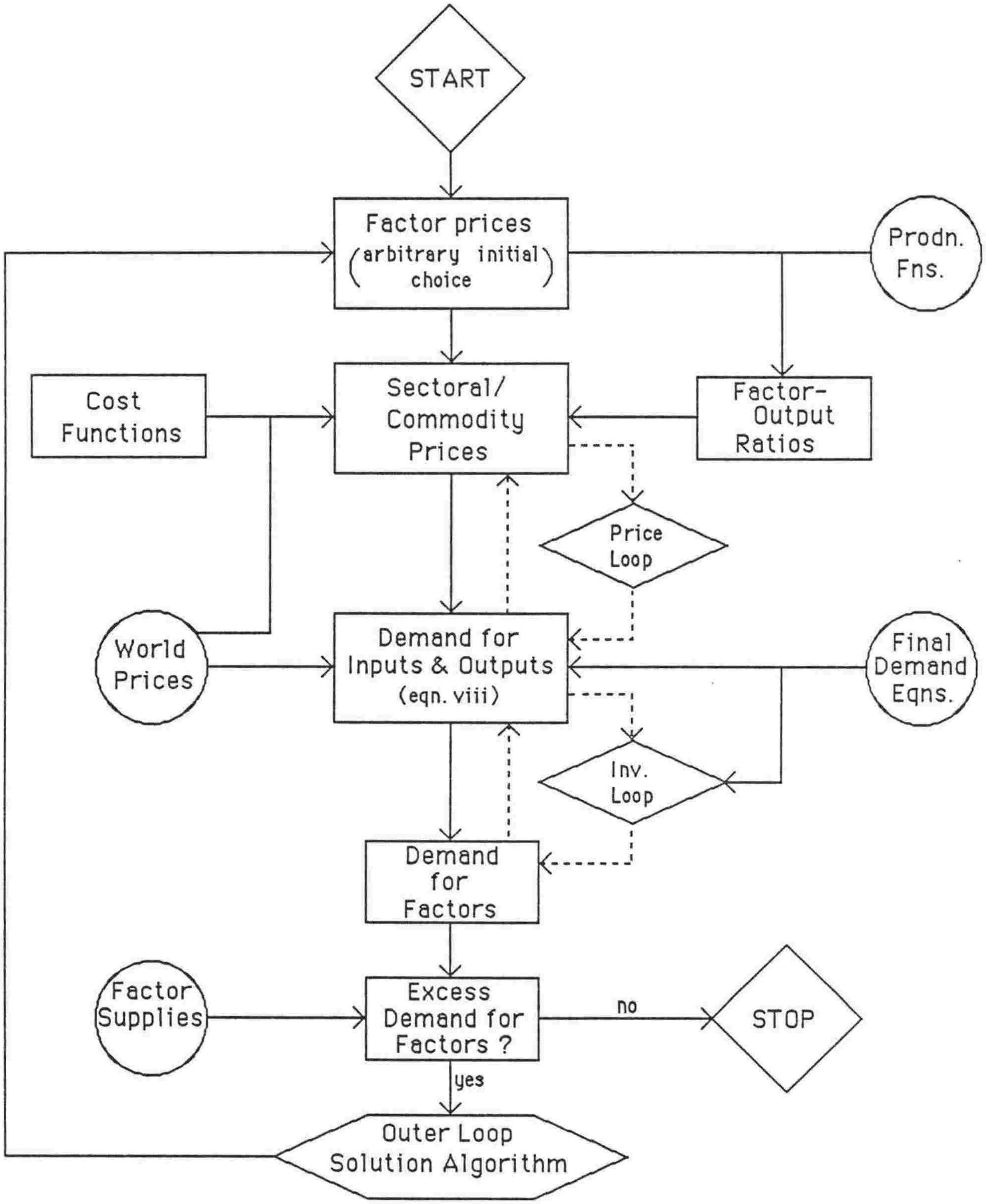
[2] References to equations are to those in Chapter 4.

[3] Some incidental advantage may attach to this choice in that any extension of the model into disequilibrium modelling (especially as regards the dynamic version of JULIANNE) would be likely to address factor market disequilibrium before adressing product market disequilibrium, as it is the former which is more prevalent. Note however, that one is not claiming that the solution procedure resembles actual market adjustment - as will be further discussed below.

Figure 1

JULIANNE Snapshot Model
Solution Strategy



Naturally the nature and number of excess demand functions depend on the exact mix of endogenous/exogenous variables and on the exact choice of model equations. But the choice of equations also has a more important effect on the solution process in that it is not always possible to carry out the entire, purely analytical substitution strategy just described. When this is the case it is necessary to solve the relevant 'inner loops' within each iteration of the outer loop. The most important areas where this may occur (to be discussed below) are:

1. Investment allocation by sector of destination
2. Sectoral prices, if substitution between composite commodities has an elasticity of zero as opposed to unity.
3. Factor input demands, if the production function is not Cobb-Douglas. (Actually a loop can be avoided here.)

If, as is usually the case, investment in each sector is set equal to the mean rate of capital accumulation between the base year and the horizon year, in that sector, a sub-loop is required for the calculation of these rates. The growth rates can only be determined once the horizon year capital in each sector is known, which is at the end of the outer loop. However, sectoral investment must be known before that stage so as to determine final demand which determines output which in turn determines capital requirements. In practice an initial guess is made about the sectoral allocation of investment which is revised once sectoral capital stocks have been calculated, if equality does not prevail between the initial guess and the model result. The algorithm returns to the point at which the initial guess was inserted and substitutes the new rates just calculated. Thus the loop is one of progressive substitution, which could cause it to be quite time consuming. Fortunately a fairly loose tolerance margin of about 0.05% is quite sufficient for the first few outer iterations. If one also bases one's initial guess on capital growth rates from a previous run, the number of iterations of this sub-loop is seldom more than three. A major reason for this stability is the similarity between columns of the investment matrix which means that the mix of investment by sector of origin, which affects sectoral output demand, is not very sensitive to (small) changes in the mix of investment by sector of destination.[4]

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[4] In connection with this see the last part of Chapter 6.

If the elasticity of substitution between composite commodities is unity, each composite input constitutes a fixed value input-output coefficient. Prices are then analytically solvable from knowledge of the sectoral cost functions only. These prices are then used to calculate the sectoral input and output demands as per figure 1. If the substitution elasticity is zero the coefficients are fixed in volume terms and it is not possible to calculate sectoral prices without knowing the domestic-imported composition of each intermediate input, for which one needs to know sectoral prices.....and so on. Once again a 'progressive substitution' loop is employed with initial prices calculated as if the elasticity of substitution between composite inputs was unity. This usually yields a very good set of starting prices with the sub-loop generally converging to within 0.001% in under five iterations. It has never failed to converge and in fact may be expected to converge quickly on theoretical grounds due to the diagonal dominance theorem, to which we will return when the major loop algorithm is described.

With Cobb-Douglas production functions, factor-output ratios are analytically calculable from the given production function parameters and a set of factor prices. Most model runs utilise the C-D specification but occasionally an elasticity of substitution between labour and capital of other than unity is desired, for which a 'reduced form' equation is adopted. (We will ignore the multi-factor CRESH option for now.) Since no corresponding structural equation is assumed here, one cannot express the factor-output ratios as functions of factor prices and structural equation parameters alone. It is relatively easy to set up factor demand equations which include net product prices as an argument but unfortunately this leads to a simultaneity problem since, in the solution strategy, product prices are obtained after factor-output ratios. Rather than solve this with yet another iterative loop, it is much more convenient and very much quicker to express the factor-output ratios in logarithmic differential (or growth rate) form as a function of the change in factor prices, For example:

$$d(L/X)/(L/X) = \sigma\alpha_K(dr/r - dw/w)$$

--- where L is labour employed, X is gross output, w is the wage rate, r is the rental rate, σ is the elasticity of substitution between labour and capital, and α_K is the share of capital in net output.

Of course for other than infinitesimal changes this transformation yields linearization errors. To overcome this the 'Richardson deferred approach to the limit' on the Euler technique for solving differential equations is used with the changes in w and r split into four or more steps. A full description of this method is given in Stroombergen [87, pp.7-9]. Testing this approximation for $\sigma=1.0$ against the standard solution procedure for Cobb-Douglas functions revealed negligible errors with four steps and with changes in w and r of about 50%. Precision can always be increased by using more steps, (decreasing the step length) if warranted by larger factor price changes.

Recall that this technique is also applied to the equation for 'factor number 1' under the CRESH production specification, namely equation (2.2.2) in Chapter 4.

The investment and price sub-loops are denoted by the dashed lines in figure 1. If the third problem had not been solved by the differential method, a further loop would have been required between the compartments labelled 'factor-output ratios' and 'sectoral prices'. Again such a loop may well converge very quickly but probably would not be as fast as the Richardson-Euler approach. These two sub-loops are always solved within each iteration of the major loop, so that at the end of each such iteration all markets except the factor markets are in balance. Hence again the reason for the name factor market strategy to distinguish it from a product market strategy (where at the end of each iteration all markets except product markets are in balance).

Given then, that the solution strategy is fundamentally concerned with solving the factor markets, what is the algorithm actually used? Before answering this question a brief history is presented of the solution method used to solve the developmental 3-sector versions of the JULIANNE snapshot model, since the algorithm which is currently in use evolved from valuable insights gained from the earlier experience.

5.3 Background to Solution Algorithm

As has been stated before and is explained more fully at the start of the next chapter, the homogeneity property of the model necessitates one variable being selected as numeraire. Usually this is the exchange rate. But the factor market strategy used here is flexible enough for one to take say the wage rate as numeraire, with the exchange rate then taking the place of the wage rate in the factor excess demand equations.[5] This was generally the situation in the earlier versions of the model. For instance, let total employment of labour and capital be exogenously given at $(\bar{L},\bar{K})$, the balance of trade (B) be constrained to equal zero, the exchange rate (e) and the rental rate (r) be endogenous variables whose values we wish to determine, and let the wage rate (w) be the numeraire.

With some initial values of e one combines varying values of r and observes the changes on L, K and B. Such observations are plotted in figure 2 for (L,K) pairs and (B,K) pairs as shown by the two curves denoted LK1 and BK1 respectively. (The scale for B is conveniently placed such that B=0 is aligned with $L=\bar{L}$.)

If the curves (L versus K) and (B versus K) do not pass through the equilibrium points $(\bar{L},\bar{K})$ and $(\bar{B},\bar{K})$ respectively, the exchange rate is accordingly adjusted and the procedure repeated. For example if the (L v K) curve is above the equilibrium point there will exist a point on it at which there is excess demand for both labour and capital. In that case imports should be increased so as to deflect demand away from domestic output. Hence the exchange rate should be lowered, that is a revaluation. Simultaneously there must have been a surplus on the balance of trade, otherwise the model would be inconsistent. This is seen to be the case.

Repeating the exercise with a lower exchange rate yields curves LK2 and BK2, from which a smaller devaluation (increase in e) yields curves LK3 and BK3. Eventually the curves pass through or close to the solution point. In practice this did not usually take very long for two reasons. Firstly, one did not need to take too many r observations to plot the curves shown in figure 2 and secondly, in the neighbourhood of the solution the curves are approximately linear. Thus linear interpolation

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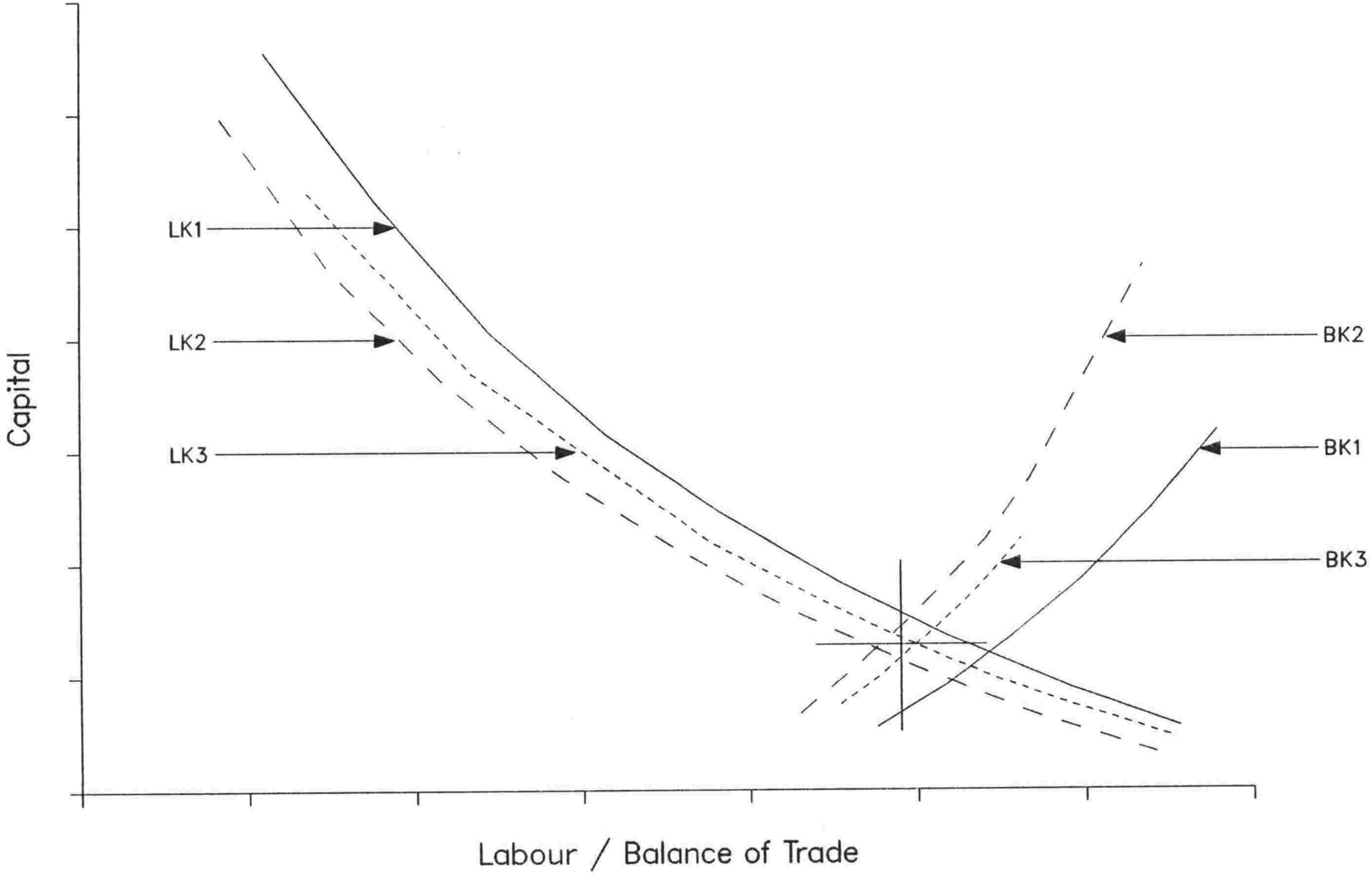
[5] We speak of the wage rate and the rental rate as if there were only one of each. This is simply more convenient than referring to a set of such rates with fixed relativities between sectors.

Figure 2
Excess Demand Curves



quickly yields the solution values for e and r. Typically 4 or 5 values of e were required, each with 3 or 4 values of r, in order to obtain accuracy of better than 0.05% for the exogenous L,K and B constraints. This generally involved 30-40 seconds of CPU time using the TSP package on a Burroughs B6700 computer.

On the basis of CPU time and since the curves can be seen to move monotonically closer to solution point, the algorithm appears satisfactory. However, its efficiency is superficial. That it is in fact inefficient is easily seen by counting the total number of (e,r) combinations required for solution; anywhere from 12 to 20 using the statistics given above. For a 3-sector model the inefficiency was not a serious problem but as the size and complexity of the model increased, so did the effect of the inefficiency. Larger models required not many more iterations but each iteration required much more time. For example, increasing the size of the model from 3 to 26 sectors multiplies by 75 ($26^2/3^2$) the size of the input-output matrices (which require inversion) and multiplies other calculations by a factor of about 9, increasing the time needed for solution to over 4 minutes. This is highly inefficient since a 26-sector linear programming model with 200 rows, 750 columns and a density of about 5%, can be solved by the MPSX modified simplex algorithm in well under one minute.

The key to improving the algorithm is immediately apparent if one perceives the importance of the following points:

1. The curves in figure 2 are strictly convex/concave and (theoretically) differentiable. (If one plotted enough points the linear segments would smoothen out.)
2. They are approximately linear in the neighbourhood of the solution.
3. This linearity, which allowed the use of linear interpolation, can be better exploited if one realises that linear interpolation essentially means using information about slopes, that is derivatives. Thus the information can be represented in a Jacobian matrix which requires only n+1 (here n=2) numerical secant iterations for its evaluation.

If the Jacobian is reasonably stable so that it only needs to be computed once, the number of iterations needed to find a solution should be less than 2n, with convergence being assured by the convexity of the curves, that is by the convexity of the excess demand functions. This then, is essentially the technique which is used to solve the current 22-sector and 40-sector versions of the model. An own-price tatonnement procedure (meaning that price is adjusted in the direction of excess demand, with the percentage adjustment usually set equal to the percentage excess) provides the information required for the evaluation of the Jacobian and also rapidly brings the values of the excess demand functions to within a 'neighbourhood' of the solution.

That the tatonnement/Jacobian method as a whole will converge is due to the diagonal dominance theorem which states that the process will converge "if the adjusting variable has a greater effect on the disequilibrium to which it responds than to all other variables taken together."[6] This is just a weaker version of the gross substitutability condition as discussed later in section 5.6 where a full account of tatonnement is given. Naturally if all cross effects were zero the own-price tatonnement process would converge exactly and quickly. But since the cross effects are often quite significant, the full Jacobian must be employed.[7] A complete description of this algorithm now follows.

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[6] From Ginsburgh and Waelbroeck [41]

[7] Of course any tatonnement process actually works on at least qualitative knowledge of the partial derivatives.

5.4 The Solution Algorithm

Define X = a vector of prices

$f(X)$ = a vector of excess demand functions

$J(X)$ = the Jacobian matrix where $J_{ij} = \partial f_i/\partial X_j$

A general function of one variable $f(x)$[8] may be approximated by a Taylor series expansion as:

$$f(x) \approx f(a) + f'(a)(x-a)$$

So for $f(x)=0$, $x = a-f(a)/f'(a)$

That is, if $x=a$ is an approximate root of $f(x)=0$, then $x = a-f(a)/f'(a)$ is generally a better approximation. The successive solution of this equation as a way of obtaining the roots of a function is known as the Newton-Raphson algorithm. Generalising it to find the solution to the above excess demand functions yields:

$$X^{n+1} = X^n - J(X^n)^{-1}f(X^n) \tag{1}$$

If we now define $F(X) \equiv \Sigma f(X_i)^2$ it is obvious that F has a minimum at $f(X)=0$. If further, F is approximately quadratic at the minimum, it is useful to employ the least squares method to find that minimum. That is:

$$F \approx [f(a) + f'(a)(x-a)]^2$$

$$= f(a)^2 + 2f(a)f'(a)(x-a) + f'(a)^2(x-a)^2$$

$$\Rightarrow \partial F/\partial x = 2f(a)f'(a) + 2f'(a)^2(x-a)$$

$$= 0 \text{ for a minimum, and one also needs } \partial^2F/\partial x^2 > 0$$

Thus $\partial^2F/\partial x^2 = 2f'(a)^2 > 0$

Generalising this gives $\partial^2F/\partial X^2 = 2J(X^n)'J(X^n) \equiv H(X^n)$, which is the Hessian matrix of second order partial derivatives. Therefore:

$$\partial F/\partial X = 2f(X^n)J(X^n) + H(X^n)(X-X^n) = 0$$

$$\Rightarrow X^{n+1} = X^n - 2H(X^n)^{-1}J(X^n)'f(X^n) \tag{2}$$

--- the repeated solution of which is known as the Gauss-Newton method, where X^{n+1} is the value of the X vector at the (n+1)th iteration.

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[8] Lower case x and f(x) will refer to the one dimensional case, leaving X and f(X) to refer to the model.

Of course using the approximation $H=2J^2$ simply reduces equation (2) to equation (1) and one is no better off. However, in the JULIANNE model the Hessian is augmented as described below.

The Gauss-Newton method given by equation (2) can only be guaranteed to converge if the Hessian (and hence its inverse) is positive definite. For the JULIANNE model, where the excess demand functions are generally all strictly convex (and approximately quadratic near the solution point), positive definiteness is automatic. Nevertheless, since both the Jacobian and the Hessian are calculated from secant function evaluations rather than analytically, it is possible for equation (1) or (2) to yield a nonsensically large step size in a suboptimal direction. This may occur if the Hessian is very small, possibly due to small step sizes being used in its evaluation, and/or if the Jacobian in the region of its evaluation is very different from the Jacobian at the minimum, where that region and the neighbourhood of the minimum are far enough apart from each other for f(X) to be 'large'. In practice an ill-conditioned Jacobian/Hessian as a result of small step sizes (and computer round-off error) has seldom occurred.

Theoretically also, the tatonnement process should bring the function to within a suitable neighbourhood of the minimum. However, one retains the facility whereby the results of some initial iterations can be manually inspected to assess whether or not this is actually the case. If not, the procedure can be restarted. It is therefore up to the user to define an appropriate neighbourhood, although this can only be done in a rather qualitative manner. Thus substantial changes to some of the major parameters in the model (such as import-domestic or labour-capital substitution elasticities) can lead to errors of judgement. One can of course automate the entire procedure. But for 'first of a kind' runs user intervention based on one's acquired knowledge of the model's behaviour is often more efficient than leaving the algorithm exclusively to its own devices when the excess demand functions are nowhere near zero.

To guard against potential inefficiency in the algorithm, since the concept of a neighbourhood is a matter of degree, equation (2) is modified to:

$$X^{n+1} = X^n - 2(H+\hat{E})^{-1}J'f(X^n) \qquad (3)$$

--- where H and J are abbreviations for $H(X^n)$ and $J(X^n)$, and $\hat{E}$ is a diagonal matrix of elements e_{ii} such that:

$$e_{ii} = ||y(X_i^n)/y(X_i^*) - 1||$$

--- and X^* is the solution value of X yielding $y(X^*)$ where by definition $f(X)=0$. (Greenstadt and Marquardt have demonstrated that the correct choice of E can guarantee $(H+\hat{E})^{-1}$ to be positive definite. See Himmelblau [51, pp. 85-88].)

Before explaining this modification it is necessary to digress for a moment. Any iterative algorithm may be expressed as:

$$X^{n+1} = X^n - \lambda^n \alpha^n d^n$$

--- where d is the (unit) direction vector
α is the basic step length
λ is an optional relaxation or damping parameter
n is the iteration count.

One of the most well known methods of selecting d is to proceed in the direction of steepest descent, namely in the opposite direction to the gradient of f(X), which in the usual notation is given by:

$$\nabla f(X) = \partial f/\partial X = J(X)$$

If as before we define $F(X) \equiv \Sigma f(X_i)^2$, then

$$\nabla F(X) = 2J(X)'f(X)$$

$$\Rightarrow X^{n+1} = X^n - \alpha^n 2J(X^n)'f(X^n), \qquad \text{(omitting } \lambda)$$

--- where α is frequently taken as $||\nabla F(X^n)||$

Now referring back to equation (3) one can see that the larger is $\hat{E}$ relative to H, the more the method of equation (3) approaches the steepest descent method, with a somewhat arbitrary step size approximately equal to the percentage discrepancy from the target value of y(X). Thus the larger the discrepancy, the stronger is the bias towards steepest descent and the smaller is the risk of an overly large step size. Close to the minimum, the numerically evaluated Jacobian should be fairly accurate so it is unlikely that the algorithm would be thrown off track by a small H combining with a small $\hat{E}$ to yield too large a step size. In any case as long as $(H+\hat{E})$ is positive definite convergence is assured. Furthermore, as stated earlier, the rate of convergence is approximately quadratic if H dominates $\hat{E}$. Random inspection of these matrices has always shown this to prevail near the minimum.

Summarising this argument then; as one intuitively expects, it is generally true that steepest descent methods are relatively better if the function value is still far away from the minimum whilst Newton-Jacobian based methods perform better near the minimum.[9] Hence equation (3) has the desired effect.

Having explained the mathematical theory of the algorithm we turn now to a more definitive description of the actual steps involved.

The exact solution procedure in the JULIANNE model is to estimate the Jacobian matrix from the first n tatonnement function evaluations evaluations[10] (given that one is within a suitable neighbourhood of the solution point), use equation (1) to determine X^{n+1}, and then use equation (3) for iteration (n+2) - namely:

$$X^{n+2} = X^{n+1} - 2[H(X^n)+\hat{E}(X^{n+1})]^{-1}J'(X^n)f(X^{n+1}) \qquad (4)$$

(Note that $J(X^n)$ denotes J estimated from n iterations, not from the n^{th} iteration).

The step given by equation (4) is used repeatedly in the form:

$$X^{n+(m+1)} = X^{n+m} - 2[H(X^n)+\hat{E}(X^{n+m})]^{-1}J'(X^n)f(X^{n+m})$$

until <u>either</u> convergence is achieved <u>or</u> m=n (the number of excess demand equations). Once m=n the last m+1 iterations (from n+1 to n+m+1 inclusive) supply enough information to re-evaluate the Jacobian. The procedure then restarts from equation (1), at which point it is up to iteration n+m+2 (=2n+2). In practice the Jacobian estimated for one model run is frequently still useful for further runs in the same series. It is only when major changes to the structural equations or elasticities are introduced, that a new Jacobian specific to the problem at hand may need to be determined. Indeed one would suspect multiple

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[9] See Himmelblau [51, pp.88 & 111] in this context.

[10] Actually the numerical evaluation of the Jacobian, being of order n, requires n+1 functional evaluations since each secant derivative describes the difference between two observations. We ignore counting the first iteration since a previous model solution can frequently be that first iteration and because it is notationally convenient to denote the first iteration after the evaluation of the Jacobian as n+1 where n is the number of excess demand functions.

equilibria if the Jacobian changed markedly for small constraint changes.

The advantage of this two step approach (using equations 1 and 4) over simply using equation (1) by itself, is that if the first n iterations do not yield a good enough Jacobian, that is; a sufficiently accurate solution from iteration n+1, it would otherwise require another n+1 iterations before any further real progress toward the solution point could be made. By augmenting the procedure with equation (4) progress occurs with every iteration beyond the n^{th} one and the Jacobian is re-evaluated only if convergence is not achieved between iterations n+1 and 2n+1.[11]

In fact the algorithm has worked so well that the $\hat{E}$ term in equation (4) is generally easily dominated by H so that equation (4) collapses to equation (1). Given also that the Jacobian is rarely evaluated more than once, it is apparent that the Newton-Raphson method with a numerically determined Jacobian is very efficient for this model, even within a fairly wide neighbourhood of the minimum. The $(H+\hat{E})$ term is essentially a safeguard just in case the algorithm begins to go astray.

Nevertheless, a better method of solving the JULIANNE model may well exist especially when the number of excess demand equations (n) in the outer loop becomes quite large, as can occur under the CRESH production specification. In general, because the outer loop equations cover factor markets (and possible miscellaneous constraints such as on the terms of trade via an endogenous uniform export subsidy), as opposed to product markets, the number of excess demand functions does not rise with the number of sectors. Typically n is in the range 1-5. For 26 sectors and 2 excess demand functions (to maintain comparability with the earlier discussion) the number of iterations required is usually 4 or 5, with a total CPU time of 40-80 seconds using the SAS matrix package on an IBM 4341 computer. For 40 sectors and 3 excess demand equations the time needed for solution is still under 2 minutes, in 6 or 7 iterations. Utilising an existing Jacobian can reduce these times substantially. In almost all cases the convergence criterion for the outer loop is 0.001%.

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[11] More generally, iterations z(n+1), (z=1,2,3...) use a new Jacobian.

5.5 Alternative Methods of Solution

It is worth just mentioning three other techniques that could probably be used to solve the JULIANNE model. There are of course many techniques for solving sets of nonlinear equations that are amenable to general equilibrium economic models and modifications to the more well known ones abound. Discussion of these is out of place here but the interested reader is referred to Himmelblau [51] or Dixon [28], or for a very theoretical and mathematical treatment to Ortega and Rheinboldt [69].

Johansen Method

The equations of a nonlinear system may be logarithmically differentiated with respect to time to yield equations which are linear in terms of the percentage changes of the variables. The system can then be solved by matrix inversion. A detailed description of the technique is given in Stroombergen [87] which also sets out its disadvantages. Briefly, these comprise the inability to incorporate inequality constraints, the bias caused by linearization errors for large changes in the exogenous variables, and the substantial amout of peripheral programming that is frequently required to firstly reduce the matrix (by equation substitution) to a size that can be handled by computer based matrix inversion routines, and then secondly to back substitute out the results.

The first two of these disadvantages can usually be alleviated by a few iterations but a certain irony arises in that one of the great advantage of the Johansen technique is that it supposedly eschews the need for an iterative process. The third disadvantage may yet be overcome by the application of algorithms for solving large sparse matrices. See for example Pearson and Rimmer [70].

Finally a fourth reason for not choosing this method to solve the JULIANNE model is that shortly after the construction of JULIANNE was commenced, work was begun by R. Wallace of the Research Project on Economic Planning, on a Johansen type model.[12]

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[12] See Wallace [97]. An applied comparison between this model (JOANNA) and JULIANNE is given in Stroombergen and Wallace [92], but there is still much scope for a more comprehensive comparison between these two types of models.

Mathematical Programming

One of the reasons for developing the JULIANNE model was as a response to the limitations inherent in the VICTORIA linear programming model of the New Zealand economy.[13] Other types of programming methods still do not overcome the major drawback of having to specify the model as an activity analysis problem. Also, in the solution to a programming problem the number of positive valued variables cannot exceed the number of constraints. This is apt to be troublesome although the difficulty can be ameliorated by the piece-wise segmentation of nonlinear functions - a technique used in the World Bank 'PROLOG' model as surveyed in Chapter 2. But too many segmentations may erode the cost competitiveness (both human and computer) of programming methods.

Fixed Point Algorithms

Much has been discovered about fixed point algorithms since the impelling work in 1973 by Scarf [79], a good summary being provided by Ginsburgh and Waelbroeck [40, Ch. 6].

The principal advantage of using fixed point algorithms is that they are guaranteed to converge to within any desired margin, for systems of equations (models) which satisfy the assumptions of fixed point theorems. But their major disadvantage is their speed of convergence which, as shown by Ginsburgh and Waelbroeck [40, p103] is proportional to the square of the number of excess demand functions. Probably for most problems to which the JULIANNE model is applied a Scarf type algorithm would compare favourably with the tatonnement-Jacobian method. However, in runs which incorporate the CRESH production specification with ten labour constraints, the Scarf algorithm is likely to be slower than the tatonnement-Jacobian method.

One must confess also, a lack of personal expertise in this area, which when combined with the absence of a fixed point algorithm computing package at this university, constituted the major reason for not selecting such algorithms to solve JULIANNE.

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[13] The VICTORIA model is described in Philpott et al [72].

5.6 The Solution Procedure and Market Adjustment

This section begins with a brief historical perspective of the theory of market adjustment with emphasis on the dynamic issue of the attainment of market equilibrium, given its (static) existence and uniqueness. In particular the Walrasian 'tatonnement' process is analysed and compared with the solution procedure used in the model in order to illuminate the working of the latter without recourse to mathematical exposition. It will be shown that neither the tatonnement process nor the solution procedure can be considered an accurate representation of actual adjustment processes since amongst other reasons, they do not allow for the fact that information held by market participants about the market, is less than perfect.

We will use the term 'market adjustment' to refer to the process by which those with goods and services to sell come into contact with potential buyers and set prices which are agreeable to all parties, prices which also clear the market. If the process reaches that point the market is said to be in equilibrium.[14] Three facets to this operation can be identified.

1. The 'rendezvous' between buyers and sellers. This rendezvouz need not be a physical one. It is sufficient that producers can manufacture a good on the expectation that buyers will somehow become aware of its existence. The eventual trade may occur through a middle agent; typically a wholesaler or retailer.
2. The forces which ensure that buyers and sellers can agree on a mutually acceptable price.
3. The forces which ensure that the price on which all agree is such as to completely clear the market for each good.

If the market clearing price is such that all expectations are satisfied and if agents continue to replicate their former actions in the future, the equilibrium will be dynamically stable. Note, however, that other future equilibria based on different expectations about a different real world may also exist.[15]

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[14] The literature abounds with articles and books on general equilibrium and related topics. See for example Simpson [82], Arrow and Hahn [3], and Bliss [6] & [7].

[15] From a modelling point of view it matters not from whence the system came when it is out of equilibrium. What matters is whether or not (and if so, how) it will then attain some unique equilibrium, which

Naturally the first stage is a prerequisite for the success of the second and this in turn is required for the success of the third. If (1) and (2) hold but not (3) trading takes place at 'false' prices whilst if only (1) holds there is no trade at all since agreement on a mutually acceptable price is not forthcoming. We will assume that producers' expectations of a market are accurate enough for them to be sure of at least some trade.

Theoretically stage (3) could be satisfied without stage (2) if traders are forced to buy and sell goods at prices decreed by some central authority, where those prices are not the ones that buyers and sellers might have agreed upon had the market been free. This is the case of a command economy. Conceivably the centralist solution could better maximise the gains from trade than the free market, particularly if the equilibrium could not be attained via the free market. In retrospect this might then be preferred by market participants. However this area of political economy involves all sorts of philosophical issues which are well beyond the scope of this paper. If we lived in a totalitarian regime and used an economic model to assess the nature of the market equilibrium with all transactions being determined by fiat, there would be little relevance in any comparison between market adjustment and model solution methods; the point of this discussion. Hence we will concentrate on market economies where the majority of transactions are voluntary. Under such circumstances will market equilibrium ever eventuate and if so how are the above three stages actually realised?

Let us proceed with our theoretical framework. Leaving aside the usual plethora of detailed qualifications surrounding the existence and attainment of equilibrium, the principle was advanced a long time ago, in particular by Adam Smith that if there was a demand for some good the potential for reward would induce someone to manufacture it. This would increase the welfare of both parties. If many producers and buyers engage in such activity, buying some goods and selling others, a complex market arises. In this market, equilibrium will prevail if at the end of the 'market period' the market has been cleared for all goods and services including factor services, and stocks are at desired levels, all at prices which fulfill the expectations of market participants.

may well differ from a former equilibrium if the world has changed. Hence we shall not distinguish between systems which were once in equilibrium and those which have never been in equilibrium.

From here one can progress to state the conditions under which the resultant pattern of trade (namely which goods, how much and at what prices) would constitute an efficient allocation of resources with all trade possibilities fully exploited and then explore how the market might get there.

We know that a Pareto optimal allocation exists when three conditions are satisfied.

1. The rate of substitution between any two goods is identical for all consumers.
2. The rate of substitution between any pair of inputs is the same for any producer who uses those inputs.
3. The rate of product transformation between any two products equals the consumers' rate of substitution.

In such a situaton the welfare of no single participant in the system can be improved without that of someone else declining. Note, however, that the Pareto optimum may not be a 'true' optimum in the sense of a welfare optimum since nothing is stated about the distribution of the ownership of factor services or about the existence of a social welfare function. Of course market imperfections may generate an equilibrium which is not Pareto optimal, let alone socially optimal. But can Adam Smith's invisible hand realise any sort of market equilibrium? (We will return to the optimality question.)

Recalling the three facets of market adjustment outlined above, it can be seen the major key to their satisfaction is information. The invisible hand notion assumes that producers have the informatiom which tells them that a profit may be earned if a certain good is produced to satisfy a known demand. We should accept the principle of this assumption; if we do not then there is no market and this discussion is irrelevant. Beyond the fact then that production of the appropriate good does occur lies the question of how much. The producer has some expectations about the size and nature of the market and produces accordingly. But usually the quantity offered by him on the market at some price which he himself may set, does not equal the quantity demanded either at that price or at some other price proposed by the buyer. How then does the market function to remove the disequilibrium, that is to satisfy stages (2) and (3)?

The best known answer to this question was proposed by Walras. He posited an auctioneer who would announce prices for all goods and services, note the offers of supply and demand at those prices and if these were unequal, adjust prices accordingly in the direction of excess demand, as occurs in the first part of the JULIANNE solution procedure. This procedure would continue until all markets were in balance. Stages (2) and (3) would be simultaneously satisfied since exchange would occur only at market clearing prices. There would be no false price trading. This interesting abstraction and ambitious simulation of the market prevailed in modern economic theory for two main reasons.

1. It fits well into the perfect competition framework since it means that no single seller or buyer influences the price. However see Richardson [75] who points out that general equilibrium requires a certain amount of information on the part of market participants which may entail the existence of some institutions that are not compatible with the perfect competition ideal.
2. For many years nobody provided a better theory.

However the Walrasian process of tatonnement does not theoretically guarantee that equilibrium will be attained. Let us look at the appropriate conditions, recalling simultaneously the mathematical treatment given in the first half of this chapter, before we assess the usefulness of the tatonnement idea.

Two conditions when satisfied will ensure covergence of the market to equilibrium by the Walrasian process.

1. The system is locally stable if gross substitutability exists between all commodities. That is, if the price of good X rises, the demand for all other goods must also rise. A necessary condition in this regard would involve some assessment of all the elasticities in the system. (Recall the Jacobian diagonal dominance condition.)
2. The system is globally stable if the weak axiom of revealed preference holds. In the case of a single consumer this means the following:

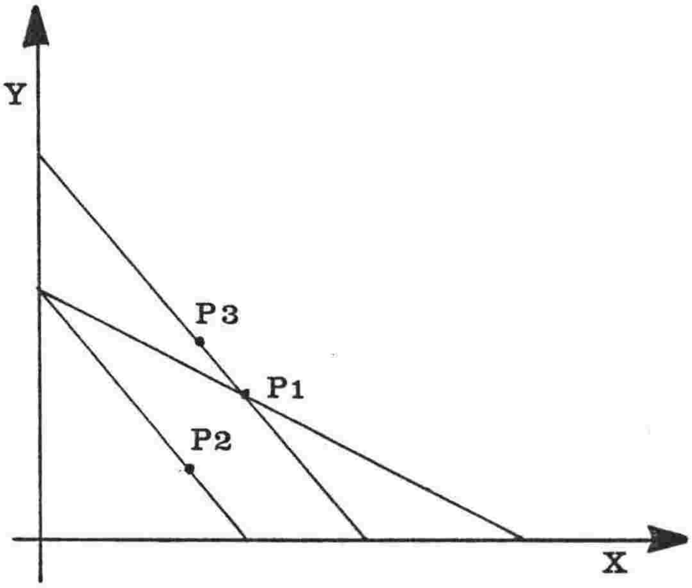

Figure 3: Revealed Preference

A bundle of goods X and Y is denoted by point P1 on the budget line as shown in Figure 3. If the price of X rises the budget line moves inward and the bundle of goods is given by point P2. If income was increased by an amount exactly sufficient to regain P1 the theory of revealed preference states that the point P3 cannot be to the right of P1. If it was then the consumer would be acting inconsistently.

Hence for an individual the theory is plausible. But to assume that it applies in the aggregate is to assume that price changes do not affect the income distribution in such a way as to alter aggregate preferences to the extent that P3 ends up below and to the right of P1.

Both conditions are satisfied in the JULIANNE model with satisfaction of the latter being automatic since there is only one 'representative' consumer in the model.

It is pertinent to point out that these conditions refer to a dynamic process which converges to an equilibrium. If the static (unique) general equilibrium does not exist the dynamic process cannot converge to it, so the usual GE properties (such as the continuity and convexity of production and demand functions) must first be satisfied. The existence of an equilibrium is prior to its attainment; an elementary point perhaps but nonetheless of considerable consequence. And there is usually more than one dynamic system consistent with a given static equilibrium. The relative speeds of adjustment of prices versus quantities are important in this regard so that one needs to specify the precise nature of disequilibrium behaviour when expounding conditions for convergence. If the adjustment behaviour involves the

Walrasian price mechanism then the above two conditions will guarantee convergence to equilibrium. But in the majority of markets trading takes place at false prices and after some trading has occurred it may be realised that excess demand/supply exists. Some price or quantity adjustment may if possible, then occur. This observation contains two features which Walras' tatonnement abstraction does not address.

1. That trading does take place out of equilibrium.
2. That the process takes real time since prices have less than infinite velocity. Enter imperfect knowledge, expectations and some price setting.

These are important real world phenomena which cast serious doubt on the practical usefulness of the Walrasian tatonnement abstraction and hence on the guarantee of convergence to an equilibrium in the real world. Some progress has been made in economics in incorporating these issues into theories on disequilibrium market adjustment; See for example Hahn and Negishi [44], Barro and Grossman [4], and Fisher [37]. However the scope of this thesis is not broad enough to assess these developments.

We have seen that the solution algorithm iterates on prices and quantities. Essentially an initial set of prices is 'announced' or rather inserted into the algorithm which is then executed once to yield those quantities which would be offered for trade if the given prices actually prevailed. If any demand and supply equations are not satisfied a revised set of prices is calculated and the process repeated until all desired markets clear.[16] Hence the process can be seen to be similar to tatonnement with convergence being assured by the above conditions. In fact it converges faster than tatonnement because it is as if the auctioneer knows every agent's response functions so that some of the steps are substituted out by using, amongst other things, the Jacobian derivatives matrix. The pattern of such substitution does not affect the equilibrium solution since that equilibrium is unique and nor does it affect the question of whether the system will converge or not. It does, however, affect the nature of any disequilibrium state along

[16] 'Desired' because one can of course allow excess supply in certain markets if it is required that some prices be stated exogenously; not necessarily that price which corresponds to the particular quantity variable. For example if the wage rate is exogenous, employment is usually endogenous subject to a supply constraint. But if employment is also to be set exogenously then some other usually exogenous constraint could be, and would need to be, made endogenous - for example the exchange rate.

the path to equilibrium. Fortunately this is irrelevant in the model since trading occurs only at solution prices. If one did wish to allow for disequilibrium solutions it would not be legitimate to ignore the pattern of substitution, as manifested in the nature and exact order of execution of the steps in both the solution strategy and the algorithm, since the path of the strategy/algorithm is unlikely to correspond to the actual adjustment path of the economy.

Horizon year capital stock in JULIANNE is allocated by the model and investment in a sector is set equal to that sector's mean rate of capital accumulation between the base year and the horizon year. The implicit assumption is one of steady growth over the period although this need not be the case. However, in terms of tatonnement it is as if in the base year producers know what the desired allocation of capital in the horizon year will be and thus invest accordingly, replicating their actions over each successive year. The horizon year equilibrium is then situated along a dynamically stable path. It is worth repeating, nonetheless, that this equilibrium could also be the outcome of an entirely different dynamic process which is not stable.

In a decentralised market each participant has limited knowledge about the entire system. This causes rigidities in prices and wages with their role in providing income displacing too much of their equally important role as conveyers of information about tastes, resource constraints, technology, etc. This distinction in roles corresponds to the theoretical distinctions between stages (2) and (3) respectively of the market adjustment process. In practice these roles/stages are frequently not so independent and without untangling this behavioural web, which is more psychological than mathematical, the use of the JULIANNE model for modelling out of equilibrium behaviour is severely limited. All one can do is model disequilibria in the sense that not all macro markets; employment, balance of payments etc (and on occasions some micro markets depending on appropriate exogenous information), need to be in balance.

The incorporation of such 'deviations' in the model (which could be made more complex than at present) are an attempt to add realism by proscribing those equilibria such as Pareto optimal solutions (where all the marginal equivalences are satisfied) which could not, or virtually never do, eventuate in a world of imperfect information. But this is not the same as modelling actual dynamic, out of equilibrium adjustment, which must take perceptions, expectations and the path of adjustment explicitly into account.

We can see then that the solution procedure of the model, whilst being similar to the Walrasian tatonnement process is, like that process, not a good representation of actual market behaviour. The type of disequilibrium modelling which is possible (as described above) certainly enlarges the range of model applicability beyond simply modelling ideal neoclassical equilibria. This is made possible by the nature of the soluton procedure which permits one to 'get inside' it so as to incorporate market rigidities and imperfections to varying degrees of accuracy. But obviously this is not sufficient for one to claim that the JULIANNE model solution procedure simulates actual market adjustment. Certainly the Walrasian tatonnement process is a useful way of describing the model's solution procedure, and the similarity here clarifies the theoretical distinction between the existence and uniqueness of an equilibrium, and the process of its attainment; that is as the distinction applies to solving the JULIANNE model. This is in contrast to the rather blurred role of these properties in Johansen type growth rate models which use matrix inversion for their solution. However, the tatonnement - solution procedure similarity is positively misleading if it creates the impression that one is simulating actual market adjustment processes since neither false trading, transactions time lags, nor expectations are admitted. In the dynamic version of the model this is slightly ameliorated, as will be seen in Chapter 9.

6

`JULIANNE´ ROUTINES IN DETAIL

CHAPTER 6

'JULIANNE' ROUTINES IN DETAIL

This chapter describes in more detail, aspects and routines of the JULIANNE model which were given only brief mention in Chapter 4, but which because of their importance merit greater elaboration. Most of these features are fairly specific to JULIANNE as opposed to CGE models in general. However, we begin with a rather common issue.

The Concept of a Numeraire

Consider the medium term consequences of the imposition of a tariff (as they would occur in the model).

Importers react to the higher domestic import prices causing a reduction in imports and an improvement in the balance of trade. There is some switching of demand to comparable domestic goods which in turn creates an (initial) increase in the demand for labour and capital. This exerts pressure on wage rates and rental rates which dampens some of the incentive to substitute for imports and, via higher domestic costs, causes a reduction in exports, which in turn alleviates some of the pressure on factor prices. If the fall in exports is not enough to counter the balance of trade improvement, a revaluation of the exchange rate will be required to make exports even dearer and to partially offset the increase in import prices initially caused by the imposition of the tariff.

So, as the French say when asked about the initials T.V.A. (taxe sur la valeur ajoutee), tout va ajouter or everything goes up, except the price of foreign exchange in this case. But this yields no information about the change in relative prices such as whether output prices rise more than wages. In fact at the new equilibrium, wage rates might even be lower than before. What is really of interest here is relative prices since these determine the allocation of resources (in a world of no money illusion). Hence a variable which is otherwise endogenous is selected as a numeraire, the value of which does not vary between runs and in relation to which all other prices are measured.

In the example which follows (taken from a 3-sector version of the model), the wage rate is the numeraire; its value is held constant. An alternative interpretation is that its value actually rises by x percent but that this and all other price increases are then reduced by x percent, effectively eliminating the rise in the wage rate so as to yield relative price changes; relative that is, to the money wage rate. From the table one can see that the rental rate is relatively lower, import prices higher (as expected) and output prices marginally less.

TABLE 1

Altering the Numeraire

	without tariffs	with tariffs	% change, w	numeraire as: e
wage rate	2.3	2.3	0.00	6.62
exchange rate	0.9019	0.8459	-6.21	0.00
rental rate	0.1281	0.1262	-1.48	5.04
import prices	0.9019	1.0574	17.24	25.00
primary sector price	0.8735	0.8652	-0.95	5.61
secondary " "	1.1372	1.1314	-0.51	6.08
tertiary " "	0.9029	0.9010	-0.21	6.40

The choice of numeraire, although mathematically arbitrary, is generally a variable whose absolute value is determined outside the framework of the model. For example the level of money wage rates could be stipulated by tripartite negotiation. In retrospect, however, one might consider that a wage rate numeraire is not especially suited to an example concerning tariff changes. An exchange rate numeraire (expressed as the price of foreign currency) may be preferable if one believes that a government that has just raised tariffs is unlikely to revalue. Of course under a floating rate regime a revaluation may be precisely what occurs. In any case the results given, based on the wage rate numeraire, can easily be re-expressed to correspond to an exchange rate numeraire by multiplying the numbers in the third column of table 3 by 1.0661, this being the negative of the change in e when w is the numeraire. This is done in the right hand column of the above table.

The relative changes are mutually invariant since for example, the change in the wage rate is always 1.5 percentage points higher than the change in the rental rate. This invariance cannot be overstated since it is easy to misinterpret the change of numeraire. The latter set of results with no exchange rate adjustment and money wages rising, may appear more credible because of one's experience about the way in which the government and the economy would in reality behave. It is more difficult intuitively, to trust the former set of results since one generally believes that wages will rise if import prices rise. When one then deflates the wage rate and all other prices by the rise in the wage rate, it appears at first glance that wages are unaltered. One knows that this is quite false but unfortunately such reactions are virtually innate. And of course real magnitudes ARE unaltered. They do not depend on either the choice of numeraire or on its value. The system is homogeneous of degree zero with respect to all real magnitudes and all relative prices for changes in the overall price level.

Between 1979 and 1982 it was the government's exchange rate policy to devalue the New Zealand dollar by 0.5% per month, about 6% per year, so as to maintain a constant real exchange rate. Against the background of the model with the exchange rate as numeraire one might ask; Does a 6% devaluation (a rise in the exchange rate) imply that all other prices will also rise by 6%? How consistent would this be with the objective of the stated policy?

Again it is our understanding of the role of the numeraire which is important here. Clearly if a devaluation is meant to maintain the real exchange rate, domestic price rises must be kept under control. Thus the exchange rate is not acting as a numeraire unless all other prices are fully indexed to it, whether by deliberate policy, the pressure of political lobbying, or simply because all resources are fully employed. One usually assumes, however, that a devaluation is contemplated only if idle resources exist, which may have become idle through a divergence of New Zealand prices from world prices. That is, the economy starts from a disequilibrium situation which may be characterised by a balance of payments deficit and say unemployed labour.

Modelling a real devaluation presents no problem provided one can state which prices are not allowed to rise, or allowed a limited rise, when the nominal exchange rate is devalued. If for example wage rates are fixed, the role of numeraire could be assumed by the mean wage rate or by some particular occupational or sectoral wage rate. If no single price is fixed but they do not all change by the same amount so that relative prices change (which is the intended effect), an overall price index such as the GDP deflator could be the numeraire. The model will produce the correct result in terms of relative prices and real magnitudes as long as the meaning of the exchange rate change is clear - whether it is meant to be a real change or a numeraire change. Confusion here has been noted by others. See for example Shoven and Walley's survey of applied general equilibrium modelling [81] where, when alluding to the role of the exchange rate as a numeraire, they state:

> ".....but, in a number of the models, results are reported for changes in exchange rates with the appearance that they have real effects. This can make the interpretation of results difficult from a theoretical point of view."

In reality the process of adjusting to a 'shock' such as a devaluation is likely to be complicated by further shocks such as consequential action by government. Such actions and reactions will usually have a considerable effect on the equilibrating adjustment of the economy and may even prevent it from reaching a new equilibrium. This whole process could be simulated by the model but when numerous variables (or parameters) are altered simultaneously, it is nigh impossible to isolate their separate influences. One of the main reasons for using an economic model is to do exactly that - alter one variable at a time and study the effects.

Overall then, three points emerge from the above discussion:

1. Whatever the choice of numeraire, it is prices relative to the numeraire which are presented, and it is relative prices which are of interest.
2. Although one stresses the point that we deal with relative prices, it is still expedient to select as the numeraire, a variable whose value is determined outside the framework of the model. The same choice of numeraire may not always be appropriate; between sets of runs the numeraire should sometimes be varied.
3. A model which incorporates relative prices and therefore necessitates the use of a numeraire, is not restricted in its applicability because of that fact (in a world of no money illusion). If one wishes to change the value of the numeraire

one must merely ascertain the circumstances surrounding such a change and possibly alter the choice of numeraire.

On Measuring Imports (Normalization)

Consider a consumer buying an imported CBU car costing NZ$20,000 which includes an 80% tariff. (The tariff or cost excess is taken to mean that a domestically assembled CKD car would also cost $20,000.) His unit of volume is one car. At world prices the unit of volume is still one car but is worth only $11,111.

More generally, with many commodities the volume unit is actually a constant price unit; a conglomeration of tonnes, metres, litres and so on, all multiplied by their respective prices in some reference year to yield a total value. That is, when speaking of constant prices one must have some particular year as a frame of reference. For convenience, prices in that year (the base year) are usually set at unity. This means that volume equals value. For example:

1. Value of GDP = volume of GDP.
2. Value of imports purchased = volume of imports purchased.

However, (1) and (2) are seemingly inconsistent. In (1) the car from the above example is valued at $11,111 since imports are measured at c.i.f. prices in the GDP identity. But in (2) the buyer of the car pays $20,000 for that same import volume unit. Both statements are correct; yet if we set the cif price of the car to unity, the domestic import price will exceed unity and also exceed the domestic price of locally made goods, contrary to our assumption about the tariff. If domestic import prices are set to unity the cif price must be less then unity which causes the value of GDP to diverge from the volume of GDP in the base year. In the model both statements must hold simultaneously. Thus two measurements of import volume appear:

1. Volume in constant cif prices.
2. Volume in constant purchasers' prices (cpp), which equals the cif volume plus an associated 'tariff volume'.

For example, in 1982 actual private consumption in value terms (current dollars) was about $17,000m of which cif imports were $2,000m and tariff payments were \$50m. The volume of consumption with 1982 as the base year is defined as \$17,000m and this appears in the GDP equation (both value and volume). However, in the import component of the GDP equation the private consumption imports are valued at only \$2000m, not \$2050m. The same collection of physical objects is being referred to but to the buyer they are worth \$2050m whereas to the nation as a whole, in world prices, they are worth \$2000m.

In years subsequent to 1982 (namely in the model's horizon year) the model's import prices, that is purchasers' prices, are expressed as (using the notation from Chapter 4):

$$q = p^{w}e(1+t)/(1+t^{0}) \qquad (*)$$

--- where q is the domestic import price

p^{w} is the world cif price

e is the exchange rate

t is the rate of tariff in the horizon year

t^{0} is the base year rate of tariff

Thus in any year if $t=t^{0}$, $q=p^{w}=e=1$ if $p^{w}=e=1$ as in the base year
and " " " " $t=0$, $q=1/(1+t^{0})<1$ " " " " " "

In terms of the car example: if the 80% tariff is retained in some future year and there is no change in p^{W} or e, the domestic import price will also be unchanged from the base year. It the tariff is removed the import price facing the purchaser falls from \$20,000 to \$11,111. Now the unit of volume, the car, costs the same in world prices as in New Zealand prices if it is imported. The domestically produced car still costs \$20,000 so substitution will occur. But note that at the same time as the domestic import price falls to the purchaser, the value of the car in the GDP equation does not change.

With m defined as the volume of imports in constant purchasers' prices, then:

1. Value of imports cpp is qm
2. Volume of imports cif is $m/(1+t^{0})$
3. Value of imports cif is $p^{w}em/(1+t^{0})$

So, with m=\$20,000, the cif volume and value will be \$11,111 irrespective of whether the tariff is retained or not. But the cpp value will be $20,000 if the tariff is retained and $11,111 if it is removed, although both situations correspond to a constant domestic price volume unit of $20,000.

Thus the normalization rule in JULIANNE is to set all domestic gross output prices and domestic import prices to unity in the base year, but simultaneously to also set all world prices to unity even when a cost difference exists. Equation (*) ensures then that this correct pricing logic is maintained in the model's horizon year.

Import-Domestic Substitution in Intermediates & Private Consumption

As outlined in Chapter 4, the demand for intermediate inputs is represented as a demand for a composite input. That is, an input which has an imported component and a domestic component which are imperfectly substitutable in production. One of these components could of course be entirely absent; namely when there is no domestic good comparable to some given imported good, or vice versa. In volume or constant price terms this may be expressed as:

$$a_{ij} = m_{ij} + d_{ij}$$

where: a_{ij} is the per unit input of good i into sector j
d_{ij} is the domestic component of a_{ij}
m_{ij} is the imported component of a_{ij}

-with import types and domestic sectors being identically classified.

We are interested in what happens to the domestic-imported mix when relative prices change, that is as between the price of the imported component of type i and the domestic component of type i. It is desirable to be able to utilise more of the cheaper component, from whatever source. Consider the case of import substitution where the degree of such is determined by three factors:

1. The technical feasibility of substitution in the long term, being represented as a matrix S of elements s_{ij} which define the degree of possible substitution of import i into sector j.

One might expect the s_{ij} to be differentiated purely with respect to type of import i so that the same degree of substitution would occur irrespective of the sector concerned. This would doubtlessly be the case if each category i actually defined a homogeneous commodity. Recall from Chapter 3, however, that each import category encompasses numerous similar commodities, each with its own degree of substitutability, and which are combined in different proportions into the various sectors. Hence the need for a matrix of s_{ij} rather than for a vector of s_i. (The S matrix for the 1981/82 based version of the model is given at the end of the thesis in the data appendix.)

2. The time horizon under consideration. A parameter π defines the proportion of s_{ij} that is thought to be feasibly substitutable over the model period, that is over the medium term.
3. Price inducement, requiring an elasticity ϵ_{ij} relating quantity response to differences in relative prices, (domestic versus imported).

These factors operate through the following equations (numbered as in Chapter 4) which determine the new volume import coefficient or, more exactly, the new imported component of the composite input a_{ij}.

$$m = hm(C) + m(NC) \qquad (3)$$

$$h = \epsilon\frac{[p/q - p(0)/q(0)]}{p(0)/q(0)} + 1 \qquad (4.2)$$

$$m(C) = m(0)\pi S \quad \text{(omitting the i and j subscripts)} \qquad (5)$$

--- where: $m(NC) = m(0) - m(C)$

C and NC denote the competitive and non-competitive components; m(0), p(0), q(0) are the base year values of m p q, and all other variables pertain to the horizon year. Note that usually $p(0)=q(0)=1$, $\Rightarrow h=\epsilon[(p/q)-1]+1$.

Thus the new import coefficient m is equal to the base year coefficient m(0) plus an allowance h for relative price based substitution of the competitive portion m(C), where m(C) is calculated from m(0) using equation (5).

It remains to determine the new d_{ij}. Either one assumes that composite inputs are substitutable with one another with unitary elasticity, or that they are non-substitutable. In the former case the input-output coefficients in value terms (α_{ij}) are constant and are defined by

$$\alpha_{ij} = \rho_{ij} a_{ij} / p_j$$

where $\rho_{ij} = (q_{ij} m_{ij} + p_i d_{ij}) / a_{ij}$

Hence $d_{ij} = (p_j \alpha_{ij} - q_{ij} m_{ij}) / p_i$ (6.2.1)

In the latter case with a substitution elasticity of zero, the a_{ij} are constant. Hence:

$$d_{ij} = a_{ij} - m_{ij} \qquad (6.2.2)$$

Consider an example to illustrate how these equations work. For some import i into sector j, let:

S_{ij}=80% π=50% ϵ_{ij}=2.0 $m_{ij}(0)$=0.20
=> $m_{ij}(C)$ = 0.08
& $m_{ij}(NC)$= 0.12

Let the price of the imported good i rise from unity to 1.2 and that of the domestic good i from unity to 1.05. Then from equation (4.2) h=0.75. So the new import coefficient is:

$$m = (0.75 \times 0.08) + 0.12$$
$$= 0.18.$$

Note that the <u>long run</u> (that is where π=1) non-competitive part has remained at 20% of 0.20, = 0.04 whilst the competitive part has declined from 0.16 to 0.14, a reduction of 12.5%. Also the change in relative price is (1.05/1.20) -12.5%. That is, the domestic price has fallen by 12.5% relative to the imported price. Thus in this example the overall relative (cross) price elasticity for the competitive import component is unity, which also equals ϵ multiplied by π.

To determine d_{ij} with unitary elasticity between composite inputs, let α_{ij}=0.45 (which is constant) so that initially d_{ij}=0.25 and let p_j rise from unity to 1.10. Then from equation (6.2.1) the new d_{ij} is:

$$d_{ij} = ((1.1 \times 0.45) - (1.2 \times 0.18)) / 1.05$$
$$= 0.2657$$

If zero elasticity between composite inputs is assumed, which is the usual choice, one has simply:

$$\begin{aligned} d_{ij} &= 0.45 - 0.18 \\ &= 0.27 \end{aligned}$$

In the former case, since p_{ij} which now equals 1.1106 has risen more than the price of the output of sector j (p_j), the 0.45 falls to 0.4457; this being a consequence of the unitary elasticity between composite inputs. In the latter case with zero substitutability there is no change in the input-output coefficient a_{ij}=0.45 and in both cases the domestic component of the composite good has increased at the expense of the imported component, the price of which has risen relatively more.

The formulation of the import demand function may seem unnecessarily complicated and possibly suspect with three parameters (ϵ π S) being employed to achieve what is essentially only one objective; the prevention of unrealistic degrees of import substitution or import expansion. What in fact is the resultant total elasticity, being the change in the import coefficient in response to p and q differences? Is the joint effect of the three parameters meaningful or would it be better to combine them into a single parameter?

Equations (3), (4.2) and (5) can be amalgamated thus:

$$m = \{\epsilon\frac{[p/q - p(0)/q(0)]}{p(0)/q(0)} + 1\}\pi S m(0) + (1-\pi S)m(0)$$

Let p/q be denoted more simply as p. Then:

$$\frac{m - m(0)}{m(0)} = [\epsilon\frac{(p-p(0))}{p(0)} + 1]\pi S - \pi S$$

$$= \epsilon\frac{(p-p(0))}{p(0)}\pi S$$

Or in differential form:

$$dm/m = \epsilon\pi S.dp/p$$

$$\Rightarrow \frac{dm/m}{dp/p} = \epsilon\pi S$$

$$= \eta \text{ say.}$$

Thus it is evident that the import demand function is a perfectly general reduced form equation which is consistent with any number of structural demand functions, with or without the assumption of profit maximization. Also its three parameters can be combined into a single parameter, namely a price elasticity, but one which is more broadly defined than the pure elasticity (ϵ). There is, however an advantage in using three parameters when econometrically estimated elasticities are scarce since it is easier to make informed guesses about the values of well defined parameters than about an all encompassing parameter. For example, until commercial quantities of gas were discovered in New Zealand, petrol had few ready substitutes especially in transport uses. Now CNG and LPG are available and a synthetic petrol plant is also being constructed. In response to these developments by how much would one change an overall elasticity of substitution (assuming such substitution was not modelled exogenously)? The inherent substitutability of these alternative fuels has not changed, just their availability. Therefore it is not strictly correct to alter a price elasticity of demand. But it makes good sense to increase the appropriate S_{ij} parameter from zero to unity, set π as usual in relation to the model's time horizon and leave ϵ_{ij} unchanged

The benefits of using three parameters may not always be very great but they can never be negative as the parameters can always be amalgamated.

When speaking of the degree of substitution between imported and domestic goods it is often convenient to use the concept of the Allen (partial) elasticity of substitution (AES). Much (overseas) information on import-domestic substitution elasticities is expressed in this terminology and one naturally wants to be able to utilise such information wherever it is appropriate. The standard definition of the elasticity of substitution between two goods is:

$$\sigma_{yx} = \frac{d(y/x)}{d(p_y/p_x)} \cdot \frac{p_y/p_x}{y/x}$$

which can be shown, as in appendix A of this chapter, to be equal to the Allen elasticity of substitution between two goods given by:

$$\begin{aligned} AES_{yx} &= \partial y/\partial p_x \; (p_x/y + p_y/x) \\ &= \frac{\partial y}{\partial p_x} \frac{p_x}{y} \frac{(p_x x + p_y y)}{p_x x} \\ &= \eta_{yx}/\theta_x \end{aligned}$$

--- where θ_x is the share of good x in the total value of x and y, and η_{yx} is the price elasticity (as before). It can also be seen that $AES_{yx} = AES_{xy}$ in accordance with the symmetry conditions of profit maximization. From the previous page then, the cross price elasticity of demand for imports with respect to domestic price is:

$$\eta = (\partial m/m)/(\partial p/p) \equiv \eta_{MD}$$

The cross price elasticity of demand for domestic products with respect to the price of imported goods is determined thus:

$$d = a - m \qquad \text{(equation 6.2.2 given earlier)}$$

$$\Rightarrow \partial d/d.d/a = -\partial m/m.m/a \qquad \text{(where } \partial a/a=0 \text{ for zero substitution between composite inputs)}$$

$$\& \; \eta_{DM} \equiv \frac{\partial d/d}{\partial q/q} = \frac{-\partial m/m.m/d}{\partial q/q}$$

$$= \frac{\eta m}{d} \text{ , as } \frac{\partial m/m}{\partial q/q} = -\eta$$

Hence $AES_{MD} = \eta/\theta_D$ and $AES_{DM} = \eta/\theta_M.m/d = AES_{MD}$

By way of example, for the economy as a whole domestically supplied inputs into both intermediate demand and final demand constitute about 62% of the total value of gross output plus final demand. Imports supply a further 9% with the remainder coming from factor inputs. Hence:

$d = 0.62$

$m = 0.09$

$\theta_D = 0.87$

$\theta_M = 0.13$ (with all prices equal to unity).

So for typical model exogenous values of $\pi=0.9$, $\epsilon=2$ and $S\approx43\%$, the mean AES value is 0.89. This value includes those imports classed as non-competitive. It is perhaps better, and certainly more conventional, to speak about an AES with respect to only those imports which are competitive. Accodingly $\theta_D=0.94$ which gives a mean AES of 1.92. This is very close to the value of 2 used in many other models with a similar level of sectoral disaggregation, such as the ORANI model.[1]

Similar calculations can be done for any single commodity category or for any sector.

Given any AES value, from some independent study say, it can easily be inserted into the model which will endogenously determine the corresponding price elasticity (ϵ) or (η), over-riding any existing (default) values where appropriate. The generalised form of the model's import-domestic substitution function means that the exact specification of the equations used to estimate the given AES value and the assumptions underlying it, are irrelevant. Thus the model has an advantage over econometric models since it allows users to set whatever values of ϵ π S, or AES they may deem appropriate to the issue under investigation, without risk of upsetting any cross restrictions with respect to other model parameters. This property also enhances the model's amenability to sensitivity analysis.

Finally it should not be forgotten that import-domestic substitution in private consumption uses the the same specification as intermediate import-domestic substitution, including the option of zero or unitary substitution elasticity between composite commodities. Thus the above discussion is relevant also, 'mutatis mutandis' to private consumption.

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[1] See for example Alaouze [2].

Import-Domestic Substitution in Other Final Demand

Import-domestic substitution in government consumption incurs a unitary elasticity of substitution. Consider a simple example with reference to equations 15.1 and 15.2 of Chapter 4.

$$G_i^D = \zeta_i^D \Phi^G Y/p_i \tag{15.1}$$

$$G_i^M = \zeta_i^M \Phi^G Y/q_i \tag{15.2}$$

--- where ζ_i is the share of government consumption (G) spent on good i
Φ^G is the share of total national income (Y) spent on G

Let expenditure on two composite inputs total \$100, and be distributed thus:

\$60 on good G_1 of which G_1^D is \$40 and G_1^M is \$20
\$40 on good G_2 of which G_2^D is \$30 and G_2^M is \$10

--- where (as usual) D and M indicate domestic and imported components. With all prices initially at unity let q_1 rise to 1.1, q_2 to 1.2, p_1 to 1.06 and p_2 to 1.04. Assuming total expenditure falls to \$90 the new pattern of expenditure is:

$$G_1^D = (0.4 \times 90)/1.06 = \$33.96$$
$$G_1^M = (0.2 \times 90)/1.10 = \$16.36$$
$$\Rightarrow G_1^D/G_1^M = 2.076 \text{ whereas it was 2.0, an increase of 3.8\%.}$$

As expected this yields a relative (cross) price elasticity of unity since the change in relative price between the domestic good G_1^D and the imported good G_1^M is -3.8%. Similarly G_2^D = \$25.96 and G_2^M = \$7.50, giving a change in the domestic-imported ratio of 15.4% in response to the relative price change of -15.4%.

Note that substitution with unitary elasticity also occurs between the composite commodities. Initially G_1/G_2 = 1.5 which rises to 1.504, a rise of 0.26%. And the composite good price ratio falls from 1.0 to 1.0731/1.0759 = -0.26%.

Substitution elasticities of unity are assumed both between composite goods and between the domestic and imported components of each composite good, for both government consumption and stock change. Only the latter form of substitution applies to investment goods. It is intended that these routines be improved as time and data permit.

Import Licensing

When import barriers take the form of non-tariff measures, in particular quantitative quotas or import licences as they are generally known in New Zealand, it can be difficult to model the effect of their removal. Although the tariff equivalent can frequently be ascertained one cannot just lower such tariff equivalents on the removal of import licences (IL) since IL removal does not (theoretically) reduce domestic import prices, as would the removal of tariffs. Before proceeding any further we should distinguish two forms of IL:

1. Strict quantity - fixed price rationing where the allocation of the available licence is based on 'non-market' criteria such as demonstrated need, past allocation or political influence.
2. Premium rationing where the licences are tendered to the highest bidder.

In the JULIANNE model base year of 1976/77, IL in New Zealand was of the former type but in recent years the auctioning of licences has become more prevalent.

For modelling purposes the difference between protection provided by tariffs and that provided by auctioned IL is irrelevant. The premium which results from the tender is eventually a surcharge on the price of the import, just like a tariff. The only difference is that the exact rate of tariff is known in advance. However, any solution of the model pertains to the end of a full year, at which time the premium rates which applied during that year are known and it is assumed that at the time of tendering no buyer was forced into paying a premium of unknown amount. Thus, premiums enter the composite commodity (M-D) demand functions in the same way as tariffs. Furthermore, when IL is removed the premium vanishes, again the same effect as when a tariff is revoked.

Hence for the remainder of this section references to IL will mean fixed-price IL unless otherwise stated. How then does one model changes in IL of that type? Two assumptions will be made; to be reviewed later.

1. The existence of IL implies that a cost excess exists on the equivalent domestically produced good.
2. Those who are fortunate enough to obtain a licence utilise their monopoly type power by charging high prices to the

> ultimate buyer, or if the importer is himself the ultimate user, he is able to realise a greater profit than if he had been forced to purchase the more expensive domestic product.[2]

When an import is brought in via an importing agent for sale to a subsequent buyer the final price to that buyer is, in an input-output table, split into two rows: the row of the import type - which represents the basic price of the import, and the row which represents the agents markup - namely the row corresponding to the sector in which the import agent is classified which is usually the W/R Trade sector.

The removal of IL should then be modelled by the deletion of this latter 'input' since the monopoly power previously conferred by the IL is lost. However, in practice this is extremely difficult since data is not (readily) available on the proportion of a sector's imports which comes through the Trade sector, nor on the mark-up introduced as the imports pass through, although presumably this is well approximated by the cost excess. Even given all the relevant information a further difficulty is that the price of inputs from the Trade sector would be different for each buyer due to each buyer having a different composition of imports. Modelling this entails the development of routines which distinguish between goods and sectors. Whilst this is not an impossible task it is nonetheless one which would require a considerable time input. If the relevant data becomes available the project may be attempted.

When a licensed import is imported directly by the actual user his supernormal profit appears in the Operating Surplus row of the input-output table. Thus the removal of IL would in this case be modelled by a reduction in the share of value added attributable to capital. Apart from the problematic impact this would have on the parameters of the model's production functions, one again does not know the proportion of imports that are directly imported. How then does one model the removal of IL as it occurs in New Zealand?

Prominent general equilibrium modellers such as those whose models were reviewed in Chapter 2, offer little help, perhaps because IL is insignificant in the economies with which they are concerned. Even

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[2] Lane [55] writing in 1974 observed: "Import agents acquired allowances which were vitually sold to the real importer," but that "... the import wholesaler is now a relatively unimportant figure in New Zealand. The Licensing Authority prefers to grant licences to the receiving firm ..."

Dervis et al [25] who investigate alternative methods (including import licensing) of coping with foreign exchange shortages, do not deal with the removal of an existing IL regime that is intrinsically embedded but not explicit in one's database. The procedure adopted in JULIANNE is as follows:

1. All import licences with associated cost excesses are converted into tariff equivalents, thereby raising values in the import duty row of the (base year) input-ouput table.
2. To compensate for this, that is to avoid double counting, indirect tax payments by sectors and final demand are reduced as if the cost excess induced profits were previously part of this category of inputs rather than, as we know, part of the Trade and/or Operating Surplus categories.

This method means that whether imports are imported directly or via an agent is irrelevant. Theoretically when IL is removed, sectors that import directly incur a reduction in profit since they must now lower their prices so as to match import prices, whilst those that import via an agent benefit since the effective price of their imports is lowered. Under neoclassical pricing a reduction in output price occurs in both cases. In the model a reduction of tariffs (equivalent to IL) has the same result.

With regard to the base year, the re-allocation from taxes to tariffs has no major distortionary effects. However, once IL is removed in some target year the model would show a reduction in tariff revenue accruing to the government whereas in actual fact this would not be occuring unless the previous supernormal profits were being directed into government coffers. Corresponding to this overstatement of the decrease in government revenue would be the understatement of the reduction in profits of importers of previously IL-restricted goods. The former is not of great concern since government revenue and expenditure flows are not modelled in JULIANNE, whilst the distortion in profits, especially in the Trade sector should be looked upon as the price one has to pay for incorporating IL, given a lack of more comprehensive data.

Returning now to the two assumptions listed earlier; what happens if there is no cost excess, or if no one is profiting from one which does exist? (Both situations are probably rather rare in New Zealand).

If there is no cost excess the justification for IL is purely as a method of balance of payments control. When IL is removed the cost of obtaining imports does not change so the above method is inappropriate. All that changes is a sector's accessibility to imports. If there is a cost excess but no one is extracting a profit from it the same logic applies except that if a sector substitutes relatively cheaper imports for domestic goods its cost structure will fall. The way to model this situation would seem to be by changing the import-domestic substitution elasticity since IL is essentially a barrier which limits the full exploitation of import-domestic price differentials, where they exist.

Of course there is no reason why changes in the substitution elasticity should be confined to cases where no IL induced profits exist. The major problem is again one of data; namely in determining by how much an elasticity should be changed when simulating IL removal. There is no precise functional relationship between the elasticity and the degree of IL, and there is no easy way to assess the degree of substitutability between IL controlled imports and the corresponding domestic goods. In the absence of any information to the contrary and given the degree of sectoral aggregation in the JULIANNE model, (a most important point), the default option is to assume that licensed imports are no more substitutable with domestic products than unlicensed imports. For the year ended June 1983 about 22.2% of imports by value were subject to licence.[3] Thus the substitution elasticity would rise by about 30% (1/(1-0.22)) as a result of IL removal. Needless to say this is a very crude valuation but meantime it must suffice.

In mentioning the degree of aggregation it should be remembered from the discussion in Chapter 3 that this also impacts in two other ways. Firstly, when ascertaining the degree of IL one must beware of situations where a particular commodity imported by a sector may not actually be subject to the licence applying to that general import category. For example, if textile imports generally incur an IL equivalent tariff of 30%, the full amount may not apply to imports of a particular textile product such as woollen carpets. Hence a sector which imports this product should not be modelled as paying the full tariff.

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[3] Source: Department of Statistics [21].

Secondly, the degree of sectoral aggregation is the major reason why it is not practical to model IL by the most obvious means; directly incorporating the actual quantitative restrictions. When such a constraint became binding the price of the good involved would rise accordingly so there would be no need to determine the tariff equivalent - a concept with well known disavantages. (See for example Dervis et al [26]). However, the level of sectoral disaggregation would need to be much finer to render this a feasible alternative to the method described above - as noted in the second part of Chapter 3.

Exports

Recall that the export demand function (for each commodity) is given by:

$$E = E(0)\psi[p(1+s)/ep^{W}]^{\eta}$$

That is, the volume of exports demanded is a function of a curve shift parameter (ψ) and the New Zealand price ($p(1+s)/e$) relative to the competing world price (p^{W}), where p is the price of production, s is the rate of export subsidy and e is the exchange rate. The base year level of exports and the price elasticity of demand are given by $E(0)$ and η respectively. Both the world elasticity of demand for each product and the size of the world market held by New Zealand are considered when setting the demand elasticity for the New Zealand product, which varies directly with the former and inversely with the latter. Unfortunately these relationships lack solid empirical quantification. Research into N.Z. trade related parameters: import-domestic substitution elasticities, export demand elasticities, supply elasticities etc., is reviewed in O'Brien [67] and this provides a convenient source of data. However, most of it relates to aggregations of traded commodities, particularly on the demand side, so that much (intelligent) guesswork is still required. Hence the somewhat deficient export demand specification in terms of the desiderata mentioned in Chapter 3.

Nevertheless the given equation will simulate (via the shift parameter) shifts in demand due to either world income growth, the removal of protectionist barriers against N.Z. exports, or to the zeal of exporters in establishing new markets. It will also handle the effects of changes in the price of competing goods, changes in the cost of production, changes in subsidies such as SMP's and EPTI's,[4] and changes in the exchange rate. Its major limitation is that it does not allow for imperfect substitution in production between goods for the export market and those for the home market, within a given sector. Such substitution can be captured with CRETH production functions, as is currently being investigated within the Research Project on Economic Planning with respect to the agricultural sectors.

How does the export demand function perform in extreme cases; that is, when the price elasticity of demand is either zero or infinity? Let the function be rewritten as:

$$E = E(0)\psi(p/p^{W})^{\eta}$$

where p is the previous $p(1+s)/e$.

When the price elasticity is zero a given quantity is sold whatever the price. This is modelled by inserting the quantity exogenously and allowing it to be sold at a price p irrespective of the price of competing products on the world market p^{W}. None of the commodities in JULIANNE are likely to have such a demand curve but those those with the lowest demand elasticities are generally considered to be dairy, meat and wool products.

With infinite elasticity the relative price term, if not equal to unity, will either vanish or explode. The former is trivial. The latter requires the level of exports to be determined by factors other than demand, notably supply conditions. Before pursuing this matter let us consider what happens when $p=p^{W}$. The equation collapses to $E=E(0)\psi$ irrespective of the value that η may have. Hence the volume of exports is essentially exogenous, so that the situtation appears identical to the zero elasticity case. However, it is not identical since with a perfectly elastic demand curve one cannot distinguish between constant price shifts of the curve and movements along it. So a given value for the shift factor (ψ) is rather meaningless. It is therefore legitimate to use the shift factor as an (extra) endogenous policy instrument to achieve some given objective. Most obviously, for example, a particular ψ_j could be used to achieve some target level of output or employment in the corresponding sector, notably in the case of

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[4] Supplementary Minimum Prices and Export Performance Taxation Incentives, all converted into price subsidy equivalents.

a sector specific factor.

Potentially the number of extra target variables is as large as the number of export commodities if they all had infinite elasticities. If relative export volumes are fixed, for those exports that have infinite elasticities, there would only be one target variable, for which a uniform scaling parameter on the shift factors is the associated instrument. Indeed, a zero mean rate of export subsidy or the terms of trade have proved to be useful targets, since under the small country assumption trade prices are given.

Reactions to 'large' elasticities during the solution process can be expected to cause the price ratio (p/p^W) to diverge from unity, yielding either zero or enormous levels of exports which would upset the convergence properties of the algorithm. Hence one has to let export subsidies be endogenous so that the unity price ratio is maintained at all times. Accordingly, one makes the not unreasonable assumption that if the price elasticity for some commodity is indeed (close to) infinity, that commodity must be sold at the going price, namely p^W, so that p and p^W must be equated via a 'subsidy'.[5] Should one simultaneously also desire a zero rate of subsidy the corresponding shift factor can assume the role of the instrument.

The essential difference between the two elasticity extremes of zero and infinity (with a price ratio of unity always associated with the latter) is that when the elasticity is zero, the quantity is for all purposes exogenous. When the elasticity is infinite the model's equations would, if left unaltered, yield that same level of export volumes. But virtually by definition one does not want exogenous exports in such circumstances. So if export volumes are to be endogenous (as is usual), some other variables such as the ratio of p to p^W, must be made exogenous for which the curve shift parameters can be the endogenous instruments.

There are no export commodities currently identified in JULIANNE which have infinite price elasticities of demand as a matter of course, although some experiments have been done with infinite elasticities in the manner just described - see Chapter 8. Usually the highest

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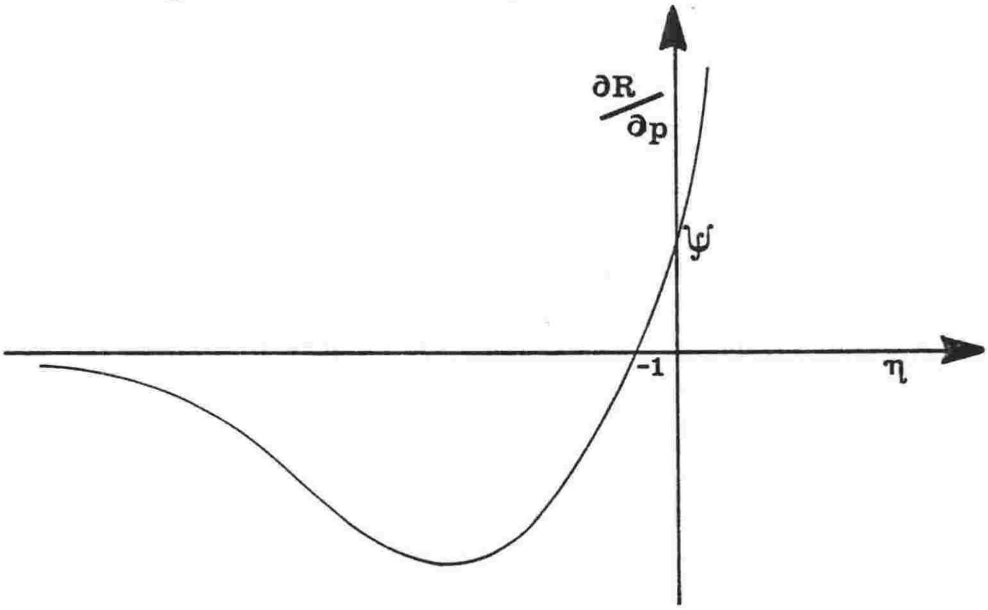
[5] In some circumstances an exchange rate change could be used instead but the homogeneity of the model implies that if the exchange rate and all factor prices change by the same amount, no re-allocation of real resources will occur.

elasticities are those for manufactures at about (negative) five or six.

A final point on the nature of the JULIANNE export demand function concerns its behaviour for particular, non-extreme, combinations of relative prices and elasticities. One usually assumes that the higher the (absolute) elasticity, the greater the benefits from a reduction in price. Surprisingly perhaps, this is not necessarily the case as is shown in figure 1 which graphs the change in revenue arising from a given change in price (p) when the relative price ratio (p/p^W) exceeds unity. Proof of the shape of this curve is given in appendix B of this chapter. (Note that e and s are ignored here as they can be subsumed into p and p^W.)

Figure 1: Revenue Changes and Elasticity



For example when the price ratio equals 1.2 there is a minimum at an elasticity of -6.48. At an elasticity of -3 the minimum is at a price of 1.284. Thus although there is always an increase in revenue for a decrease in price (with $\eta<-1$), this increase reaches a maximum. That is, it reaches a point beyond which no <u>further</u> revenue gains accrue from having a higher absolute elasticity. This is because the revenue gains are progressively negated by the fact that for any price ratio greater than unity, the higher is the elasticity, the less is the quantity sold and thus the less the revenue. And not unexpectedly, the higher is the price ratio the lower is the critical elasticity (with a limit of -1) at which this turning point occurs.

The situation is an oddity in the nature of the function and it is as well to be aware of it, especially when testing model sensitivity to different export demand elasticities over various combinations of p, p^W and e. Again one stresses that such a turning point can arise with quite common variable/parameter values, although the effect on model results should generally be very small. There is certainly no justification for discarding the function forthwith since there is nothing which is logically at fault. One should, however, be aware of an equation's eccentricities so that one will not be puzzled or misled by results on the occasions that this eccentricity surfaces.

Production Specifications (CRESH)

As stated in Chapter 4 the JULIANNE model has three production function specifications.

1. Cobb-Douglas
2. Reduced form CES
3. Constant Ratios of Elasticities of Substitution, Homothetic

The Cobb-Douglas specification is well known and thus requires no elaboration here. A 'reduced form CES function' is a convenient way to describe the differential function detailed in Chapters 4 and 5, as it is consistent with the CES function but does not entail the exact CES form being assumed. Again the CES function is well documented in the literature.

The CRESH specification is less widely understood. (An excellent presentation is given Hanoch [45]). Essentially it is a function which permits different pairwise elasticities of substitution between inputs, subject only to the restriction that the ratio of the elasticity between inputs i&j to that between i&k is the same for all inputs. It is thus not as general as the translog function to which the ratio restriction does not apply, nor is it as good at handling complementarity between inputs and of course it cannot be considered as a second order approximation to any unknown function. However, these disadvantages are fairly minor when, as in JULIANNE, only ten labour input categories are identified. On the purely practical side one must balance the theoretical disadvantages against the fact that Australian estimates of the substitution elasticities based on a CRESH function are available, whilst (to the author's knowledge) no Australian or New Zealand translog specifications have been estimated for ten labour types. In New Zealand the required data does not exist - for either translog or CRESH. Even the Australian database was far from ideal.[6]

As has been maintained throughout this thesis, the estimation of all the parameters for the JULIANNE model is a thesis in itself and estimating CRESH or translog functions would constitute a significant part of it. Thus when suitable information is available from other studies one has no hesitation in including it in JULIANNE. An incidental benefit to this is that it goes some way to answering those critics of general equilibrium modelling who do not like the liberty the modeller has in setting parameter values.

The occupational substitution elasticities from the Australian study are given in Chapter 7, section 5. From these values it is possible to work backwards to obtain the values of the parameters in the actual CRESH equation. This procedure is described and exemplified in Stroombergen [88].

Non-Constant Returns

It was shown in Chapter 3 that a simple GE model could easily be indeterminate unless assumptions such as free factor mobility, perfect substitutability between domestic and imported goods, or constant returns to scale, are abandoned. Fortunately, discarding (some of) these assumptions is expedient both practically and theoretically; the former because indeterminacy is thereby removed and the latter because, as discussed earlier in this chapter with respect to import-domestic substitution, such assumptions are frequently unrealistic. Limited factor mobility for example, is more relevant in the short term than in the medium term. Even land has some mobility beyond the short term - in the sense of use. Thus, since JULIANNE is a medium term model, sector specific factors are not usually distinguished.

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[6] See Higgs et al [50, pp. 10-11 & 37-45].

Non-constant returns, like imperfect substitutability between domestic and imported goods, are a fact of (economic) life, although probably not as pervasive at the JULIANNE level of disaggregation. Still, it is desirable that an economy wide model be amenable to their inclusion. In JULIANNE non-constant returns are incorporated by augmenting the production function. We deal firstly with decreasing returns, of which there are two types:

1. Decreasing returns to all but one factor of production where that factor is in fixed supply.
2. Decreasing returns to scale involving all factors.

Increasing returns are discussed afterwards and some model runs are then presented to exemplify the modelling routines.

Modelling decreasing returns in the case of a fixed factor presents no problems. For example consider the specification of a production function in agriculture as:

$$X = \theta L^{\alpha} K^{\beta} N^{\gamma} \qquad (*)$$

--- where $\alpha+\beta+\gamma=1$ and land (N) is in fixed supply.

If we increase L and K by some proportion λ, X rises to X':

$$\begin{aligned} X' &= \theta(\lambda L)^{\alpha}(\lambda K)^{\beta} N^{\gamma} \\ &= \lambda^{\alpha+\beta} X \\ &< \lambda X \text{ as } \alpha+\beta<1 \end{aligned}$$

As output expands, requiring proportionately more of inputs L and K, their marginal products decline whilst that of land increases. So as it becomes scarcer it commands a higher price. Diagrammatically this is shown in figure 2 (ignoring K).

Initially employment is at L_1 with the wage at w_1 and the VMP of land is given by the area at the top of the diagram above the line $w=w_1$. When output rises, requiring more labour, the wage rate declines since the marginal product of labour declines and the value of land rises - by the area shaded ////.

Under decreasing returns <u>to scale</u> with marginal productivity payments to factors, the sum of those payments does not exhaust the value added product, whereas it does do in the case above. In physical

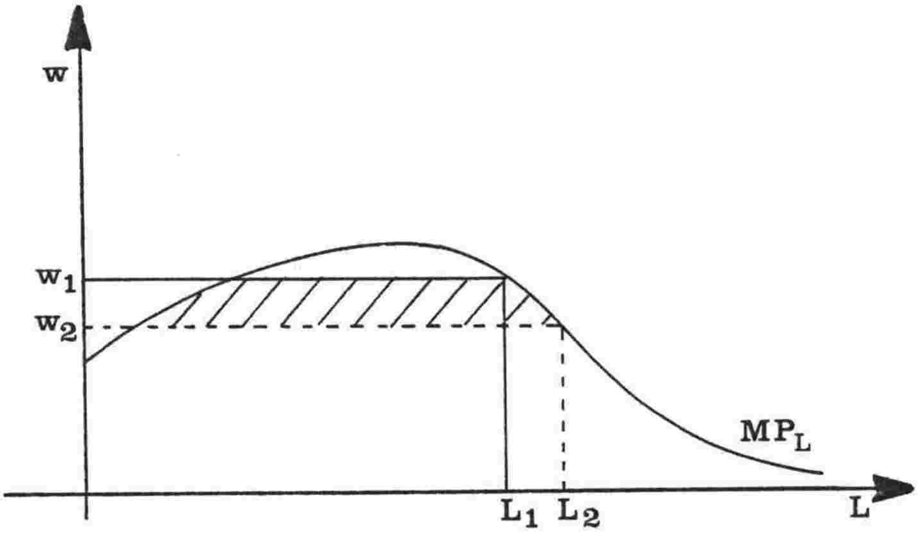

Figure 2: Marginal Product of Land

terms decreasing returns to scale are certainly possible in the sense that successively adding more of every input yields progessively smaller additions to the volume of total product. But in general equilibrium all income and expenditure must be accounted for, even if industries with decreasing returns to scale exist; so that one cannot have the sum of payments to factors, possibly including profits in excess of pure profits, not equalling the total value of net output without causing some kind of imbalance or disequilibrium.

In order to secure income-expenditure equilibrium it is necessary to tax the producer so that factor input payments will exactly exhaust the net product, thereby forcing production at the socially optimal point where price equals marginal cost. This is shown in figure 3 by the point B. The producer still makes a profit at this point although not as much as at point A.

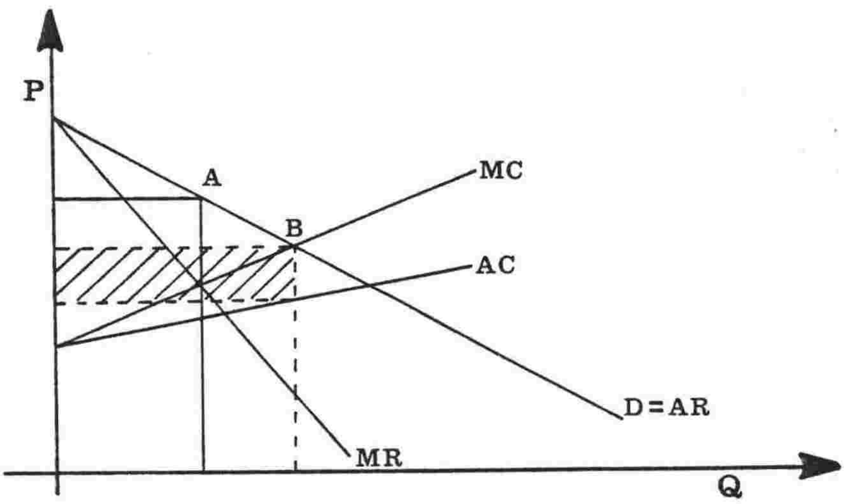

Figure 3: Decreasing Returns

One way of levying the tax (to prevent the supernormal profit) is to incorporate an extra factor into the production function such that constant returns to scale are re-introduced via the 'true' production function. The extra factor is a proxy for some externality, possibly subject to a fixed supply (as above), with a price that ensures the equality of net product and factor payments. For example, in a situation where progressively less able labour is hired causing decreasing returns to scale, the proxy factor could be interpreted in association with the labour input as the effective labour input - a physical unit of labour multiplied by a level of training or education, the cost of which is the price of the proxy factor. This cost would rise faster the scarcer is the supply of the factor; be it education, management skills or whatever. Hence under a fixed supply constraint the modelling of decreasing returns to scale is very similar to modelling decreasing returns to all but one factor.

With or without fixed supply one is redefining the production function to include by proxy, the influence of some externality that was previously omitted in an 'incorrect' specification.[7]

Alternatively one could simply levy a production tax equal to the amount of the excess profits but it is conceptually more satisfying and (as it happens) computationally easier in the model's solution algorithm, to define an extra production factor.

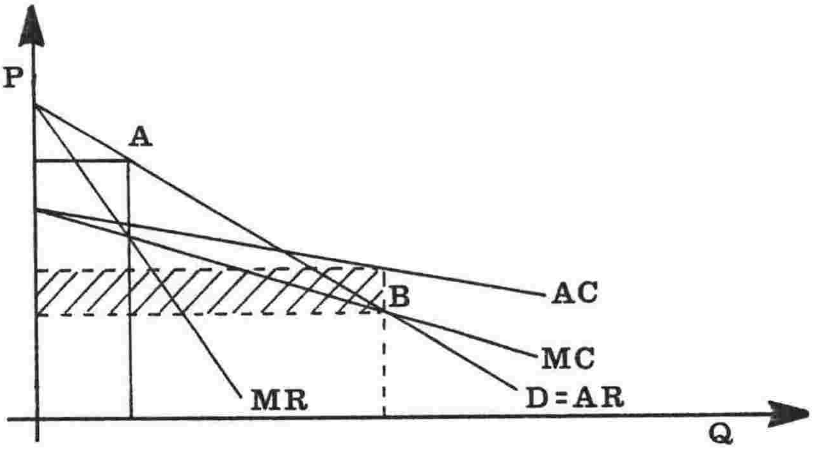

Figure 4: Increasing Returns

Increasing returns to scale can be handled by similar means. Instead of an extra factor with a positive price the extra factor has a negative price. That is a subsidy is required to induce production to be at the

[7] In this connection see Layard and Walters [56, p65].

socially optimal point where the firm pays each factor its VMP, (although under increasing returns the firm would pay each factor its marginal product times marginal revenue, which is below VMP). Without the subsidy, payments to factors would exceed the value of net output resulting in a loss to the producer, given by the shaded area in figure 4. Note that above normal profits would occur if the firm was allowed to produce at the profit maximising point.

An Example

The model is subjected to a 10% outward movement of the demand curve for exports of horticulture and wool under three different production specifications in the Agricultural sector, viz:

1. Constant returns with a labour share (α) of 52% and a capital share (β) of 48%. Then using equation (*):
2. Decreasing returns under a fixed factor (N) say land, with a share (γ) of 5% and with the labour and capital shares reduced by 5%.
3. Increasing returns using a proxy factor (again in fixed supply) with a share of -5% and with the labour and capital shares raised by 5%.

What differences does one expect if decreasing returns (DR) prevail instead of constant returns (CR)?

1. A greater per unit change in the input of labour and capital.
2. A higher price of Agricultural output.
3. Ceterus paribus; higher prices everywhere leading to less exports, less GDP and less employment.

The results are given in table 2 and confirm one's expectations. Agricultural output rises less under DR than under CR and the change in the usage of both L and K increases more so that per unit input requirements have certainly risen.[8] The price of Agricultural output rises more under DR due primarily to the increase in the price of the proxy factor - land, if we interpret the DR as occurring with respect to labour and capital; or due to say farm management skills if we interpret the DR as decreasing returns to scale, where the production function is incorrectly specified with only labour and capital being included and

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[8] The shift to labour intensity is because the total supply of capital to the economy was fixed but employment was not.

TABLE 2

Modelling Non-Constant Returns - an example

(% changes on a control run)

	constant returns	decreasing returns	increasing returns
Employment	1.51	1.49	1.55
Private Cons. (real)	1.18	1.16	1.20
Exports (real)	0.23	0.14	0.29
Imports (real)	1.27	1.22	1.30
Gross Domestic Prod, (real)	0.66	0.58	0.68
Agriculture: Output	2.88	2.75	2.97
Employment	4.25	4.27	4.23
Capital	1.40	1.42	1.33
Price	1.08	1.17	1.01
3rd factor price	--	4.29	4.23*
Horticultural Exports	7.79	7.63	7.89
Wool Exports	7.70	7.51	7.84

(* from a negative value to a larger negative value)

with the sum of the exponents being less than unity.

The greater increase in the Agricultural price under DR has effects throughout the economy, causing smaller increases in private consumption, total exports, GDP, and total employment.

In the case of increasing returns not much needs to said since the differences between IR and CR are the reverse of those between DR and CR, although not always of exactly equal absolute magnitude.

One has not attempted to accurately model increasing or decreasing returns in Agriculture, but rather to illustrate the means by which non-constant returns can be incorporated in the JULIANNE model. Conceptually one can think of decreasing returns, given a fixed supply of some factor (with the decreasing returns accruing to the other factors), as distinct from externality-induced decreasing returns to scale. However, if the latter are interpreted as being attributable to a mis-specified production function, then modelling-wise the same procedure can be used for both and also, whilst accepting some sacrifice in the meaning of the proxy factor (although see Chapter 8), for increasing returns to scale.[9]

Another way to model non-constant returns to scale is via the efficiency parameter in the production functions. However, this method is not as theoretically appealing as that just described. It is generally used only for intertemporal changes in the relationship between inputs and output. That is, any increasing or decreasing returns to scale which might occur between the base year and the horizon year are subsumed into the exogenous efficiency parameter. Then, in any single horizon year, with efficiency held constant across alternative scenarios, non-constant returns to scale are modelled as above. Of course one is not bound to this procedure.

The model runs demonstrated that the method of production function augmentation yields results which conform to one's expectations. This should encourage further study of the actual degree of decreasing or increasing returns in New Zealand industries, study which at present is severely lacking.

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[9] Increasing returns as in the first sense of decreasing returns are considered to be most improbable.

Investment

Part 1: The JULIANNE Formulation

Consider figure 5. Let the long run maximum equilibrium growth rate of capital be represented by the vector a, whilst the present growth path is along b. To attain vector a there is a once and for all surge of growth entailing a major reallocation of resources, possibly with negative growth in some sectors. This is represented by vector c. By definition this cannot be sustained so the extreme resource shifts quickly abate. In familiar growth theory, vector c is the on-ramp onto the von Neumann turnpike given by a.[10]

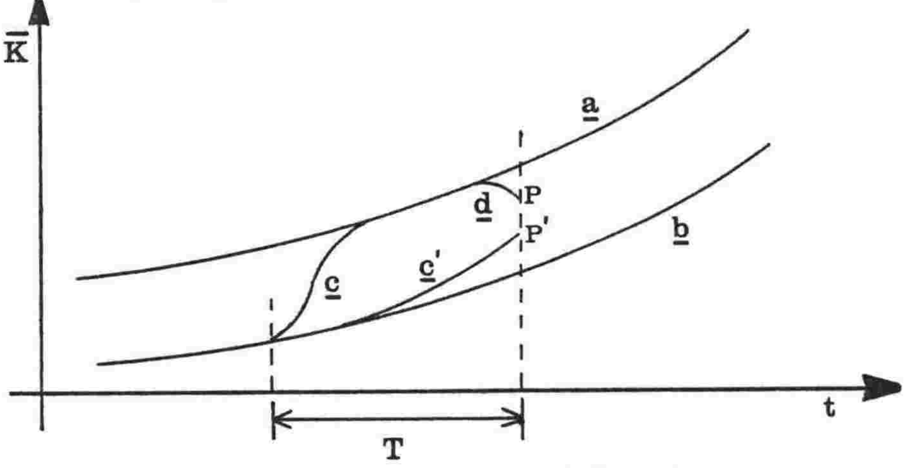

Figure 5: A Representation of Growth

Let P represent the horizon year of a snapshot model. Again by definition, P will be below a if society's preferences are such that the mix of capital it desires is other than that which yields maximum balanced growth. Of course for unbalanced growth, which may well be the case in the horizon year, P could be above a. Wherever P is positioned the optimum path is given by cad. Thus if the path is known so can be the profile of investment - both over time and by type. But with a snapshot model, especially a non-optimising one, this cannot be simulated.

How then should one formulate sectoral investment in the horizon year of a snapshot model? Since our primary concern is with medium term modelling where between the base year and the horizon year there is a void of 5-10 years, it is important to prevent the model from yielding

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[10] A good description of von Neumann growth theory is given in Koopmans' article "Maximal Rate of Growth", in Sen [80, pp. 295-339].

results which could never actually eventuate because of the implied reallocations of capital over the interim. Hence we need to ensure a not unrealistic capital mix in the horizon year. And because the model knows nothing about events beyond the horizon year (and neither do we), one can only assume that the post horizon year economy will be similar to the horizon year economy since the momentum of the profile of horizon year activity will dictate similar (immediate) post horizon activity.[11] The composition of the capital stock will thus change only slowly to match whatever pattern of activity might eventuate beyond the terminal year.

Sectoral investment in the JULIANNE model is therefore formulated as follows, (where all variables relate to the terminal year unless otherwise denoted and sectoral j subscripts are not shown):

(1.1) $I = (\lambda+d)K$ where d is the physical rate of depreciation

(1.2) $\lambda = [(K/K(0))^{1/n}-1]$

--- where n is the number of years between the base year and the horizon year, and K(0) denotes base year capital.

Or the alternative specification:

(2.1) $I = \lambda(K_t-K_{t-1}) + dK$ where $t \in \{1...n\}$

(2.2) λ = an exogenous parameter which may be constant across sectors.

In both sets of equations λ performs the role of a stock-flow factor, relating the total change in sectoral capital stocks between two given years (usually but not necessarily the base year and the terminal year), to the change in capital in the terminal year. There are numerous ways of setting this parameter, from simply specifying $\lambda=1/n$ for all sectors to more complicated expressions which allow for changes in sector specific capital that are known to have occurred between the model's base year and the current year.

Equations (1.1) and (1.2) set sectoral net investment in the horizon year equal to that sector's mean annual rate of capital accumulation throughout the model period. Thus a path such as $\underline{c}'$ in figure 5 is

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[11] In optimization and intertemporal equilibrium models that argument is even stronger since the optimum pattern of activity achieved in the horizon year should by definition be sustained.

implicitly assumed to reach a point P'. (Note that $\underline{c}'$ can only reach P' and not P since the path $\underline{c}'$ is less than optimal and therefore it either takes longer to attain P or alternatively, over a given length of time (T), only P' can be reached). In some experiments with the model investment was set as a special case of (1.1) with the value λ undifferentiated across sectors so that all sectoral capital stocks expanded at the same rate. But allocating investment in this way is only valid if the horizon year economy is on a steady state equilibrium growth path. Generally this would be an heroic assumption, although less so if the horizon year is reasonably distant from the base year. If the interim time span is too short there is a danger of the model producing absurd reallocations of capital as it is forced to quickly adjust the economic structure to the long run equilibrium growth path - a problem that also occurs with IE models, as noted in Chapter 2.

This possibility could exist even if a non-steady state growth path is admitted. For example, results pertaining to 1985 from a model based on 1977, could seem incongruous from a 1983 standpoint if the actual path of the economy between 1977 and 1983 had diverged significantly from the implicit model path. Hence the presence of equation (2.1) which links net investment in the horizon year (n) to the known change in capital stock between two recent years (t) and (t-1), where t can theoretically be any year from t=1 to t=n but is likely to be the most recent year for which data on investment is available.

A sector is seldom prevented from disinvesting faster than its rate of capital depreciation since many capital goods are intersectorally mobile - in the sense of use rather than portability. The model will indicate when such an occassion occurs, which is rare in medium term modelling, so that its realism can be (subjectively) assessed by the modeller. If it is deemed to be unrealistic one must allow idle capacity in the relevant sector.

Both of the above specifications of sectoral investment will yield an endogenous level of total investment by simple aggregation. However, it is sometimes desirable to set total investment or the investment-gdp ratio exogenously, at a level which is not necessarily exactly consistent with the implicit total. Such is frequently the case when one knows that the path of capital accumulation between the base year and the horizon year is not steady (as also in regard to equations 2.1 and

2.2). For instance, faster growth during the initial part of the period followed by slower growth toward the end could yield no difference in horizon year capital stock but a lower level of horizon year investment, than under steady growth. An exogenous investment-gdp ratio or total investment level may sometimes also be desirable across alternative contemporaneous scenarios, irrespective of what happens between the base year and the horizon year.

In cases such as these if equation (1.1) is used, the model endogenously scales the sectoral capital growth rates upward or downward as appropriate, via a simple loop as explained in Chapter 5. Clearly it is the responsibility of the user to ensure that whatever level of total investment or investment-gdp ratio is chosen, it must not be such as to yield a vast amount of scaling as one may then lose the very property that equation (1.1) is intended to achieve; that of base year - horizon year - post horizon year consistency. Naturally it is difficult to quantitatively define when consistency is no longer present. Model runs to date have generally encompassed a ±10% scaling restriction. If that is violated then the investment constraint and/or the capital stock constraint is revised to ensure greater mutual consistency. Indeed one may wish to let total capital stock be determined endogenously by the exogenous horizon year investment constraint and by the assumption of steady sectoral capital growth rates.

When it is desired to set both the total capital stock and the level or ratio of total investment, possibly using information extracted from 'outside' projections which may not be based on steady growth paths,[12] one should recall that the implicit steady growth path is really only a default assumption or an artefact, albeit a highly useful one. Thus, especially if better information is available, some degree of divergence between implicit investment and actual investment is a legitimate freedom.

Let us look then at how the JULIANNE investment formulation operates by assessing it with respect to the terminal conditions problem.

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[12] See Chapter 7 on the linking of JULIANNE to a macro forecasting model when it is used for projection purposes.

Part 2: The JULIANNE Investment Formulation Illustrated against the Terminal Conditions Problem

Whilst the JULIANNE model is not subject to the true terminal conditions problem, as it is not an optimization or intertemporal equilibrium (IE) model (as analysed in Chapter 3), there is still a need to ensure that the model does some investment in the horizon year. The closure rules of the model can supply an aggregate investment constraint or equation, but this in itself is not sufficient to guarantee 'correct' horizon year investment in each sector. So in a wider sense the terminal conditions problem is not irrelevant to JULIANNE. But it is forestalled by setting each sector's horizon year investment equal to the mean rate of capital accumulation throughout the model period, in that sector. This achieves the desired consistency, both between the base year and the horizon year, and between the latter and the immediate post horizon years. Unless terminal conditions can be set to be reasonably consistent with the solution values of the model's variables, as in JULIANNE where they are endogenous, there is a risk that the peculiarities of a given set of 'arbitrary' terminal conditions will distort the horizon year solution, indeed the entire period in a dynamic model. Thus to conclude this chapter on the details of the JULIANNE model, its sectoral investment routine is examined by assessing it with respect to the importance of non-distortionary terminal conditions.

To simulate the imposition of 'arbitrary' terminal conditions, the usual investment sub-loop within the solution algorithm (as described in Chapter 5) is <u>temporarily</u> nullified and sectoral investment is determined by the usual response to the terminal conditions problem, namely:

> In advance of solving the model an assumption is made about the mean rate of capital accumulation over the model period and the capital stock flow coefficients are then calculated using this rate.[13]

No matter how carefully such a growth rate is selected, even if it is different for each sector, it is inevitably inconsistent with the endogenous horizon year investment levels, that is in terms of the implied growth rates. To ascertain the effect of this inconsistency the

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[13] See for example Stroombergen [86] on this procedure in relation to the Project on Economic Planning's VICTORIA model.

model solution is compared with a solution, where for each sector, the growth rate assumed for the calculation of the stock-flow coefficients is identical to that implicit in the model solution. This is effected via an 'open' iterative approach on the stock-flow coefficients whereby these coefficients are manually revised after each model run. Such is the standard procedure when the model cannot endogenously perform the iterations, as is usually the case with programming optimization models,[14] and as opposed to JULIANNE where they are endogenous.

Algebraically the procedure is as follows. Net investment in each sector is set as (in the usual notation):

(3) $I_j = \lambda_j K_j$ (ignoring replacement investment)

--- where initially $\lambda_j = \lambda^*$, an exogenous value. Subsequently:

(4) $\lambda_j = [K_j(I)/K_j(0)]^{1/T} - 1$, where T=4 in the runs below.

Terminal year capital is denoted as K(I) rather than as K(T) to conform to the following nomenclature:

K(I) - terminal capital, 1st iteration, with λ exogenous at 2.71% pa.
K(II) - " " 2nd " with λ from equation (4).

In the third iteration K(I) in equation (4) is replaced with K(II) and so on until convergence is achieved which is when

$$[K(n) - K(n-1)]/K(n-1) \approx 0, \quad \text{for } n = I, II.....$$

Should convergence not be achieved by this method, some form of damping procedure may need to be introduced.

Table 4, given at the end of the text along with tables 5 to 7, shows how far actual net investment in run (I) diverges from implicit net investment as implied by equations (3) and (4). Table 5 shows the convergence process, which is essentially completed by the fifth iteration. At that stage there are only two sectors with a greater than 2% discrepancy but there is clearly a marked convergence tendency, albeit one of damped oscillations in some cases. The unweighted root mean square error diminishes rapidly.[15] This together with the lack of

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[14] The approach is very similar to what Philpott and Spencer [71] call comparative-dynamic modelling. They iteratively adjust both base year and terminal year investment to be mutually consistent. Here the base year situation is taken as given and immutable.

[15] The curious behaviour of the Water sector is caused by its high capital-output ratio. However, when all other sectors show no

any significant changes in the endogenous macro variables between the fourth and fifth iterations renders the latter close enough to a convergent result.

Tables 6 and 7 show various sectoral results from iterations (I) and (V). Clearly there is a significant difference in the profile of investment between these runs, with an RMSE of 119%, excluding the Gas sector. Thus if any reasonable idea of the distribution of investment amongst sectors is required, a few iterations on the initial solution are indispensable. The differences between runs (I) and (V) in sectoral capital stocks and outputs are generally fairly small - around 2% on average, with two obvious exceptions being the Construction and Mining sectors which are heavily dependent on investment activity. Still, differences of about 2% could be large enough to distort or even swamp changes in sectoral output between alternative contemporaneous scenarios. If one was solely interested in macro information, in which case the use of a multi-sector model is rather misplaced, then admittedly the differences between runs (I) and (V) are negligible, as can be seen from table 3. This congruency improves directly with:

1. The similarity of columns in the investment matrix, which are dominated by the Fabricated Metal Products row.
2. The more concentrated the distribution of sectoral capital growth rates is about the economy-wide rate. One would generaly expect a higher concentration when total capital stock is exogenous, as is the case here.

TABLE 3

Run (I) v Run (V) Macro Differences

	Run (I)	Run (V)	% diff.
Real Private Consumption	$8668m	$8687m	0.219
" Gross Investment	3435	3433	0.055
" Exports	4933	4956	0.467
" Gross Domestic Product	15129	15132	0.020
Nominal " " "	23919	23922	0.013
" mean wage rate	10.552	10.576	0.227
" mean rental rate	0.12994	0.12960	-0.262

further change between iterations, the capital stock in Water must necessarily also stabilise.

The unweighted distribution of sectoral capital growth rates is compared with the standard normal distribution in figure 6. The former is more negatively skewed but also has a greater central concentration. Thus provided that in the first iteration the value of λ is equal to the mean rate of capital accumulation (which it will be if total capital is exogenous) and given a similar capital goods structure across sectors, the first and final iterations will show only minor differences in the macro results. If all sectors required an exactly identical mix of capital goods, the allocation of investment by sector of destination would be of academic interest only. At the other extreme, if capital mixes displayed wide variation the approximate normality of the growth rate distribution would be of less significance and much larger differences could be expected between the first and final iterations - in all variables. Note that the smaller the number of sectors the higher the probability of both similar capital mixes and similar capital growth rates. Thus the greater the sectoral disaggregation the more important it is to model sectoral investment.

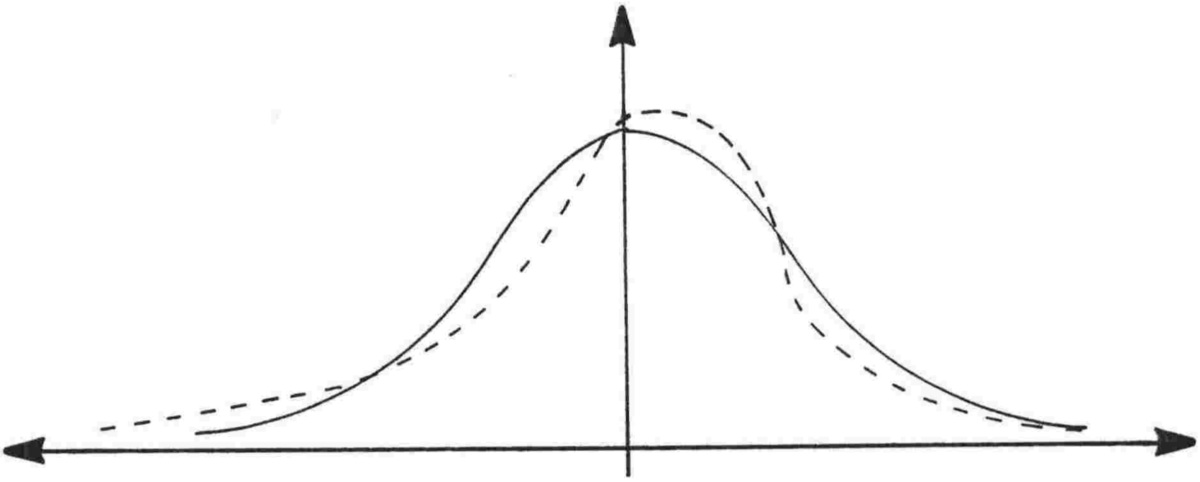


Figure 6: The Distribution of Run (V) Sectoral Capital Growth Rates

In conclusion it is clear that arbitrary terminal conditions can severely distort model results, especially sectoral investment levels. They need to be endogenous to the model, as indeed they are in the JULIANNE by virtue of equations (1.1) and (1.2), and by virtue of the solution routine which automatically iterates on the λ values. Distortion is less in other variables such as sectoral output but it could still be significant enough to lead one into false insights about policies which have sectorally different effects. Having said this, however, one should not forget that the JULIANNE model investment equations do not purport to accurately portray the process of investment. In a level form, medium term snapshot model it is not possible to ensure the satisfaction of the base year - horizon year - post horizon year consistency requirements, whilst simultaneously doing justice to factors such as relative profit rates and expectations. These are more suited to a non-optimizing dynamic model where the intertemporal connectivity automatically takes care of the consistency requirements. The specification adopted in JULIANNE snapshot is appropriate for that type of model.

* * *

TABLE 4

Run (I) Net Investment Discrepancies

Sector	K(0)	K(I)	K(I)/K(0)	net investment	
				actual	implicit
Agriculture	10422.0	12980.6	1.245	351.8	732.3
Fishing	55.2	67.7	1.226	1.8	3.5
Forestry	242.7	242.4	0.999	6.6	-0.1
Mining	372.4	362.0	0.972	9.8	-2.6
Food	1636.4	1873.0	1.145	50.8	64.3
Textiles	527.2	614.3	1.165	16.6	23.9
Wood	398.4	388.2	0.974	10.5	-2.5
Paper	932.1	1132.1	1.215	30.7	56.4
Chemicals	603.4	630.9	1.046	17.1	7.1
Non-Metallic	297.5	259.6	0.873	7.0	-8.7
Base Metals	306.5	480.3	1.567	13.0	57.1
Fab. Metals	1028.1	1297.3	1.262	35.2	77.7
Other Mfg.	56.0	49.8	0.889	1.3	-1.4
Water	494.0	552.0	1.117	16.0	15.5
Construction	828.0	516.3	0.624	14.0	-57.5
Trade	10996.7	11339.1	1.031	307.3	87.3
Transport	3093.2	3283.8	1.062	89.0	49.5
Communications	892.3	961.2	1.077	26.0	18.0
Insurance	4346.9	4555.5	1.048	123.5	53.7
Own. Dwell.	15324.7	17270.1	1.127	468.0	523.8
Govt. Services	--	--	--	--	--
Priv. "	1762.2	1839.3	1.044	49.8	19.8
Coal & Nat. Gas	73.5	77.3	1.052	2.1	1.0
Petrol	119.0	122.0	1.025	3.3	0.7
Electricity	3803.0	4239.2	1.115	114.9	116.6
Gas	47.5	45.9	0.966	1.2	-0.4

TABLE 5

Convergence of Iterations

Sector	$\frac{K(II)-K(I)}{K(I)}$	$\frac{K(III)-K(II)}{K(II)}$	$\frac{K(IV)-K(III)}{K(III)}$	$\frac{K(V)-K(1V)}{K(IV)}$
Agriculture	-0.04675	0.01393	-0.00431	0.00055
Fishing	0.03697	-0.03604	0.01216	-0.00408
Forestry	0.04196	-0.00381	-0.00241	0.00185
Mining	0.24021	-0.13296	0.07863	-0.02108
Food	0.01356	-0.01052	0.00285	-0.00100
Textiles	0.02545	-0.00572	-0.00037	0.00020
Wood	0.05372	0.03083	-0.01749	0.00806
Paper	0.01883	-0.01840	0.00568	-0.00177
Chemicals	-0.00596	0.00704	-0.00355	0.00145
Non-Metallic	-0.10771	0.08249	-0.02573	0.00946
Base Metals	-0.01950	-0.00980	0.00252	-0.00102
Fab. Metals	0.08315	-0.07161	0.02486	-0.00750
Other Mfg.	0.02567	-0.00952	0.00158	-0.00026
Water	0.00572	0.00898	0.01372	0.02214
Construction	0.08876	0.04230	-0.01914	0.01196
Trade	-0.00779	0.01038	-0.00515	0.00148
Transport	0.04519	-0.02865	0.00917	-0.00248
Communications	0.02331	-0.01114	0.00316	-0.00098
Insurance	0.00864	-0.00407	-0.00027	0.00010
Own. Dwell.	0.00891	-0.00137	-0.00043	-0.00006
Govt. Services	--	--	--	--
Priv. "	0.00766	-0.00151	-0.00041	0.00011
Coal & Nat. Gas	0.00503	-0.00189	-0.00034	0.00030
Petrol	0.00600	0.00309	-0.00168	0.00085
Electricity	0.01000	-0.00440	0.00069	-0.00014
Gas	0.00962	-0.00552	0.00064	-0.00007
unweighted rmse	6.20%	3.78%	1.86%	0.73%

TABLE 6

Iteration Comparison: Capital & Investment

Sector	K(I)	K(V)	% diff.	I(I)	I(V)	% diff.
Agriculture	12980.6	12498.9	3.85	351.8	580.9	-39.4
Fishing	67.7	68.2	-0.76	1.8	3.7	-51.4
Forestry	242.4	251.4	-3.60	6.6	2.2	200.0
Mining	362.0	411.1	-11.93	9.8	10.3	-4.9
Food	1873.0	1882.0	-0.47	50.8	66.9	-24.1
Textiles	614.3	626.2	-1.90	16.6	27.5	-39.6
Wood	388.2	417.6	-7.05	10.5	4.9	114.3
Paper	1132.1	1136.7	-0.40	30.7	57.8	-46.9
Chemicals	630.9	630.2	0.11	17.1	6.9	147.8
Non-Metallic	259.6	248.5	4.45	7.0	-10.9	-164.2
Base Metals	480.3	467.0	2.84	13.0	51.8	-74.9
Fab. Metals	1297.3	1327.0	-2.23	35.2	87.4	-59.7
Other Mfg.	49.8	50.6	-1.69	1.3	-1.3	-200.0
Water	552.0	580.4	-4.90	16.0	23.9	-33.1
Construction	516.3	581.5	-11.22	14.0	-49.2	-128.5
Trade	11339.1	11325.8	0.12	307.3	83.8	266.7
Transport	3283.8	3356.1	-2.15	89.0	69.1	28.8
Communications	961.2	974.8	-1.39	26.0	21.8	19.3
Insurance	4555.5	4575.4	-0.43	123.5	59.0	109.3
Own. Dwell.	17270.1	17391.8	-0.70	468.0	559.0	16.3
Govt. Services	--	--	--	--	--	--
Priv. "	1839.3	1850.1	-0.58	49.8	22.7	119.4
Coal & Nat. Gas	77.3	77.6	-0.31	2.1	1.0	110.0
Petrol	122.0	123.0	-0.82	3.3	1.0	230.0
Electricity	4239.2	4265.1	-0.61	114.9	124.0	-7.3
Gas	45.9	46.1	-0.46	1.2	-0.3	-500.0
unweighted rmse			4.09%			153.8%
- excl Min. & Con.			2.56%			
- excl Gas						119.2%

TABLE 7

Iteration Comparison: Output & Prices

Sector	X(I)	X(V)	% diff.	P % diff.
Agriculture	3351.2	3215.1	4.23	0.216
Fishing	62.7	62.8	-0.11	0.046
Forestry	234.9	242.7	-3.21	0.290
Mining	141.0	159.4	-11.55	0.266
Food	3048.3	3043.2	0.17	0.056
Textiles	1005.6	1017.8	-1.20	-0.017
Wood	564.6	603.8	-6.48	0.093
Paper	1119.4	1117.9	0.13	0.167
Chemicals	959.1	952.7	0.68	0.133
Non-Metallic	306.1	291.6	4.98	0.194
Base Metals	595.8	576.9	3.28	0.270
Fab. Metals	2701.0	2743.9	-1.56	0.012
Other Mfg.	92.6	93.7	-1.14	0.118
Water	55.6	58.3	-4.54	0.328
Construction	1825.0	2043.2	-10.68	0.089
Trade	5822.5	5787.9	0.60	0.219
Transport	1768.7	1796.0	-1.52	0.056
Communications	408.2	411.1	-0.69	-0.008
Insurance	1941.3	1940.9	0.02	0.244
Own. Dwell.	864.4	870.5	-0.70	0.701
Govt. Services	2307.5	2305.6	0.08	-0.230
Priv. "	1206.0	1206.6	-0.05	0.166
Coal & Nat. Gas	51.0	50.8	0.38	0.009
Petrol	611.7	615.5	-0.62	0.289
Electricity	594.9	596.7	-0.30	0.385
Gas	27.0	27.0	0.09	0.125
unweighted rmse			3.84%	0.230%
- excl Min. & Con.			2.38%	

APPENDIX A

The 'Allen' Elasticity of Substitution

For the standard two good case the elasticity of substitution is given by:

$$\sigma_{yx} = \frac{\text{\% change in quantity ratio}}{\text{\% change in price ratio}}$$

$$= \frac{\partial(y/x)}{y/x} \; \frac{p_y/p_x}{\partial(p_y/p_x)}$$

$$= \frac{x\partial y - y\partial x}{x^2} \; \frac{x}{y} \; \frac{p_y}{p_x} \; \frac{(p_x)^2}{p_x\partial p_y - p_y\partial p_x}$$

$$= \frac{p_x p_y \partial y}{y(p_x\partial p_y - p_y\partial p_x)} - \frac{p_x p_y \partial x}{x(p_x\partial p_y - p_y\partial p_x)}$$

$$= \frac{p_x\partial y}{y\partial p_x} - \frac{p_x\partial x}{x\partial p_x} \qquad \text{when } \partial p_y = 0$$

$$= \frac{p_x\partial y}{y\partial p_x} + \frac{p_y\partial y}{x\partial p_x} \qquad \text{since } \frac{p_x}{p_y} = \frac{f_x}{f_y} = -\frac{\partial y}{\partial x}$$

--- by the tangency condition and the implicit function theorem.

$$= \frac{\partial y}{\partial p_x}\left[\frac{p_x}{y} + \frac{p_y}{x}\right]$$

--- which is the Allen partial elasticity of substitution.

APPENDIX B

On the Nature of the Export Demand Function

From the text we have: $E = \psi(p/ep^W)^\eta$

--- where subsidies are subsumed into p and E(0) is subsumed into ψ.

$\Rightarrow$ Revenue $R = p\psi(p/ep^W)^\eta$

$\Rightarrow dR/dP = (\eta+1)\psi(p/ep^W)^\eta$

Thus at: $\eta=0$, $dR/dp = \psi$

$\eta=-1$, $dR/dp = 0$

$\eta\to-\infty$, $dR/dp \to 0^-$ if $(p/ep^W) > 1$

or $\to -\infty$ if $(p/ep^W) < 1$

(We are not interested in $\eta>0$.)

Now: $$\mathrm{Ln}(dR/dp) = \mathrm{Ln}(\eta+1) + \mathrm{Ln}(\psi) + \eta[\mathrm{Ln}(p) - \mathrm{Ln}(ep^W)]$$

$$\Rightarrow d(dR/dp)(dp/dR) = [1/(\eta+1) + \mathrm{Ln}(p) - \mathrm{Ln}(ep^W)]d\eta$$

$$\Leftrightarrow d(dR/dp)/d\eta = \psi(p/ep_W)^\eta \{1 + [\eta+1][\mathrm{Ln}(p) - \mathrm{Ln}(ep^W)]\}$$

$$= 0 \text{ if } \psi=0 \quad \text{(trivial)}$$

$$\text{or if } [\eta+1][\mathrm{Ln}(p) - \mathrm{Ln}(ep^W)] = -1$$

Thus a turning point exists at $\eta = -1 - 1/\mathrm{Ln}(p/ep^W)$.

What is the nature of this turning point? A few lines of algebra yields:

$$d^2(dR/dp)/d\eta^2 = \{[\mathrm{Ln}(\rho)]^2[\eta+1] + 2\mathrm{Ln}(\rho)\}\psi\rho^\eta \quad \text{where } \rho=p/ep^W$$

Inserting $\eta = -1 - 1/\mathrm{Ln}(\rho)$ yields a positive value for $\rho>1$ and a negative value for $\rho<1$. Thus the turning point is a minimum or maximum respectively. When $\rho=1$ the expression equals zero indicating a straight line through the points $(-1,0)$ and $(0,\psi)$. Note, however, that the above expression equates to zero if:

$$\mathrm{Ln}(\rho)[\eta+1] = -2$$

$$\Rightarrow \eta = -2/\mathrm{Ln}(\rho) - 1$$

Thus there is a point of inflexion at that value of η. Overall then, the graphs for $\rho<1$ and $\rho>1$ are as shown in figures B1 and B2 respectively, where the turning points occur at η_1 and the points of inflexion at η_2. Only figure B2 reveals unexpected behaviour for $\eta<-1$, as discussed in the main text.

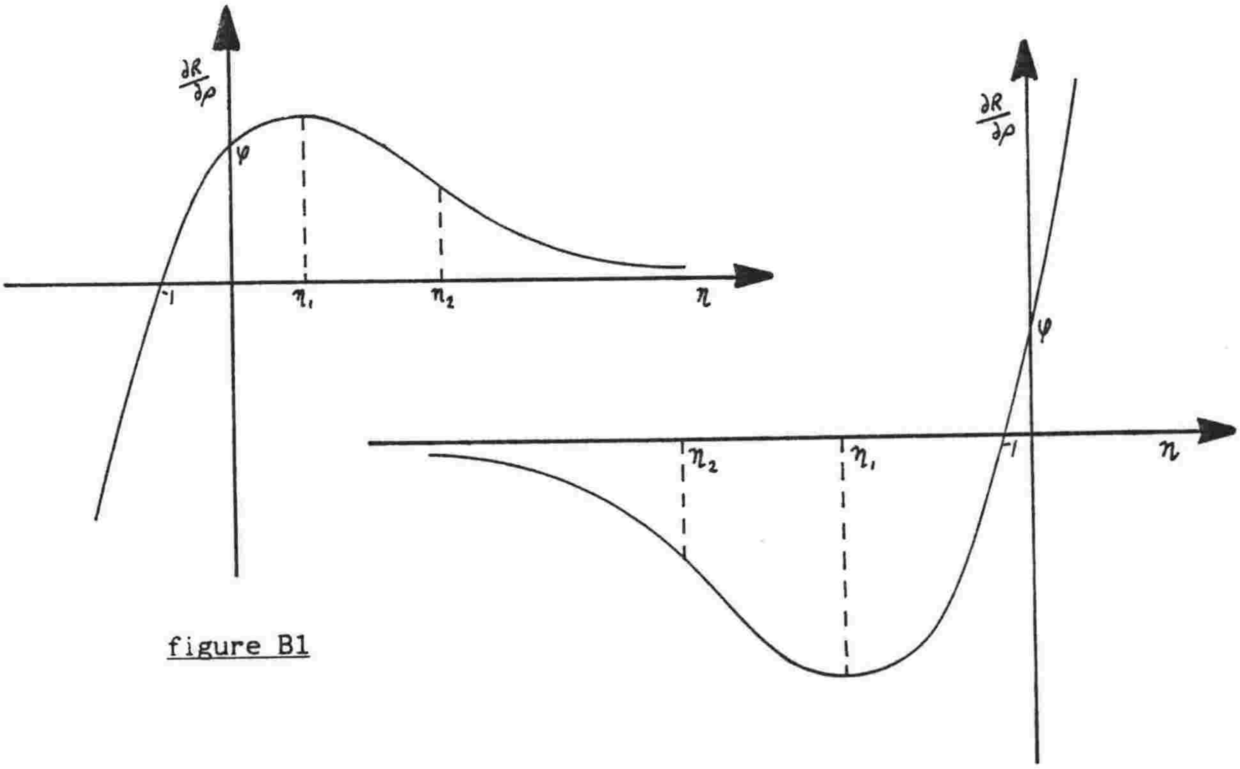


figure B1

figure B2

7

APPLICATIONS OF `JULIANNE´ SNAPSHOT

CHAPTER 7

APPLICATIONS OF JULIANNE SNAPSHOT

This chapter comprises five sections which present a logical progression of JULIANNE applications: starting with some sensitivity tests in which one seeks to establish an initial 'feel' for the importance of particular parameter values; consolidating this by using the model in an historical simulation mode in order to assess its parameters, assumptions and general structure on a broader, more holistic basis; extending the methodology of the simulation to obtaining a projection of some future year which can act as a reference point against which to compare alternative pictures of that year; and then presenting some alternative pictures by altering the positions of various export demand curves and examining the appropriate policy responses. The fifth section presents an application of JULIANNE which incorporates the CRESH production structure.

The principal application of JULIANNE in this thesis is an in-depth investigation, again in a contemporaneous comparative analysis framework, of the effects of protection in New Zealand, as that is where the strength of the model is focussed. This merits a separate chapter, namely Chapter 8.

The five sections then are as follows:

7.1 Sensitivity Tests
7.2 Simulation and Validation
7.3 Projection and a Control Scenario
7.4 The Effects of Export Subsidization and Slow Export Growth
7.5 The Effects of Wage Rate Changes

7.1 Sensitivity Tests

Introduction

Before the model can be applied to any real world questions there are numerous parameters and exogenous variables to be quantified. The latter are usually question-specific and fairly readily measurable. But the former are general in nature, with values that are (hypothesized to be) invariant across applications. Moreover they frequently entail econometric investigation using substantial volumes of data.

One has stated before that the estimation of model parameters is beyond the scope of this thesis. A literature search together with one's best guesses provide the usual sources of parameter values. Especially in this situation, but still also with econometrically estimated parameters, it is useful to test the sensitivity of model results to variations in certain important parameter values, and indeed to variations in the exogenous variable values.

Thus this chapter begins with a few very general runs which, in the context of a reduction in tariff equivalents, illustrate how a particular group of parameters and exogenous variables can affect results. The use of the model to study a reduction in tariffs is a realistic application of JULIANNE, both in terms of the data used and because JULIANNE is designed for this type of question. However, to reiterate, the runs presented in this section are primarily intended as parameter/variable sensitivity tests and as an introduction to JULIANNE applications; not at this stage as an indication of the probable effects of tariff reduction in New Zealand.

In these runs then, variations in the following parameters and variables are explored.

(a) The levels of exogenous employment, capital utilization and the export demand curve shift parameters (ψ).

(b) The elasticity of substitution between composite commodities in intermediate demand (ε).

(c) The domestic-import substitution elasticity (σ).

(d) The export price elasticities of demand (η).

The tariff equivalents on three types of imports are reduced as follows:

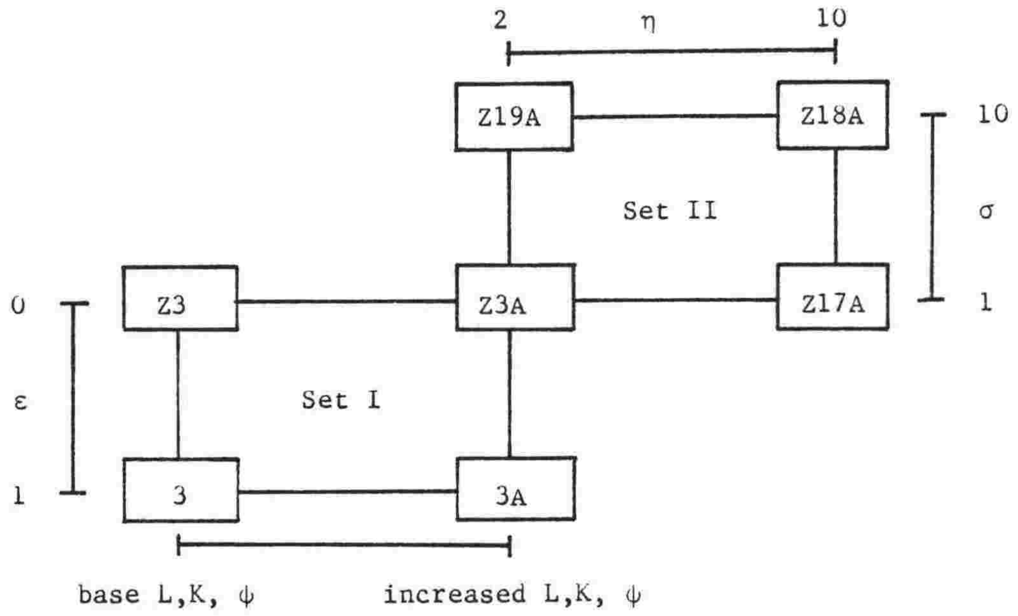
Chemical Products	8.8% points
Non-Metallic Products	12.3% points
Fabricated Metal Prods.	14.1% points

No special relevance attaches to these values other than that they are approximate indications of the degree of protection reduction that the three sectors would incur if protection was completely removed from the <u>sub</u>sectors: Tyres and Tubes, Glass and Ceramics, and Vehicle Assembly and Automotive Components, respectively.

Seven runs are analysed and these are related as shown below:

Figure 1

Schema of Runs



In all runs there is no change in the real wage rate, in the level of total real gross investment or real government consumption, or in the degree of capital utilization. The exchange rate is the numeraire and the nominal ratio of stock change to private consumption is fixed.

The results are presented as the percentage changes which occur when the tariff equivalents are reduced. Thus each run actually involves two runs - one with the tariffs in place, known as a control or base run, and a second run where the tariffs are reduced. Comparing the two runs then yields the percentage changes shown. In the run names a 'Z' indicates $\varepsilon=0$ and an 'A' indicates higher labour (L) and capital (K), and export demand curves shifted further to the right by the curve shift factors (ψ).

Gross output changes are given for the three sectors which incur a reduction in protection as well as for an exporting sector, Agriculture and for an essentially non-traded sector; Insurance, Finance and Real Estate.

Analysis

Set I

As can be seen from Figure 1 run Z3A is the central run but it is useful to begin with run 3. With reference to Table 1, the levels of employment and capital are set at their base year levels of 1,275,000 people and $65,280m respectively, with no shift in the export demand functions from their base year 1976/77 positions. Unitary elasticity is assumed amongst composite intermediate inputs.

On the macro scene the reduction in prices when tariffs are reduced provides a boost to exports, increasing employment by 0.7%. But the expansionary effect does not feed through into private consumption. Agriculture gains from the increased export opportunities and Chemicals and Non-Metallic Mineral Products (NMMP) gain from the removal of protection but Fabricated Metal Products (FMP) contracts. The forces at work can be deduced by comparing these results with those from run Z3 where $\varepsilon=0$. There, Chemicals and NMMP although still benefiting from the reduction in protection, do not do any where near as well as in run 3. The reduction in the price of Chemical and NMMP imports feeds through into reduced domestic prices of output from the Chemicals and NMMP sectors, relative to other prices, since both sectors are major buyers of their respective import types, which does not hold to the same extent in FMP. With $\varepsilon=1$ this means that Chemical and NMM products will be used

Table 1: Results

(% changes)

Run No.	3	Z3	3A	Z3A	Z17A	Z18A	Z19A
ε	1	0	1	0	0	0	0
σ	1	1	1	1	1	10	10
η	-2	-2	-2	-2	-10	-10	-2
Employment	0.71	1.29	0.74	1.27	2.09	1.67	1.08
Real Private Consumption	-0.70	0.26	-0.66	0.26	1.22	0.86	0.05
Real Exports	2.51	3.24	2.61	3.26	4.04	5.63	3.71
Real Imports	1.08	1.40	1.14	1.42	3.18	4.44	1.62
Real GDE	-0.51	0.26	-0.48	0.24	1.08	0.71	0.08
Consumer Price Index	-1.50	-1.80	-1.56	-1.81	-0.72	-0.89	-2.05
Real Output: Agriculture	1.81	2.67	1.84	2.64	2.61	4.33	3.52
Chemicals	4.36	0.84	4.22	0.80	2.11	-2.90	-3.71
NMMP	3.37	0.50	3.29	0.40	-0.83	-19.8	-18.0
FMP	-2.08	-2.94	-1.91	-3.03	-0.90	-6.30	-6.77
Finance etc.	-0.44	0.16	-0.41	0.14	0.72	0.26	-0.08

In the 'A' runs: base L = 1,413,000; K = \$66567m; $\Delta\phi$ = 15%

in production in place of other inputs. For example, synthetic compounds instead of organic compounds, or concrete instead of wood. With $\varepsilon=0$ this type of substitution is not possible. Hence the lower output gains in run Z3.

The Fabricated Metals sector also experiences the effects of $\varepsilon=1$ versus $\varepsilon=0$ but in both runs output declines. The postive relative price effect of $\varepsilon=1$ is outweighed by the negative effect of cheaper imports.

Also in run Z3 there is a bigger gain in exports, employment and (hence) in consumption, which declined in run 3. Underlying these differences is the greater fall in prices - If $\varepsilon=0$ there is a greater increase in the demand for imports than if $\varepsilon=1$ since under the latter value some of the higher import demand is transferred to those domestic sectors that are now more competitive due to lower import costs. Thus the fall in capital rental rates needed to maintain capital demand in the face of cheaper imports, and the fall in wage rates needed to prevent real wages from rising when prices decline (due to lower tariffs), are less when $\varepsilon=1$ than when $\varepsilon=0$, and so prices decline further under the latter elasticity value.

Moving now to runs 3A and Z3A, it will be seen that not only are the differences between 3A and Z3A virtually identical to the differences between 3 and Z3, but also that runs 3 and 3A are extremely similar and likewise for runs Z3 and Z3A. Hence the above comments are equally applicable here and one can conclude that the initial levels of employment, capital and exports do not affect the changes that occur following a tarif reduction, whether with $\varepsilon=1$ or $\varepsilon=0$. It is clear that a valid analysis of tariff reductions may proceed without the need to align or calibrate the model to some given set of (contemporaneous) exogenous data, provided of course that one does not use completely unrealistic values for the exogenous variables.

Set II

Taking run Z3A we ask: How do the results change if η and σ are raised to much higher values.

Run Z17A shows what happens when η is raised (absolutely) from 2 to 10 for all export commodities. For any given fall in prices generated by a reduction in tariffs the quantity exported will rise, rising more the greater is the absolute elasticity. Since the economy is subject to an overall capacity constraint exports cannot rise too rapidly. Hence prices decline less in than run Z3A. In total there is still a greater increase in exports, as expected, leading to higher employment and a gain in private consumption.

Agriculture expands by fractionally less then in run Z3A indicating that the positive effect of a higher export demand elasticity is outweighed by the negative effect of moving up the demand curve with the lower fall in prices. Chemicals and FMP both do better but the NMMP sector does worse, undergoing a small contraction in output. The reason is investment; even though total gross investment is unchanged its composition changes due to the increase (or smaller decline) in output from sectors such as Chemicals and FMP whose investment mix has relatively less inputs from Construction and hence from NMMP, Construction being the major destination of output from NMMP.

The differences between runs Z3A and Z17A are due to increases in the export demand elasticities. The same changes in these elasticities occurs between runs Z19A and Z18A respectively, but for a different mean σ, 10 instead of 1.[1]

As before employment, consumption and exports improve with higher η. Chemicals and FMP, whilst now suffering contractions in output, still fare better with the higher export elasticity, with NMMP still doing worse. The change in exports between runs Z19A and Z18A (3.71% to 5.63%) is greater then the change between runs Z3A and Z17A (3.26% to 4.04%) which is reflected in the fact that Agriculture now gains from a higher η whereas before (in 17A versus 3A) it fared slightly worse due to adverse price movements. Now, however, the import - domestic substitution elasticity is large enough to generate a significant fall in Agricultural input costs, enough to counteract the rise in factor prices between run Z19A and Z18A.

Overall relative movements between Z19A and Z18A are similar to those between Z3A and Z17A.

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[1] At the time these runs were done the model worked primarily on price elasticities rather than (Allen) substitution elasticities. (See Chapter 6.) The initial price elasticities were set so as to yield an average substitution elasticity of unity.

The other lines of comparison which can be discerned from the set B runs are between Z3A and Z19A, and Z17A with Z18A. These portray the effects of increasing the elasticity of substitution between domestic and imported commodities.

With a higher mean σ, employment and consumption do not rise as much but there is a larger increase in exports. Allowing greater domestic - import substitution means a more widespread influx of the now cheaper imported goods which contributes to a general lowering of the CPI (from -1.81% to -2.05% and -0.72% to -0.89%), which in turn provides a boost to exports. Again Agriculture benefits from this but Chemicals, FMP and especially NMMP suffer significant reductions in activity. All three sectors lose out to cheaper imports. Initially in runs 3A and Z3A Chemicals and NMMP gain from tariff removal but the higher elasticities obliterate the advantages these sectors enjoyed by being both less substitutable with imports than FMP and to a lesser extent, through being major buyers of their own import types. The dramatic plunge in NMMP output is of some concern, perhaps illustrating the absurdity of a very high σ for broad product groups, but also demonstrating what might occur if a high σ is used to simulate the removal of import licensing - as discussed in Chapter 6.

In general the effects of changing the σ's are reasonably independent of the value of the η's, just as before the effects of varying the η's were seen to be fairly independent of the value of the σ's. Note, however, that the effects of changes in these two parameters are not completely independent, nor are they linearly related. One cannot add the effects of changes in σ to those due to changes in η, to yield the effects of changing both elasticities simultaneously. For example using private consumption:

$\Delta\eta$: 0.26 to 1.22 = 0.96 (runs Z3A and Z17A)
$\Delta\sigma$: 0.26 to 0.05 = -0.21 (runs Z3A and Z19A)

0.75

But $0.26 + 0.75 = 1.01 \neq 0.86$ (from run Z18A)

Conclusion

The effects of changing η under a scenario of a reduction in tariffs are fairly predictable especially as far as the macro variables are concerned. If the economy is in a better position to exploit the benefits of reduced costs on the export front, employment and GDE will rise. Consequently exporting sectors will increase their output and to a lesser extent, other sectors benefit from the general increase in economic activity.

The effects of changing σ are less easy to predict. One cannot say in advance whether a greater displacement of domestic goods by cheaper imported goods will increase or decrease private consumption, especially when the real rage rate is inflexible. The above results show a decline but this may be purely a function of the relative magnitudes involved - the size and incidence of the tariff reduction, or of the high σ values. Although a complete removal of protection is known to yield at least a small increase in welfare if (factor) prices are flexible, the theory of the second best tells us that the welfare effects of reducing some protection cannot be known a priori, particularly if the small country assumption is abandoned as is the case here.

At the micro level especially with regard to the three sectors that incur a loss of protection, the effects of changing η and σ are sometimes difficult to predict. Chemicals and FMP gain from a higher η whereas NMMP loses out and all three sectors lose from a high σ. The nontraded sector Insurance, also loses from a higher σ but as expected it is not very sensitive to changes in tariffs whatever σ and η prevail. Only Agriculture gains from a higher σ. When ε is altered from zero to unity Agriculture and Insurance lose out and the other three sectors benefit.

Changing ε from zero to unity is a sensible change in the value of this parameter since its real values are largely unknown and the results show this to be an important parameter about which more information should be obtained, not just for tariff analysis. Changing the value of η from -2 to -10 brought about fairly significant changes in the results but a reasonable proportion of these can be explained by the absence of a constraint on employment. Under fixed factor supplies changes in the export price elasticities of demand could be expected to produce less variation.

Varying the mean σ from 1 to 10 produced rather greater changes at the sectoral level than at the macro level. For most commodities a domestic - import substitution elasticity of 10 is outrageously high, at the 20-40 sector level of aggregation. Other model runs have confirmed that results are generally not too sensitive to realistic changes in this parameter. However, at the sectoral level it can still be important. For most sectors one would expect a value of around 2, but for a finer classification it could be much higher. [2] There are presumably critical values, specific to each sector, at which the loss of market share to imports outweighs any expansion of exports, which rise because of lower costs. Of course these critical values will vary with the incidence of protection, the export elasticities and so on.

Overall then, endeavouring to weigh the sensitivity of the macro results against some reasonable range of values for the three parameters considered, it appears that in order of declining importance the sequence is ε, η, σ. For sectoral results the sequence seems to be $\varepsilon, \sigma, \eta$. Further sensitivity evaluation is left until Chapter 8. We have at least an initial appreciation for the effects of altering some parameter values; an appreciation which provides a background for the next section.

Finally and in contrast to the above conclusions, model results are very insensitive to the exogenous supplies of capital and labour, and to the positions of the export demand curves; hence also to the general level of economic activity. Whether the model is set in say a 1982 context or a 1986 context, as measured by the level of some macro aggregate such as GDE, has virtually no bearing on the results obtained from a reduction in tariffs, as evidenced by the similarity of runs 3 and 3A, and Z3 and Z3A. This is an encouraging result as it means that one need not go to great lengths to calibrate the model to some particular year in order to validly study changes in protection, or some other scenario. There are of course advantages in knowing the level of activity or the absolute sizes of changes between runs, which will then require correct calibration, or at least information on the initial values of the relevant variables. But the validity of model results does not depend on such knowledge.

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[2] See for example Alaouze [2] for Australian evidence on import - domestic elasticities.

7.2 Simulation and Validation

Introduction

The assessment of the reasonableness of parameter values begun in the previous section is pursued here by seeing how well the model can simulate some documented year, beyond the base year. Simulation of the base year itself is trivial, occurring by definition since the model is built on, and calibrated to, base year data. But to simulate beyond the base year is much more ambitious since relative prices have changed. Accordingly the model has the opportunity to shift resources. There is domestic import substitution, substitution between goods in consumption, substitution between labour and capital in production, and so on. The decision rules such as profit maximisation, and the values of the elasticities and other parameters, which govern such substitution are therefore tested in this type of exercise, perhaps not individually but at least in combination. If the model cannot produce a reasonable picture of a given year on the basis of the behavioural relationships, decision rules and parameter values assumed, then clearly, such formulations and values need to be reconsidered.

However, the word 'reasonable' is important here. One cannot hope to exactly replicate some given year other then the base year for two reasons:

(i) Not all the exogenous variables can be properly updated due to gaps or deficiencies in historial data.

(ii) Events occur in the real world which have no corresponding variable or equation in the model. For exammple the model cannot track the effects of demographic changes on consumer expenditure patterns.

The model is here used to simulate 1981/1982 from a 1976/77 base. We look firstly at model input.

Input

The following exogenous variables were altered from their base year 1976/77 values. Most of the list is macro orientated due to the paucity of sectoral data for 1981/82.

1. Employment - total
2. Capital stock - total
3. Sectoral wage relativities
4. Total real gross investment and real government consumption
5. Real balance of trade
6. Stock change to private consumption ratio
7. Agricultural export subsidies
8. Real investment in government social services and housing
9. Real oil price
10. Export volumes.

Dealing with each of these in more detail:

1. Employment

Total employment in 1981/82 is estimated at 1280 thousand (from MAS tables 5.02 and 5.03), up from 1200 thousand in 1976/77.[1]

The alternative to setting total employment exogenously is to set the wage rate in some given sector (sector k in eqn. 27, Ch. 4) given a vector of sectoral wage relativities, (see item 3). The main reason for not choosing this option is that the level of employment is not only determined by variables such as relative factor prices and aggregate demand, which the model does include, but also by direct government action such as employment promotion schemes which the model does not include. A further reason is that in the model wage rates are defined in Input-Output terminology as compensation of employees divided by employment. Since no 1981/82 input-output table existed (at the time of this experiment) it was felt that an exogenous total employment figure would be both more satisfactory and more likely to yield a better result

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[1] New statistics have since revised these figures to 1283 and 1251 respectively. Also, all references to the MAS refer to issues between April 1982 and April 1983 unless otherwise stated.

than would an exogenous reference-sector wage rate.

2. Capital Stock

From work by Montrivat [60, p15] an estimate of the total capital stock for the year ended March 1982, excluding capital in the Government Services sector, is $62,865m in 1976/77 prices.

3. Sectoral Wage Relativities

Since sectoral employment and sectoral wage rates are not exogenous it is necessary to set the corresponding wage relativities exogenously, so that all wage rates move equiproportionally to yield the exogenous level of total employment.

Table 2 shows the 1976/77 relativities and the calculation of the new 1981/82 relativities from MAS table 21.01 of nominal weekly wage rate indices. It is assumed that nominal wage rate movements are a reasonable proxy for movements in 'compensation of employees', at least as far as sectoral relativities are concerned. Also the MAS data has a December quarter 1977 base which is not ideal, but prior data is not sectorally compatible.

4. Gross Investment and Government Consumption

Total real gross investment is set exogenously at $3054m in 1976/77 prices. This value is obtained from the BERNZ Statistical Bulletin [11]. From the same source real government consumption is $2187m.

5. Balance of Trade

The balance of trade on goods and services is exogenously set at a deficit of $-502m in 1976/77 prices, from BERNZ [11].

6. Stocks - Consumption Ratio

Since there is no stock accumulation function in the model, stock change is usually set as a proportion of GDP or GDE. For this exercise, however, due to the exogeneity of the items under (4) and (5), it is more convenient to set it as a proportion of private consumption. The ratio is set in nominal, not real terms, by which it is meant the model's 1981/82 prices which correspond to actual 1981/82 prices deflated by some general price index - a procedure allowed by the homogeneity property of the model. Ideally the model would yield the correct relative prices for 1981/82; only the level of prices would differ from actual. The general price index used in this regard is that for non-oil import prices, as will be explained in item (9).

7. Export Subsidies

Supplementary Minimum Price payments in 1981/82 of $120m for meat exports and $180m for wool exports are converted into price subsidy equivalent rates of 7.76% and 13.80% respectively.

8. Sectoral Investment

Sectoral investment is endogenous with two exceptions; social investment by the Government Services sector and housing investment in Ownership of Dwellings.

(i) Real government social investment is estimated at $360m in 1976/77 prices by Montrivat [60, p15].

(ii) A value for new dwellings of $345m is obtained by multiplying the number of houses and flats built during 1981/82 (16,400 from MAS Table 9.04) by the mean 1976/77 price of $21,040 (from MAS Table 9.01).

To the $345m is added the value of additions and alterations to existing dwellings which are estimated at $122m (from MAS Tables 9.05 and 9.01). Thus total exogenous investment in Ownership of Dwellings is $467m.

Table 2: Wage Relativities

	Wage Rate	- relative	Relativities	
	Index	to sector 9	Actual 1976/77	Assumed 1981/82
AGR	2004	1.0503	0.709	0.745
FIS	1984	1.0398	0.563	0.585
FOR	1942	1.0178	0.940	0.957
MIN	1864	0.9769	1.141	1.115
FBT	2063	1.0812	0.962	1.040
TEX	1969	1.0320	0.637	0.657
WOD	1918	1.0052	0.766	0.770
PAP	1964	1.0294	0.854	0.879
CHE	1908	1.000	1.000	1.000
NOM	1986	1.0409	0.822	0.856
BAS	1904	0.9979	1.161	1.159
FAB	1911	1.0016	0.822	0.823
OTH	2074	1.0870	0.564	0.566
WAT	1915[a]	1.0037	1.324	1.329
CON	1971	1.0330	0.748	0.773
TRA	2008	1.0524	0.813	0.856
TRN	1960	1.0273	0.989	1.016
COM	1849	0.9691	0.828	0.802
FIN	1869	0.9796	0.917	0.898
GOV	1864[b]	0.9767	0.874	0.854
PRI	1899[c]	0.9953	0.715	0.712
COA	1908[e]	1.000	0.689	0.689
PET	1908[d]	1.000	1.030	1.030
ELE	1915[a]	1.0037	0.798	0.801
GAS	1915[a]	1.0037	0.759	0.762

a. From the MAS (SNA) combined sector; Electricity, Gas and Water.

b. The average of MAS sectors; Central and Local Government.

c. From the MAS sector; Community and Personal Services.

d. As for Chemicals since Petrol is part of Chemicals in the MAS.

e. Even though this sector is originally part of Mining and Quarrying, its wage rates are thought more likely to follow those in Petrol due to the impact of the 'major projects'.

9. Real Oil Price

In an ideal validation of the model beyond the base year, one would need to increase all world import prices according to their actual movements. Since we cannot achieve an exact replication (partly) because of the difficulty of obtaining the appropriate data on price movements (that is, with the appropriate classification), it is assumed that all import prices increased by approximately the same amount. The obvious exception is the price of oil, so it is treated separately.

The change over the years 1977-82 is calculated at 238.6% whilst non-oil import prices increased by 69.9% (from MAS tables 21.10 and 11.05). Hence the relative increase in the price of oil is 99.3%, say 100%. The procedure in the model is to set the oil import price at 2.0 whilst other import prices are kept at their base year values of unity. Thus the general price level in the model's simulation of 1981/82 should be about 70% below actual. Ideally this should be the case with all prices.

10. Exports

Theoretically the export demand curve for each commodity should be shifted according to changes in world income, the establishment of new markets, changes in tastes etc, - specific to each commodity. Export volumes would then be free to move along the demand curve as a function of New Zealand prices relative to world prices. However, the determination of the demand curve shifts is too vast an undertaking so it was decided instead to set export volumes exogenously, with the individual demand curve shifts adjusting endogenously to ensure the compatibility of quantities and prices.

The exogenous quantities are given in table 3 and are ascertained from numerous sources: BERL [9], MAS tables; 10.01, 11.01, 11.09, 19.01, 20.01, 21.06, 56, and 105.[2]

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[2] The last two table numbers refer to the May 1979 issue.

Table 3

1981/82 Export Volumes

($m 1976/77)

Agriculture (mostly Horticulture)	121.3
Fishing	57.5
Forestry	12.8
Mining	17.0
Dairy	429.8
Meat	857.9
Wool	750.8
Other Food Products	358.8
Textiles	134.3
Wood and Wood Products	82.5
Paper	187.9
Chemicals	66.6
Non-Metallic	19.7
Base Metals	144.2
Fabricated Metal Products	187.9
Other Manufacturing	22.8
Energy	30.0
Services	726.0
Total	4208.0

As well as the above 10 items there are also various parameters to set.

(i) Import-domestic (within commodity) substitution: The various parameters are set to as to achieve a mean Allen elasticity of substitution for those imports which are competitive, of about 1.0.

(ii) Composite commodity substitution: The choise here is either zero elasticity or unitary elasticity. The former is assumed.

(iii) Export price elasticities of demand: Dairy, Meat and Wool exports have an elasticity of -1.0, Horticulture and Energy have -2.0 and all other exports have a value of -5.0.

Output

Macro Comparison

The macro results are presented in table 4 along with some estimates of actual real 1981/82 values from BERNZ [11].

Overall, the model results compare favourably with the (adjusted) BERNZ estimates.[3] But it will be observed that the model balance of trade deficit at $451m does not equal the supposedly exogenous value of $502m from item 5 above. It was found that with this value, real private consumption rose to over $8450m, so the balance of trade was arbitrarily tightened by 10%. The fact that the model then produces approximately the same level of GDP but with a lower deficit implies that there may have been some build-up of imports in 1981/82, over and above that which

Table 4: Macro Results
($m 1976/77)

	1976/77		1981/82		change
	I-O	MAS	BERNZ	Model	% pa
Private Consumption	8418	8313	8371	8393	0.19
Government Consumption	2067	1953	2187	2187*	2.29
Gross Investment	3383	3448	3054	3054*	-2.40
Stock Change	469	698	769	777	2.17
Exports	3623			4208*	
" incl. re-exp.	3784	3824	4320	4358	2.65
Imports	4083			4659	
" incl. re-exp.	4244	4248	4822	4809	2.51
Balance on Trade	-460	-424	-502	-451*	
GDP	13877	13988	13879	13958	0.24
- incl. stat. disc.	13714	13792	13943		

* exogenous

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[3] The BERNZ stock change figure has been adjusted to achieve correspondence with the model which implicitly interprets the value of stock change in the base year as being equal to the volume change when in fact this was not the case.

the model can track through relative price changes and income changes, such as capital imports for the major projects. The BERNZ estimates of the real trade deficits in 1980/81 and 1982/83 of $178m and $361m respectively, support such a hypothesis. But are the model's relative prices correct?

In the context of this question, four other aspects of the macro results are worth mentioning.

1. The model's GDP price index relative to 1976/77 is 1.192. Adding on the 69.9% homogeneity adjustment (from item 9) yields a price change of 102.5% which compares well with a BERNZ estimate of 108.2% - a per annum difference of about 1%.

2. The model's increase in the mean real wage rate if 1.16% pa which compares favourably with a value of 1.24% calculated from the effective weekly wage rate index in MAS table 22.01.

3. The model's terms of trade on exports and imports of goods (not including services) is 1.009 relative to 1976/77, compared to the MAS table 21.09 value of 0.994 - a difference of a mere 1.5%.

4. The model's index of competitiveness defined as the mean gross output price divided by the mean import price (including services) is 1.076 which (again) compares most favourably with a value of 1.074 calculated from the chart by Easton [32, p53] who uses the same definition. Both values are on a 1976/77 base of 1.000.

One should not forget the degree of statistical discrepancy in this type of exercise - the BERNZ estimates contain a discrepancy of $64m in GDP. Moreover, an alternative estimate of real GDP from the MAS index in table 10.01 is $14396m. Hence there is quite a large difference between the BERNZ and MAS estimates; the former being derived from the deflation of the expenditure side of GDP and the latter from sectoral net products.

Definitional differences such as those between the SNA and I-O classifications as shown on the left of table 4, can also cause problems in assessing model output, since much of the input data is based on SNA/MAS information whereas the model itself is of course I-O based.

One can see then that the differences between model results and ostensibly actual values should be taken in proper perspective. Measurement errors and conceptual differences (which can be quite substantial) imply that even a close/poor correspondence between model results and offical data, cannot necessarily be cited as proof of model realism/error. This would apply even if all the required input data existed. The fact that it did not - relative import prices except oil were kept constant, sectoral tax rates and capital rental rate relativities were not varied, efficiency changes were uniformly applied, and so on; all of which constitute the micro foundations of the macro aggregates - allows one some degree of comfort in the correspondence between model results and the 'actual' 1981/82 situation.

Having advised caution in the interpretation of results, let us now turn to a sectoral comparison.

Sectoral Comparison

No official data exists on real output by sector relative to 1977, but MAS table 5.02 does give employment by sector as at February 1981. Naturally, employment in 1981/82 may not equal employment in February 1981 and also, any correspondence between MAS figures and model figures does not imply an output correspondence. Nor, conversely, does a lack of correspondence in employment imply a lack of output correspondence. Nevertheless, the differences are likely to be small so a comparison is presented in table 5.

Most of the figures are within 10% of each other and they have a correlation coefficient of 0.995. By far the largest percentage difference is in the Textiles sector and one suspects that the model does not pick up the closure of many textile establishments since 1977.[4] Altering the protection accorded to this industry would probably have produced a closer correspondence between model and official figures.

The Construction sector exhibits the opposite difference. In the model employment falls along with output whereas in reality, there has probably been some retention of (underemployed) labour and self-employed

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[4] One might say 'since 1972' as the 1976/77 I-O table used here is an RAS update of the 1971/72 I-O table. Between 1972 and 1977, and between 1977 and 1982, the Textile sector underwent considerable restructuring. See BERL [10].

Table 5

Employment Comparison

	Model Employment 1981/82		Actual Employment as at Feb. 1981 (from MAS)	
	26 sector	re-grouped		
Agriculture	138.3)			
Fishing & Hunting	5.7)	151.7	141.9	
Forestry	7.7)			
Mining & Quarrying	2.8	4.9	4.8	includes Coal
Food	69.6	69.6	73.2	
Textiles	51.9	51.9	42.9	
Wood	27.3	27.3	27.3	
Paper	32.2	32.2	35.0	
Chemicals	24.6	25.4	26.3	includes Petrol
Non-Metallic	10.8	10.8	10.3	
Base Metals	5.8)			
Fab. Metals	86.6)	101.4	92.6	
Other Mfg.	6.0)			
Water	1.1	16.6	16.9	Ele. Gas Water
Construction	79.6	79.6	87.3	
Trade	209.9	209.9	230.3	
Transport	81.3)			
Communications	38.2)	119.5	109.9	
Finance etc.	81.8	81.8	89.7	
Own. Dwell.	--	--	--	
Govt. Services	234.6)			
Priv. "	62.7)	297.3	291.4	
Coal & Nat. Gas	2.1		)	
Petrol	0.8		)	included in
Electricity	14.4		)	above sectors
Gas	1.1		)	

persons in the building industries.

The service sectors; Trade, Transport etc, and Finance exhibit differences of about 10% which is probably due to the lack of sector specific efficiency parameters. However, the understatement by the model of employment in Trade and Finance suggests that efficiency growth in these sectors was even more negative than for the economy as a whole, somewhat contradicting the evidence of extensive microprocessor penetration in these sectors. Is it that computerised transactions mechanisms have not had a net labour saving effect?

Overall, the comparison is quite good, probably better than expected considering the dearth of recent data at the micro level which is suitable for model input.

Conclusion

The fact that the model yields a fairly good simulation of 1981/82, given the data problems, validates the choice of parameter values, holistically speaking. One cannot claim that the results verify any particular parameter values or model assumptions such as utility maximization, Cobb-Douglas production functions and so forth. But one can feel reasonably confident that if any were wildly inaccurate it would be reflected in the results.

For instance there is certainly no guarantee, even with constraints on exports and the trade balance, that the model will yield the correct value and volume of imports from the correct set of relative prices, given an arbitrary set of import-domestic substitution elasticities. That is, correct relative NZ-World prices (as measured by the competitiveness index) could not yield the correct value and volume of imports if the elasticities had been grossly in error.

Where differences do exist between the results and (purportedly) true figures it is admittedly difficult to establish whether parameter values and/or equation structures are at fault, perhaps due to model-external events,[5] or whether the lack of appropriate input data is to blame, especially at the sectoral level. But if one accepts that the

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[5] This point is discussed further in Chapter 10.

significance of the sectoral data problem is of a lower order or magniture than the requirement to incorporate the corresponding macro data, (that for example, a uniform efficiency allowance is better than none at all), then the choice of parameter values must also be reasonably correct, at least to the right order of magnitude. One discounts the possibility that poor input data and poor parameter values have fortuitously combined to yield a reasonable result.

A fully time staged dynamic version of JULIANNE (to be presented in Chapter 9) provides the best means to test model assumptions and parameter values since they then need to yield good results over a number of years. In the meantime the simulation presented here together with the sensitivity analysis presented at the beginning of this chapter, engenders a satisfactory degree of confidence about parameter values and about the model as a whole.

Thus we proceed to section 7.3 where, in order to obtain a control scenario of some future year against which alternative policies can be evaluated, the linking of JULIANNE to a macro projection model is described.

7.3 Projection and a Control Scenario

Introduction

A general equilibrium model such as JULIANNE cannot yield projections on its own account. Firstly, it requires a certain amount of exogenous information for both macroeconomic closure (as described in Chapter 3) and for the updating of time dependent variables and parameters. Beyond this, however, there is also the problem (mentioned in the last section) of model-external events. For instance we know that demographic changes will affect future consumer expenditure patterns over and above the effects of price and income changes. The latter are in the model but not the former. Thus we must assume that these sorts of events will have relatively unimportant effects.

To minimise the chance of model results being determined by one's own subjective assumptions, one utilises as much information as is practical from outside sources, in this case from the New Zealand Planning Council's National Sectoral Programme. (see Haywood et al [49]). With this information it is possible to construct a control scenario of some future year, here 1990, that can be used as a benchmark against which to explore the effects of variations in policy (or other) variables such as levels of protection, the exchange rate, factor mobility, etc. This is effected both by altering the control run constraints and by swapping the endogenous-exogenous status of some of the variables. For example a preset level of employment in the control run will generate a real wage rate which can then be held fixed in a subsequent run with employment becoming endogenous. This procedure will be further described in the next part of this chapter. We look here only at the model interface itself.

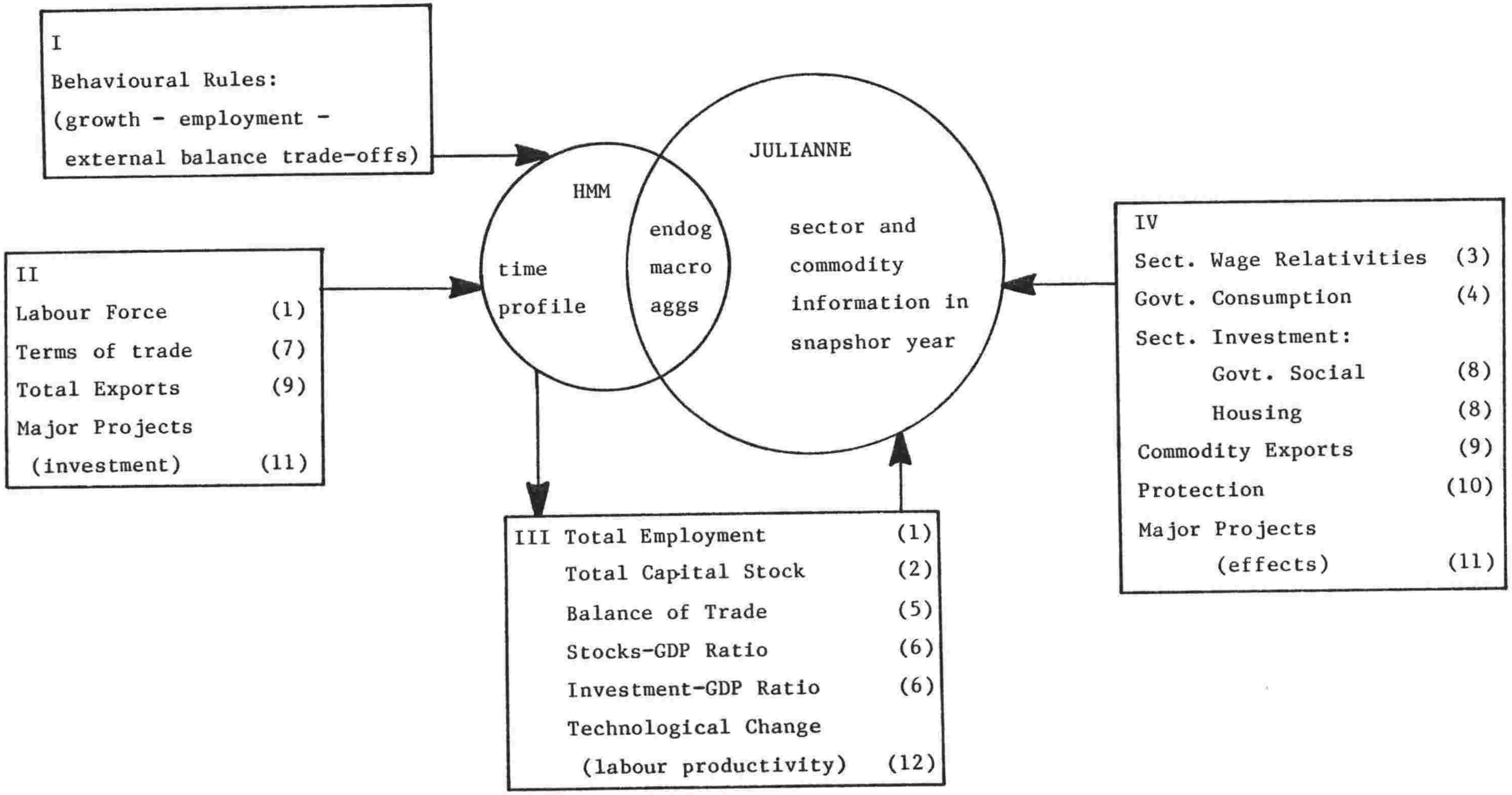
The Structure of the Interface

Figure 2 illustrates the relationship for the control run, between the JULIANNE model and the Haywood Macro Model (HMM); the macro forecasting model to which JULIANNE is linked.

In one sense HMM can be considered a subset of JULIANNE as the aggregate output from the former is given a sectoral composition by the

Figure 2

JULIANNE - HMM Interface Linkages



latter, which also provides a consistent set of relative prices and the disaggregation of consumer expenditure, imports, exports etc. However, HMM is not completely subsumed by JULIANNE. If it was, a model interface would be unnecessary. Its major distinguishing characteristic is that it is a multiperiod forecasting model based on a few key econometrically estimated macroeconomic relationships and closed by the exogenous setting of a number of behavioural functions which reflect the government's economic stance as manifested by the (inferred) trade-off between various policy objectives, such as between maximum growth and a sustainable balance of payments.[1]

The various constraints and assumptions relevant to HMM and JULIANNE which are set out in figure 2, are divided into four blocks. The first one is exclusive to HMM, being the set of behavioural assumptions used to simulate policy. The second group consists of inputs into HMM which are also required in JULIANNE. These originate from sectoral consultations and official data wherever possible, and as a last resort, from assumptions made by members of the NSP team. The items in the third group are results from HMM which are then used as input into JULIANNE and those in the fourth group are additional inputs required only by JULIANNE - sources as for the second group.

The numbers on the various items correspond to their ordering in the next subsection where they are discussed in more detail.

Assumptions and Constraints

The list of alterations to model parameters and variables is essentially that used in the previous Section (7.2) for model validation, plus a few extras.[2]

1. Total employment and labour force
2. Total capital stock

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[1] Complete details on HMM can be found in Haywood [47] and Haywood et al [49].

[2] The version of the model used here encompasses 40 sectors - up from the 26 used in the previous Section. The latter was based on provisional 1976/77 inter-industry tables whereas final tables are now available, allowing an expansion of the number of sectors in the model.

3. Sectoral wage relativities
4. Real government consumption
5. Balance of Trade
6. Gross investment and stock change ratios
7. Terms of trade (export subsidy rates and import prices)
8. Real investment in government social services and housing.
9. Exports
10. Protection
11. Major projects
12. Technological change - efficiency parameter.

1. Labour Force and Employment

From the NSP publication; Haywood et al [49],[3] the labour force in 1990 is projected to be 1595 thousand and total employment is projected by HMM to be 1517 thousand.

2. Capital Stock

Total capital stock in 1990, excluding that in Government Services, is set at $72870m in 1976/77 prices, being built up from the HMM gross investment profile less annual depreciation.

3. Sectoral Wage Relativities

In the absence of any information about future wage rate relativities, those prevailing in 1981/82 are assumed to apply in 1990. The relativities were calculated in Section 7.2 so the detail is not reported again. Table 6 gives the results for 40 sectors.

4. Government Consumption

A growth of 2.0% pa on 1979/80 is assumed (from NSP), yielding a 1990 value of $2765m in 1976/77 prices.

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[3] All references to NSP will refer to Haywood et al [49] unless otherwise stated.

5. Balance of Trade

The balance of trade on exports and imports of goods and services is set at \$-136m in 1976/77 prices adjusted for the projected change in the terms of trade between 1976/77 and 1989/90. (See item 7.) The mechanics of this calculation are as follows.

Algebraically we have:

$$E - M = A$$

$$\& \quad Pe\,E - Pm\,M = B$$

where: E is the volume of exports in 1976/77 prices.
M " " " " imports " " "
Pe and Pm are the respective price indices, base = 1976/77.
A is the balance of trade in 1976/77 prices.
B " " " " " " current (1990) prices.

Note that in practice, Pe and Pm are vectors of prices, and E and M are vectors of quantities.

One does not pretend to be able to forecast Pe and Pm but one does make an assumption (equal to that in the NSP) about their relative movement; that is, about the terms of trade. This is effected by deflating Pe and Pm by a general world price index. Thus:

$$\frac{Pe\,E}{Pw} - \frac{Pm\,M}{Pw} = \frac{B}{Pw}$$

or $Pe^{*}E - Pm^{*}M = B^{*}$ where $Pe^{*}=Pe/Pw$ and so on.

and $\frac{Pe}{Pm} = \frac{Pe^{*}}{Pm^{*}}$ = the terms of trade.

The balance of trade constraint in JULIANNE is B^{*} and its value of \$-136m comes from the HMM run presented in Haywood et al [49].

Note that the deflation of Pe and Pm by Pw also implies that all model prices are relative to a world price index, so that the rate of world inflation deflated by some index and converted into NZ currency is essentially the numeraire of the model. The homogeneity property of the model allows one to set the numeraire at any value without affecting real magnitudes and relative prices, such as the terms of trade. Thus for convenience all world prices are set at an index value of unity (as in 1976/77) except for the price of oil which is set at 2.125 as explained in item (7) below.

6. Gross Investment and Stock Change

Gross investment is set as a ratio to gross domestic product of 21.0%-21.5%. Stock change is set at approximately 5% of GDP. These values are from HMM.

7. Terms of Trade

The terms of trade are exogenous to HMM, being a simple ratio of two prices. In JULIANNE there are numerous export and import prices, with quantity weights that vary across scenarios, thereby generating different terms of trade for unchanged traded goods prices. Even if the terms of trade do equal those in HMM, JULIANNE results are not invariant to the composition of the terms of trade. That is, whether import prices or export prices change and of which commodities. Also, whilst C.I.F. import prices are exogenous to JULIANNE, export prices are generally determined by costs of production plus whatever subsidies may exist.

To obtain the same terms of trade in JULIANNE as are set for HMM, the following procedure is adopted.

(i) The real (1976/77) price of oil in 1990 is set at 2.125 (see also Section 7.2, item 9), which corresponds to no further real increase above its 1983/84 real price.

(ii) The 1981/82 profile of price-subsidy equivalent export incentives (namely EPTI's and SMP's as in 7.2, item 7) adjusts uniformly upwards or downwards to achieve the desired terms of trade, should the real oil price change not suffice.

The HMM terms of trade are 0.973 on a 1976/77 base of 1.000. A tolerance margin of 0.001 is allowed in JULIANNE.

Table 6

Wage Rate Relativities & Rates of Technological Change

	relativity	% pa
DAB	1.107	1.1
SHE	0.783	1.1
HOR	0.697	1.1
FOR	0.967	1.7
FIS	0.835	1.0
COA	0.718	1.0
ORE	0.959	0.0
MEA	1.204	0.37
DAI	1.213	0.37
FBT	1.024	0.37
TEX	0.887	0.75
CLO	0.666	0.75
WOD	0.850	2.0
PAP	1.129	2.0
PUB	0.775	2.0
CHE	1.425	1.4
PET	1.096	0.0
RUB	0.951	1.4
PLA	0.751	1.4
CER	1.000	0.0
BAS	1.388	0.0
FAB	0.795	2.0
TEQ	0.900	2.0
OTH	0.746	2.0
ELE	0.889	1.0
GAW	1.342	3.0
CON	0.752	1.16
TRA	0.829	1.0
RES	0.720	1.0
FRT	0.795	3.0
ROA	0.775	3.0
AIR	1.416	3.0
COM	0.935	2.3
FIN	0.885	0.0
OWN	--	0.0
GOV	1.075	0.0
LEI	0.889	0.0
PRI	0.502	0.0
NSE	1.637	-
SPM	1.532	-

Table 7: Exports

	1976/77	% pa
Horticulture	88.2	10.67
Fishing	43.2	5.83
Forestry	29.5	-0.85
Mining	14.5	10.72
Dairy	415.0	2.96
Meat	768.1	0.57
Wool	654.7	2.41
Other Food	192.5	1.15
Textiles	175.5	3.50
Clothing	49.6	3.54
Wood	39.7	3.78
Paper & Print	154.7	3.13
Chemicals	19.6	11.05
Rubber	1.9	11.05
Plastics	9.6	11.05
Ceramics	8.0	6.88
Base Metals	108.1	8.35
Metal Prods.	96.7	8.08
Transport Equip.	16.8	8.08
Other Mfg.	10.0	13.60
Energy	36.8	4.35
Services	699.4	3.71

8. Sectoral Investment

(i) Growth in government social investment of 0.90% pa from 1976/77 yields a 1990 value of $446m in 1976/77 prices. This rate of growth is approximately equal to projected population growth.

(ii) It is assumed that 21,000 houses are constructed in 1990 at a total value of $420m in 1976/77 prices.

All other sectoral investment is endogenous.

9. Exports

In the control run export volumes are set exogenously according to the expectations of the sectors involved, as in the NSP. The figures for the 18 export commodities there identified are expanded to cover the 22 export types distinguished in the JULIANNE 40 sector model, as shown in table 7.

From the model's solution one can then determine for each commodity the implicit 1977-1990 shift of the demand curve, given an assumption about its price elasticity of demand. As before, the elasticity for dairy meat and wool is set at -1.0, for horticulture and energy at -2.0, and for all other goods and services at -5.0.

In subsequent runs one can then revert to the correct theoretical procedure of setting the shift factor, as determined from the control run, and allowing quantities to move endogenously along the demand curves as a function of relative NZ-World prices.

10. Import Protection

Given that HMM is agnostic about levels of proteciton and since its equations have been estimated over a period during which protection has been extensive, one thought it best to assume unchanged protection in 1990 - at least for the control run. This can then be altered in later runs. It is also useful to have a control run based on the assumption of no policy change.

11. Major Projects

There are three aspects to incorporating the major projects into the model:

- (i) Investment which is unusually high or uneven over time and thus needs to be inserted exogenously.
- (ii) Exports
- (iii) Import substitution

Item (i) is negligible by 1990 as may be seen from table 8a and exports (in table 8b) are embedded in the values in table 2. Note that these tables are in 1981/82 prices - NSP [49, pp 20, 67, 68].

Import substitution effects are shown in table 8c and necessitate the following exogenous coefficient changes:

1. A reduction in the proportion of refinery inputs accounted for by crude and naphtha, and a corresponding rise in domestic feedstock from the Coal and Natural Gas sector.
2. The routing of synthetic petrol and methanol as (perfect) substitutes for normal petrol.
3. A reduction in liquid fuel use by Railways and an increase in electricity usage.
4. A reduction in petrol use in the transport sectors and an increase in CNG/LPG use.
5. Domestically produced urea fertilizer to replace some imported fertilizer.
6. New Zealand produced steel to replace some of the projected increase in imported steel.

Table 8a: Major Projects Gross Investment ($m 1982)

(figures in parentheses are import content)

	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/99	89/90	Total
Ammonia-Urea	50	27	35								112
(Chemicals)	(29)	(16)	(20)								(65)
Methanol		54	130	56							240
(Chemicals)		(32)	(78)	(34)							(144)
Refinery Expansion	40	110	330	300	265	60					1105
(Petrol)	(20)	(55)	(165)	(150)	(132)	(30)					(552)
Synthetic Gasoline	9	65	398	522	215	91					1300
(Petrol)	(5)	(39)	(239)	(313)	(129)	(55)					(780)
NZ Steel Expansion		60	295	200	200	120	50				925
(Base Metals)		(35)	(174)	(118)	(118)	(71)	(29)				(545)
Comalco Expansion	30	110	70								210
(Base Metals)	(9)	(33)	(21)								(63)
NI Main Trunk Elect.			20	25	35	50	50	4	4	4	192
(Transport)			(10)	(13)	(18)	(25)	(26)	(2)	(2)	(2)	(98)
Total	129	426	1278	1103	715	321	100	4	4	4	4084
	(63)	(210)	(707)	(628)	(397)	(181)	(55)	(2)	(2)	(2)	(2247)

Table 8b: Major Projects Exports ($m 1982)

(figures in parentheses are import content)

	82/83	83/84	84/85	85/86	86/87	87/88	88/99	89/90
Ammonia-Urea		30	30	30	30	30	30	30
(Chemicals)		(2)	(2)	(2)	(2)	(2)	(2)	(2)
Methanol			90	90	90	90	90	90
(Chemicals)			(12)	(12)	(12)	(12)	(12)	(12)
Refinery Expansion								
(Petrol)								
Synthetic Gasoline								
(Petrol)								
NZ Steel Expansion			140	140	140	78	88	97
(Base Metals)			(31)	(31)	(31)	(17)	(19)	(21)
Comalco Expansion		70	125	125	125	125	125	125
(Base Metals)		(33)	(59)	(59)	(59)	(59)	(59)	(59)
NI Main Trunk Elect.								
(Transport)								
Total		100	385	385	385	323	333	342
		(35)	(104)	(104)	(104)	(90)	(92)	(94)

Table 8c: Major Projects Import Substitution ($m 1982)

(figures in parentheses are import content)

	82/83	83/84	84/85	85/86	86/87	87/88	88/99	89/90
Ammonia-Urea (Chemicals)		7	7	7	7	7	7	7
Methanol (Chemicals)								
Refinery Expansion (Petrol)					190 (18)	190 (18)	190 (18)	190 (18)
Synthetic Gasoline (Petrol)				100 (15)	300 (46)	300 (46)	300 (46)	300 (46)
NZ Steel Expansion (Base Metals)						117 (26)	132 (29)	145 (32)
Comalco Expansion (Base Metals)								
NI Main Trunk Elect. (Transport)				10	10	20	20	20
Total		7	7	117 (15)	507 (64)	634 (90)	649 (93)	662 (96)

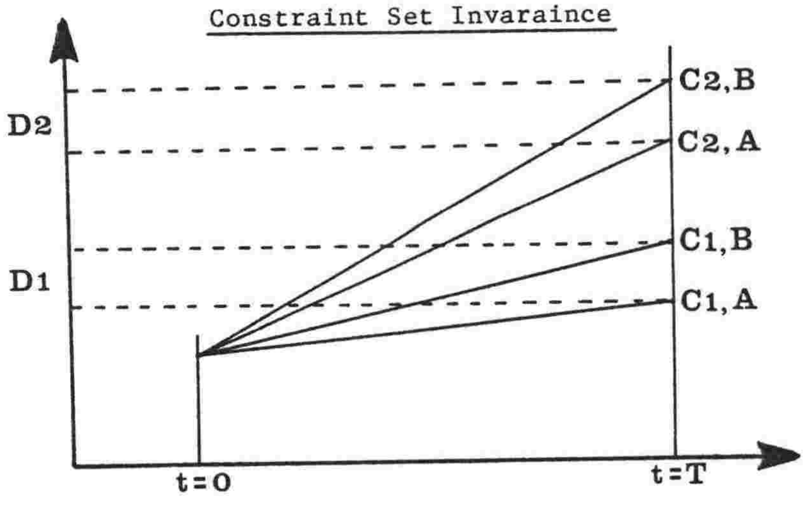
12. Technological Change

Rates of technological change come from the NSP sectoral consultations for 26 sectors and adapted to 40 sectors. The per annum rates are shown in table 6 and average about 1%. This applies from 1981 onwards which comes after a period of declining rates such that for the whole thirteen year period 1977-90, the mean rate is abouit 0.64% pa.

Before moving on to the results it is pertinent to recall that Section 7.1 provided evidence which showed that differences between alternative contemporaneous scenarios are not sensitive to the overall level of exonomic activity; a dictum about snapshot GE modelling which has been reinforced by other unreported runs. This means that JULIANNE results are more reliable when compared contemporaneously than when compared intertemporally. Thus, as with Johansen type models which yield results in terms of percentage differences from a hypothetical 'what would otherwise occur' situation, the particular characteristics of that situation (or control run in JULIANNE terminology) will not generally have any significant effect on the (percentage) differences from the control situation. Figure 3 illustrates this argument.

Figure 3

Constraint Set Invaraince



Two alternative horizon year macro constraint sets are represented by C1 and C2. A known exogenous shock produces outcome B given a control run A. The contention is that the percentage differences D1 and D2 will generally be very similar. That is, they are largely independent of the particular constraint set used. Naturally, however, any comparison with the base year is very dependent on the particular horizon year scenario in question.

Nevertheless, since JULIANNE requires a control run of some sort to act as a reference point for any comparative contemporaneous analysis, one may as well select a realistic projection of some future year. The more realistic it is (which one might perhaps judge a priori by the quantity and/or quality of those who contribute to the exercise), the smaller is the chance that one might overlook some event which could influence model results. And by choosing a future year rather than providing alternative pictures of the past or present; that is, of what could have been, one is less susceptible to accusations of inductive reasoning and one may just occasionally have some influence on that future.

Results

Table 9 gives the results of the JULIANNE run together with those of the HMM run. Actual 1976/77 data is also given.

The results show that with the constraints specified above, JULIANNE can achieve a higher GDP than HMM, corresponding to a growth rate of about 2.5% pa from 1976/77 as against 2.1% in HMM. Such differences are to be expected between a relatively simple projection model and a GE model which incorporates assumptions of profit maximisation and utility maximisation, and permits substitution between factors of production, between domestic and imported goods of a given type and, in some areas, between composite goods of different types.

Export subsidy rates, about which HMM is silent, are required to increase by 10% on their 1981/82 values in order to satisfy the terms of trade constraint. In fact, of the 2.7% decline in the terms of trade between 1977 and 1990, the higher oil price accounts for about 3/4 and the lower export prices for the other 1/4.

The value of the CPI, it should be remembered, is the change in consumer prices over and above any world inflation after allowing for the real oil price increase. It is certainly not a forecast of inflation.

Evidence from other runs of the JULIANNE model (as reported in Stroombergen and Philpott [89]) shows that the HMM level of GDP can be obtained by JULIANNE with somewhat lower capital-labour substitution and

Table 9

Macro Results

($m 1976/77)

	1976/77	1989/90	
	Actual	HMM	JUL.
Private Consumption	8038	--	11335
Government Consumption *	2090	--	2765
Gross Investment	3418	3810	4012
Stock Change	707	--	973
Exports *	3665	5666	5666
Imports	3992	--	5635
Balance of Trade	-327	--	31
Gross Domestic Product	13926	18231	19117
- % pa growth on '77	-	2.09	2.47
Consumer Price Index	100	--	113.4
Mean Real Wage Rate (% pa change on '77)	-	--	1.03
Export Subsidy Rate (% change on '82)	-	--	10.0
Terms of Trade *	100	97.3	97.2
Employment (000's) *	1249.6	1517	1517
Investment - GDP Ratio (%)	24.5	20.9	21.0
Import - GDP Ratio (%)	28.7	--	29.5

* denotes exogenous

import-domestic substitution,[4] and with about 3.5% less of both capital and exports than given above; a result supported by runs from the VICTORIA linear programming model (described in Haywood et al [49]).

However, the aim here is not to analyse the variations of the constraints that are required to secure similar results between JULIANNE and HMM. That can be read about in the aforementioned papers. The

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[4] The run presented here utilised Cobb-Douglas production functions with Hicks neutral technological change, and mean import-domestic substitution elasticity = 1.50.

objective has been to demonstrate how a control scenario for contemporaneous comparative analysis purposes, can be derived through interfacing JULIANNE with a macro projection model. For this reason a discussion of sectoral results is deferred. To a large extent these will only be as reasonable (in relation to 1976/77) as the input data is plausible. Hopefully the results given are seen to be realistic but they should never be interpreted as forecasts of 1990; not about the level of economic activity, nor about particular policy stances. Of far greater interest and reliability are the sectoral changes that occur between alternative scenarios of some given year, here 1990. Intertemporal comparisons are not where the comparative advantage of general equilibrium models lies. On then to Section 4.

7.4 The Effects of Export Subsidisation and Slow Export Growth

Introduction and Procedure

This first 'proper' application of the JULIANNE model looks at whether there is any benefit in subsidising exports in the face of substantial reductions in world demand, that result from say slow world income growth or market access problems.

Nine runs are presented which may appear imposing but their strictly symmetrical ordering makes for easy interpretation, as shown in figure 4. Excluding the control run, the other eight runs are divided into two groups of four, the first of which incorporates backward movements (or rather, slower forward movements) of the demand curves for exports of dairy, meat and wool, equal to 50% of the implied shifts between 1976/77 and 1989/90 as calculated from the control run. The second group of runs incorporates identical demand curve shifts for all other exports except services. The reason for taking such a large number of export commodities in this group is in order to obtain an absolute dollar value close to the dollar value of dairy, meat and wool exports. If this is not done the 50% shifts in each group's demand curves will not represent comparable shocks. We will refer loosely to the two groups as agricultural and manufacturing.

Each group consists of four runs, differentiated as follows:

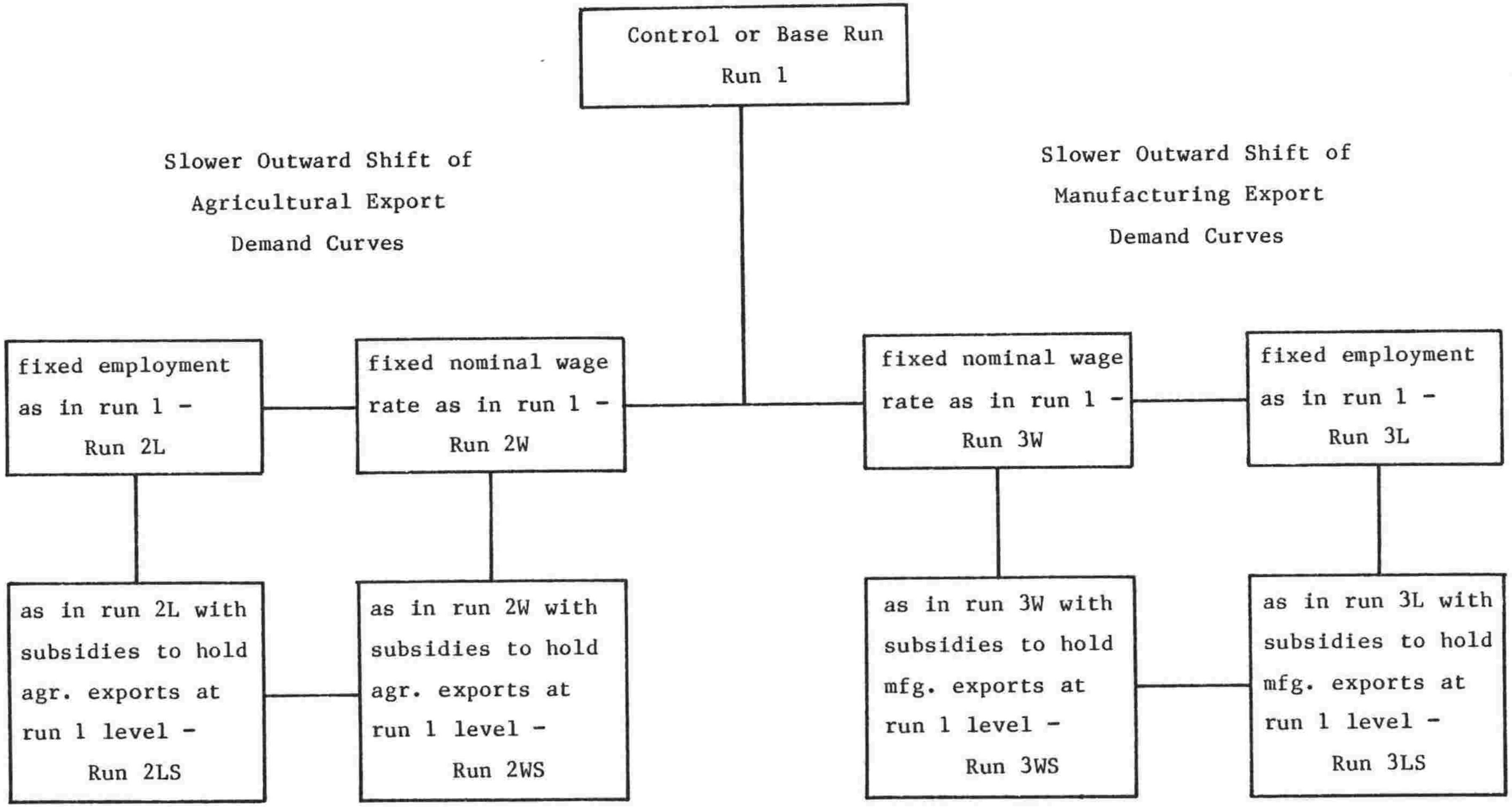
1. Flexible employment and fixed nominal wage rates - the latter being fixed at the control run rates. (Note that the fixed wage rate is relative to the exchange rate numeraire. Thus it is effectively fixed relative to world prices.)

2. Flexible wage rates and fixed employment - at the control run level.

3 & 4. Each of (1) and (2) above with the inclusion of export subsidies to hold agricultural/manufacturing exports at their level in the control run.

Figure 4

Schema of Runs



These runs will enable one to ascertain if export subsidies are worthwhile, whether it depends on the type of exports concerned and whether it depends on the degree of flexibility in the labour market.

A run such as that presented in the previous section would normally suffice as a control scenario. But since the subsidisation of exports is the main issue of interest here it was thought that it would be better to begin with a control run that had no net increase in export subsidy rates. (Recall that the previous run had an increase of 10% on 1981/82 rates.) Removing the subsidy increase renders the terms of trade endogenous which implies that strict comparability with HMM is lost. However, this is of no consequence since one is primarily interested here in contemporaneous differences. A further departure from HMM occurs by holding nominal wage rates at the levels obtained in the previous run and letting employment be endogenous. Finally a few cost differences (tariff equivalents) were revised due to new data becoming available.[1]

All of these changes are minor and indeed the results of the new control run (run 1 in table 10) are virtually indistinguishable from the earlier one. The differences will not be discussed as they are irrelevant to the stated topic.

In all subsequent runs real government consumption, capacity utilisation, the nominal balance of trade and the usual array of sector specific parameters and exogenous variables, are held constant at control run levels.

Results

The macro results are given in table 10 and some sectoral results are presented in tables 11 and 12. From the former one makes the following observations and deductions.

> The shifts in the demand curves for manufacturing exports cause greater falls in employment and/or private consumption than do the shifts in the demand curves for agricultural exports. This is primarily because manufacturing exports respond more to reduced

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[1] Modifications of this type occur continually in this line of work. They do not usually merit more than passing mention.

Table 10: Macro Results (76/77 $m)

	1	2W	2L	2WS	2LS	3W	3L	3WS	3LS
	Control	Demand Fall for Agr. Exports				Demand Fall for Mfg. Exports			
	Run			with Agr subs				with Mfg subs	
Private Consumption	11350	11149	11295	10991	11122	10917	11216	11123	11227
Gross Investment	4016	3957	4000	3909	3947	3888	3975	3948	3978
Exports	5625	5620	5701	5850	5915	5486	5653	5717	5764
Imports	5606	5485	5536	5458	5503	5275	5375	5484	5505
Gross Domestic Product	19124	18961	19192	18999	19199	18716	19196	19023	19191
Effective GDP	18978	18702	18901	18484	18661	18381	18795	18663	18805
% change on control	-	-1.45	-0.41	-2.60	-1.67	-3.15	-0.96	-1.66	-0.91
Real Exchange Rate ('77=1.000)	1.051	1.036	1.026	1.037	1.030	1.018	1.006	1.038	1.031
Terms of Trade ('77=1.000)	0.974	0.954	0.949	0.912	0.909	0.939	0.929	0.937	0.933
Export Subsidy (% point inc.)	-	-	-	10.7	10.5	-	-	5.3	4.8
Imports/GDP (%)	29.3	28.9	28.8	28.7	28.7	28.2	28.0	28.8	28.7
Employment ('000)	1507	1471	1507*	1476	1507*	1433	1507*	1481	1507*
Exports: Agriculture	2324	2058	2066	2324*	2324*	2404	2425	2355	2368
Services	1087	1179	1207	1166	1191	1248	1315	1148	1182
Mfg. (mostly)	2214	2383	2428	2360	2400	1834	1914	2214*	2214*

* denotes exogenous varaible

domestic costs when agricultural exports fall, than do agricultural exports when manufacturing exports fall, irrespective of whether wage rates are fixed or flexible.

Neither subsidies nor flexible wage rates are ever sufficient to restore private consumption to the level obtained in run 1. Run 2L (agriculture: flexible wage rates, no subsidies) does, however, come fairly close.

Whether agricultural exports or manufacturing exports incur the demand curve shifts and irrespective of whether subsidies are introduced, a flexible wage rate yields better results in terms of employment and private consumption than a fixed wage rate.

With lower agricultural export demand the subsidies reduce consumption and effective GDP, although in the fixed wage case employment does rise by 5000 persons, (run 2WS v 2W).

With lower manufacturing export demand the subsidies increase private consumption and effective GDP, and under a fixed wage rate employment rises by 48,000 persons, (run 3WS v 3W).

The desirability of subsidising exports thus depends on the price elasticity of demand of the exports in question. If the elasticity is low (absolutely) as for agricultural exports, the required subsidy is too large causing a severe decline in the terms of trade; two severe for it to be negated by the access to cheaper imports which the higher export volumes allow.

Whether subsidies increase or reduce private consumption (which depends on whether one refers to the manufacturing or agricultural case respectively), the effect of the subsidy on private consumption is always better, or not so bad, under a fixed wage rate than under a flexible wage rate. But whilst the flexibility of the wage rate and the presence of subsidies have an interdependent effect on private consumption:

The subsidy rate required to hold agricultural or manufacturing exports is insensitive to the assumption about wage flexibility.

The changes in the real exchange rate (which is measured here by the sectoral gross output price index divided by the c.i.f. import price index)[2] confirm the above observations. It falls relative to control in all eight runs. If world growth is slow and this is reflected in the rate of outward movement of the export demand curves, then New Zealand's competitiveness must improve especially in the 'L' runs where employment is not permitted to fall.

In both the agricultural and manufacturing cases the real exchange rate is lower in the runs without subsidies than in those with subsidies, demonstrating the (partial) substitutability between subsidisation and devaluation.[3] However, this substitutability is not purely a matter of policy choice. Subsidies channel resources into particular exporting activities which forces up the prices that other users (including 'unfavoured' exporters) must pay for those resources, causing an inevitable rise in the real exchange rate, relative to a subsidy free situation.

The difference between the agricultural and manufacturing cases is that in the latter the subsidies do a better job, in terms of minimising the fall in private consumption, than does a reduction in the real exchange rate. A problem specific remedy is usually more efficient than a broadly targeted one. But in the agricultural case, because subsidies are inefficient as they exacerbate the fall in private consumption, it is naturally better not to apply them. A fall in the real exchange rate prevents the prodigal absorption of resources by the agricultural sectors that subsidies encourage, helping instead those exports and import substitutes that are more responsive to price signals.

Micro Results

Rather than give volumes of sectoral results for all nine runs, presented in table 11 are the changes in gross output to the control run, for a few representative sectors, for four runs; the best and worst outcome in terms of private consumption under each of lower agricultural exports and lower manufactured exports.

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[2] The numerator is frequently relaced by the GDP price index but in the presence of export subsidies a downward bias may occur.

[3] Of course whether the latter is effected by a nominal devaluation that 'sticks' or by a reduction in NZ's relative inflation rate, is not something the model can answer.

Table 11

Sectoral Output Changes

(% diffs from control)

	Agriculture		Manufacturing	
	2WS	2L	3W	3LS
	Worst	Best	Worst	Best
Dairy & Beef Farming	-2.14	-7.10	0.02	0.96
Sheep Farming	2.15	-4.66	1.69	2.57
Meat Processing	3.05	-3.10	0.30	0.72
Dairy Processing	-5.60	-9.92	-0.05	1.13
Textiles	4.14	3.40	0.65	6.84
Clothing & Apparel	-1.53	1.02	-4.25	1.44
Chemicals	-0.03	0.89	-2.91	0.51
Plastics	0.62	2.78	-5.08	-0.57
Ceramic & Non-metallic Products	-0.65	1.58	-2.31	0.47
Fabricated Metal Products	-0.77	1.59	-4.53	-0.20
Transport Equipment	-2.05	0.85	-3.74	-0.45
Construction	-2.26	-0.24	-2.59	-0.39
Transport (excl. Air & Road Pass.)	0.77	2.08	-0.18	3.10
Leisure Services	-2.08	0.00	-2.62	-0.49

Looking first at agriculture: In the best outcome where wage rates are flexible and there are no subsidies (run 2L), all four of the primary sectors suffer unsurprising reductions in output - of up to 10% in the case of Dairy Processing. Simultaneously those sectors engaged in import substitution or in the production of manufactured goods for export, increase output. The Leisure Services sector output remains static as it is very much a function of the level of private consumption. Similarly with the Construction sector and the level of investment.

When subsidies are introduced in a situation of fixed wage rates Run 2WS), the primary sectors all improve relative to run 2L with the output of Sheep Farming and Meat Processing actually surpassing the control run levels. However, most of those sectors which in run 2L expanded output, now contract in relation to the control run; Plastics and Transport only contract relative to run 2L. The major exception to this trend is the Textiles sector, the output of which rises relative to run 2L. That sector provides a significant proportion of wool exports in the form of scoured wool. Thus its fortunes rise in run 2WS due to the subsidy on wool exports.

For the decline in manufactured export demand runs 3W and 3LS represent respectively the worst and best outcomes. In run 3W the output of all the manufacturing sectors declines quite sharply although once again the dual nature of the Textiles sector as an exporter of both agricultural and manufactured goods ensures that its output does not slip back.

The falls in private consumption and investment in run 3W, relative to the control run, are again reflected in the reductions in output of the Construction and Leisure Services sectors. The Transport sector is not significantly affected due to the increase in service exports - see table 10.

When subsidies are introduced under a flexible wage rate regime (run 3LS), all sectors do better than in run 3W and no sector's output is much below its control run level. This is in contrast to the difference between runs 2WS and 2L where the introduction of a subsidy reduced the output of many sectors.

Table 12 gives for three (interesting) sectors the share of the market held by imports and the proportion of output exported, for each of the runs given in table 2 plus the control run. The second row for each sector shows at a glance the directions of movement relative to the control run. Double headed arrows which occur only under run 2L (which is a 'best' run) indicate that the directions of change from control to run 2WS (a 'worst' run) are reinforced in run 2L. No such reinforcement from control to worst to best run occurs in the manufacturing case.

The import share of the market for all three goods drops in run 2WS and falls even more in run 2L, which is in line with the changes in the real exchange rate. Export ratios rise in 2WS, which in the case of Meat Processing and Textiles (that is, wool) is due to the subsidies, but Fabricated Metals exports rise without this assistance. Their only stimulant is that provided by lower production costs generally. In run 2L exports of Meat and Textiles decline with the removal of the subsidies, but Fabricated Metals exports rise even further due to the

Table 12

Import and Export Ratios (%)

	1 (control)		2WS (worst)		2L (best)		3W (worst)		3LS (best)	
	m	e	m	e	m	e	m	e	m	e
Meat Products Processing	4.96	62.9	4.83	64.5	4.67	61.6	4.63	63.7	4.74	63.2
(direction cf control)			↓	↑	↓↓	↓	↓	↑	↓	↑
Textiles	60.7	57.9	58.7	58.2	58.1	56.6	57.0	55.9	58.6	58.4
(direction cf control)			↓	↑	↓↓	↓	↓	↓	↓	↑
Fabricated Metal Products	33.9	9.09	33.6	9.72	33.5	9.84	33.3	7.51	33.5	9.06
(direction cf control)			↓	↑	↓↓	↑↑	↓	↓	↓	↓

m = M/(X+M-E) & e = E/X where M = cif imports in real 1976/77 prices
E = exports " " " (producers')
X = gross output " " "

The double arrows under run 2L indicate that the ratios are lower / higher than those in both the control run and run 2WS. No such situation exists in run 3LS relative to run 3W.

lower labour costs. Overall then, import substitution is always appropriate but the change in the real exchange rate consistent with this, is insufficient to increase the share of output exported by the Meat Proc. and Textiles sectors. Subsidies to export are required whereas the Fab. Metals export ratio rises without recourse to subsidisation.

In the manufacturing case the import shares also fall in the worst run (run 3W) relative to control but do not drop further in the best run, 3LS. Again this is in accordance with the changes in the real exchange rate. In run 3W only the Meat Processing sector's export ratio increases in response to the lower manufactured exports. The subsidies in run 3LS are sufficient for the Textile export propensity to rise above control whilst the Fab. export ratio is still just below control, although better than in run 3W. Note that the Meat Proc. export ratio falls slightly in relation to 3W as resources are diverted to the subsidised exports, which also have a higher (absolute) price elasticity of demand.

In all four runs, for all three sectors shown in Table 12, the import ratios fall relative to control. The import-GDP ratio given in Table 10 also falls relative to control. These results confirm one's prior expectations, namely that a policy of import substitution is appropriate if one is faced with slow growth in export demand, and that the degree of import substitution must be higher if no export subsidies are introduced. However, the relative emphasis that should be accorded to import substitution as against export promotion (via subsidisation), depends on which exports are originally affected by the slow growth. If agricultural commodities are involved the emphasis should be on import substitution. Conversely, export subsidies are appropriate in the manufacturing case. But both options entail a real devaluation, as may be seen in table 10.

Conclusion

The results have shown that the price elasticity of demand is the main factor in determining whether export subsidies are net beneficial. The more elastic the demand curve the greater is the chance that an export subsidy will increase welfare. Given this relationship an interesting extension to this study would be to ascertain the cut-off elasticity values for different export types.

In a wider context one might also investigate the effects of countervailing duties in the countries to which NZ exports are sent. This could be modelled by a further negative shift of the relevant demand curves, which may well render the use of export subsidies totally uneconomic. An alternative method of promoting exports might be to reduce our own import barriers and thus lower production costs. More on this in the next Chapter.

The sectoral results mirror events at the macro level but there are nevertheless substantial differences in the relative performance of sectors. In retrospect the directions of sectoral change in runs such as 2L and 3W could in most cases have been predicted in advance. But when subsidies are introduced such predictions would be more difficult, to say nothing of predicting the magnitude of the changes. Hence the need for a model.

For those readers who have formed the impression that significantly slower growth in export volumes (at constant prices) does not produce particularly large falls in consumption or in effective GDP (although a fall in employment of 30,000 is hardly small), one hastens to assert that the levels of total employment and/or total capital utilisation were expressly held constant. Thus it is resource allocation which is important here rather than total usage. Recall that we are looking at alternative pictures of some future year so it is not as if we are suddenly faced with slow export growth. Obviously consumption and GDP will decline if total resource use declines. It would not be difficult, nor very interesting, to model such scenarios. One's basic premise in the analysis presented here is that if world growth is slow or protectionism rises, then we must implement changes in New Zealand if we wish to (approximately) maintain our standard of living. Hopefully one now knows a little more about the nature of those changes.

7.5 The Effects of Wage Rate Changes

Introduction

Much interest in New Zealand has recently been focussed on wage rate differentials amongst various occupational groups and on the effects of granting wage increases to some groups, especially the metal trades groups (in the context of the major projects), with or without a follow-on effect on other groups. This provides a background to the subject of this last section of Chapter 7, which is to explore the workings of the CRESH version of the model applied to changes in occupational wage rates.

The CRESH version of the model incorporates Constant Ratios of Elasticities of Substitution, Homothetic production functions. Ten occupational categories are distinguished and the versatile CRESH specification permits different pairwise elasticities of substitution between these groups. Because there is much uncertainty regarding the value of these elasticities particular interest is centred on the implications of different assumptions about the elasticities of substitution between the various types of labour and between labour and capital, denoted as σ_{LL} and σ_{LK} respectively.

We revert to the 26 sector version of the model as it was not considered cost effective to incorporate CRESH functions in the 40 sector version, given that most of the extra data required is not readily available for that many sectors. They are, however, being included in the 1982 based, 22 sector version.

Specification of Runs

The following runs are considered:

Set A: Mean σ_{LL} = 0.35, mean σ_{LK} = 0.70 (See Table 13).

(1) An increase in the money wage rate of "Skilled Blue Collar - Metal and Electrical" workers of 20% with no follow-on

Table 13

CRESH Elasticities of Substitution

	PROF	SWC	USWC	SBC-ME	SBC-B	SBC-O	USBC	RUR	AS	O-NEC	CAP
PROF		0.42	0.25	0.17	0.42	0.30	0.10	0.40	0.19	0.35	0.50
SWC			0.63	0.43	1.05	0.75	0.24	0.99	0.49	0.88	1.26
USWC				0.26	0.63	0.45	0.14	0.59	0.29	0.53	0.75
SBC-ME					0.43	0.31	0.10	0.40	0.20	0.36	0.51
SBC-B						0.75	0.24	0.98	0.48	0.88	1.26
SBC-O							0.17	0.70	0.35	0.63	0.90
USBC								0.23	0.11	0.21	0.30
RUR									0.45	0.84	1.20
AS										0.40	0.57
O-NEC											1.05

mean $\sigma_{LL} = 0.35$, mean $\sigma_{LK} = 0.70$

Occupation Key:

PROF	Professional White Collar	USBC	Semi & Unskilled Blue Collar
SWC	Skilled White Collar	RUR	Rural Workers
USWC	Semi & Unskilled White Collar	AS	Armed Services
SBC-ME	Skilled Blue Collar - Metal & Electrical	O-NEC	Others - Not Elsewhere Class.
SBC-B	" " " - Building	CAP	Capital (all types)
SBC-O	" " " - Other		

effects on the other groups.

(2) An increase in the money wage rate of "Skilled White Collar" workers of 20% with no follow-on effects on the other groups.

(3) An increase in all money wage rates of 20%.

Set B: The above three runs but with all $\sigma_{LL} = 10.0$ and all $\sigma_{LK} = 1.0$.

These values, especially the former, are not necessarily realistic; rather they are set to approximate the situation under a Cobb-Douglas specification.

Set C: All money wage rates up by 20% using the Cobb-Douglas version of the model. Here $\sigma_{LK} = 1.0$ and $\sigma_{LL} = \infty$ (effectively).

Recall from Chapter 6 that the σ_{LL} in table 13 actually originate from Australian data but they should nevertheless be reasonably applicable to New Zealand.

In each run the following variables are held constant:

Total real gross investment
Total capital utilisation
Real government consumption
The nominal balance of trade deficit
The exchange rate (which is the numeraire)
All money wage rates other than those being exogenously changed.

Note that the value of the wage rate increases at 20% is chosen purely as an amount large enough to produce some significant changes.

Results

The results are given in Table 14 and are presented as percentage changes on a control run (obtained as in 7.3) of which there are three, one for each set. Separate control runs are required whenever the analysis involves changing parameter values in a future year, since one must be able to distinguish the effects of the contemporaneous changes across runs from the intertemporal changes between the base year and the horizon year. That is, a control type projection of 1990 will not generally be invariant to the choice of elasticities (σ_{LL} and σ_{LK}) if factor price relativities change between 1977 and 1990. The effects of this could easily corrupt the effects of the given exogenous wage rate changes if for example, run B1 were to be compared against the set A control run.

Looking firstly at the results from Run A1, it is evident that the low possibilities for factor substitution are responsible for an extensive degree of rigidity in the economy where resources, especially labour, are not permitted to respond to relative price (wage) changes. This exerts an upward pressure on prices (with the GDP deflator rising by 0.30%), which causes exports to decline by 0.37%. The increased wage for SBC-ME would initially raise the demand for labour from the other occupational groups but the decline in economic activity generally, which accompanies the drop in exports, causes a reduction in employment of all types. Only Armed Services employment exhibits a very small net increase. It benefits somewhat from the higher SBC-ME wage but does not suffer from the general decline in activity since government consumption is held constant and Armed Services are employed only by the Government Services sector.

In Run A2 SWC wages are increased by 20%. This group employs a similar number of people to the SBC-ME group.[1] Hence a comparison of results is legitimate. The overall effects are fairly similar to those in Run A1. Total employment falls more due to the very sharp fall in SWC employment. However, prices do not rise as much owing to the greater substitutability between SWC and other occupations, than between SBC-ME and other occupations. Thus exports and GDP do not fall as much.

[1] The model base run employs 92,000 and 94,700 people in SWC and SBC-ME respectively.

Table 14: Results (% diffs. from Control)

Assumptions re σ	A: mean σ_{LL} = 0.35, σ_{LK} = 0.70			B: all σ_{LL}=10.0, σ_{LK}=1.0			C: C-D
Run no. & occ. of wage rise	1(SBC-ME)	2(SWC)	3(all)	1(SBC-ME)	2(SWC)	3(all)	1(all)
Real Gross Domestic Product	-0.19	-0.06	-3.64	1.31	2.13	-7.82	-8.17
" Private Consumption	-0.21	-0.07	-4.00	1.53	2.61	-9.67	-9.84
" Exports	-0.37	-0.11	-7.16	1.94	2.85	-9.68	-12.0
" Imports	-0.17	-0.06	-3.39	0.86	1.29	-4.44	-5.75
GDP Deflator	0.30	0.11	6.36	-1.56	-2.37	7.86	9.63
Mean Nominal Rental Rate	-0.49	-0.16	-3.85	2.47	6.25	-1.80	-2.51
Employment: Total	-0.74	-1.09	-10.3	-3.07	-1.49	-16.3	-14.0
PROF	-0.10	-0.05	-3.38	0.78	1.39	-6.03	N/A
SWC	-0.47	-14.3	-16.2	2.59	-68.2	-18.2	
SUWC	-0.33	-0.11	-11.2	2.44	4.47	-18.6	
SBC-ME	-6.46	-0.13	-10.1	-69.0	4.52	-17.8	
" -B	-0.35	-0.08	-14.6	1.96	3.41	-15.6	
" -O	-0.39	-0.16	-12.4	2.48	4.62	-17.0	
SUBC	-0.32	-0.12	-7.61	2.55	4.20	-17.0	
RUR	-0.24	-0.09	-18.4	1.53	2.36	-22.9	
AS	0.02	-0.02	-0.90	-0.11	0.24	-1.00	
CAP	-0.46	-0.14	-13.0	2.67	3.82	-15.9	
Gross Output: Agriculture	0.10	0.01	-2.78	-0.06	-0.26	-9.80	-11.0
Fab. Metal Products	-0.99	-0.19	-8.22	4.91	3.20	-6.05	-7.48
Govt. Services	0.02	-0.02	-0.91	-0.11	0.24	-1.10	-0.97

Since Government Services is an intensive employer of SWC workers (as opposed to SBC-ME) its output falls fractionally thus causing a decline in AS employment in this run.

When all nominal wage rates are increased by 20%, as might occur if one occupation receives an increase and all other occupations succeed in maintaining relativity, the effects are predictable, at least in terms of direction. Total employment falls by 10% with falls in private consumption of 4% and in exports of 7%. The occupation which suffers the sharpest decline in employment is Rural Workers - a direct result of the fall in (agricultural) exports.

The rise in the GDP deflator of 6.36% is small in relation to the 20% increase in wages. One might expect a larger change. However, it is essential to distinguish here between the short run impact effects and the longer run effects - certainly the former would be larger. But recall that the level of capital utilisation is held constant. The increased purchasing power of consumers does not prevent an overall decline in activity, attributable mainly to the fall in exports. This negative income effect dominates the positive substitution effect on the demand for capital so its price must fall which it does, by 3.85%. This counteracts to some extent the effect on prices of the initial rise in labour costs and prevents an even greater decline in GDP.

In the set B runs with all $\sigma_{LL} = 10.0$ and all $\sigma_{LK} = 1.0$ the results are vastly different from those in set A. In response to the higher SBC-ME/SWC wage rates, the demand for these types of labour falls dramatically with a corresponding increase in the demand for other labour types. Essentially, when $\sigma_{LL} = 10.0$ the own price elasticities are so high that employers can more than compensate for the increased cost of one type of labour by hiring other types of labour and still lower the total wage bill. Hence the increase in economic activity. Again the greater flexibility associated with SWC workers over SBC-ME workers is responsible for the better picture in Run B2 compared with B1. In both runs the mean rental rate of capital rises as both the substitution effect and the income effect are positive this time. It rises more in B2 than in B1, just as it fell less in A2 than in A1.

Paradoxically the impact on sectoral outputs is the reverse of that in the A Runs. Neither Agriculture nor Government Services are major employers of SBC-ME workers so that in Run A1 when their wage rates rise, these sectors incur a relative price advantage whereas the opposite applies to the Fab. Metals sector. Again, Agriculture does not employ many SWC workers so it retains its price advantage in Run A2. However, in Runs B1 and B2 the situation is entirely reversed. For example, in Run B1 the shedding of SBC-ME workers by Fab. Metals is nowhere near negated by the extra employment of other types of labour by that sector so its production costs fall considerably. Conversely, Agriculture and Government Services cannot shed large numbers of SBC-ME workers since they are not there to begin with. But they must pay the higher capital prices so their production costs rise. Similar reasoning applies to Run B2.

The high own price elasticities associated with higher σ_{LL} also dictate the outcome in Run B3 where all occupational wage rates rise by the same amount. The greater the σ_{LL} and hence the own price elasticity, the greater is the fall in the demand for labour in response to some given wage increase (as is evident in Table 2). This enlarges the negative income effect on the demand for capital and so increases the downward pressure on rental rates. However, the higher σ_{LK} acts to reduce that pressure by reinforcing the positive substitution effect. Hence one has no way of knowing a priori which influence will dominate. The results show the latter to be stronger with the mean rental rate falling by 3.9% in Run A3 but by only 1.8% in B3. Consequently the rise in prices is higher in B3.

To place the CRESH results in perspective the effects of a uniform increase in all wage rates of 20% are also explored using the two input Cobb-Douglas production functions. The results are given by Run C1.

Private consumption and GDP fall slightly further, exports fall significantly further and prices rise more than in Run B3. The magnitudes of these changes are thus completely consistent with those in Runs A3 and B3 in the sense that they are what one expects as σ_{LL} moves from 0.35 through 10.0 to an effective value of infinity. Since there is no further increase in σ_{LK} between Runs B3 and C1, there is no extra beneficial substitution effect to counteract the greater negative income effect on the demand for capital. Accordingly rental rates fall by more than in Run B3. However, this is not sufficient to prevent prices from rising further in C1 than in B3 - 9.6% versus 7.9%.

Total employment which naturally still shows a decline, is actually up on the Run B3 result. One suspects that this is a quirk due to some inconsistencies between the Cobb-Douglas database and the CRESH database, in that the sectoral wage relativities in the former are not always the same as those that result from applying the occupational wage relativities to the occupation by sector matrix.[2] Therefore a uniform wage increase has different relative effects on sectoral cost structures between model versions. This in turn causes different relative price advantages which affects the distribution of sectoral output and employment movements, such that small differences at the macro level are quite plausible.

Overall the CRESH and Cobb-Douglas results display a high degree of mutual consistency, which although expected theoretically, is nonetheless rather remarkable considering the disparate data sources used for the two production specifications.[3]

Conclusion

This exercise has depicted the high sensitivity of model results to the values of the elasticities of substitution between labour types (σ_{LL}), and between labour and capital (σ_{LK}), in the context of changes in particular/all occupational wage rates. As is the case generally with elasticities, the value of unity is important as it determines whether reactions to price changes are less than compensatory or more than compensatory. One does not believe that $\sigma_{LL} = 10$ is realistic but the results obtained do imply that if any σ_{LL} (or σ_{LK}) are significantly greater than unity the economic impacts of wage rate changes are likely to be vastly different from when $\sigma_{LL} = 0.10$ say.

The results also show that if the relativity between the Metal Trades and other occupations is broken then the effects of Metal Trades wage rises (which may be justified with respect to the major projects) do less harm to total employment and the economy generally than if relativities remain. This is common sense. But if labour - labour

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[2] One is endeavouring to eradicate these inconsistencies in the 1982 based model.

[3] See Stroombergen [88].

elasticities of substitution are high enough, such wage rises could actually be beneficial to all occupations except Metal Trades (!).

It is essential therefore to use reliable estimates of such parameters when addressing questions about wage relativities, changes in these relativities or the associated issue of shortages of particular skill groups. Where doubts exist about the values of the elasticities it is important to locate the crucial elasticies and ascertain the crucial values of those elasticies.

Given the sensitivity of results to the σ_{LL} and σ_{LK} values why not use the CRESH functions all the time? The main reason for not doing so relates to the time horizon of the model. By projecting forward to some year in the medium term future one can frequently argue that there is enough time for labour to be trained and educated to meet whatever profile of occupational demand the model may yield. And, if occupational wage relativities remain as inflexible as in the past, the sectoral wage relativities (which proxy for different occupational wage relativities and the different occupational composition of each sector's labour force) and the associated C-D production functions should be generally satisfactory.

There is still much scope for general equilibrium research into the New Zealand labour market with plenty of potential use for the CRESH version of JULIANNE. As usual the nature of the issue being investigated dictates whether the use of more complicated model routines will be cost effective - in terms of both human time and computer time.

8

ALTERNATIVE PROTECTION REGIMES

CHAPTER 8

ALTERNATIVE PROTECTION REGIMES

8.1 Introduction

This chapter details a comprehensive application of the JULIANNE model, namely a study of the gains and losses associated with changes in New Zealand's import protection. One is interested in ascertaining whether there are protection regimes which are superior to either the current protection regime or to free trade; under what conditions and by how much. In so doing one also hopes to discover something about the degree of curvature of the production possibility frontier and the importance thereof.

Numerous alternative protection scenarios are presented with alternative labour market assumptions, and two of these runs are selected for more in-depth sensitivity testing. As in the previous chapter the horizon year for all runs is 1990. Thus a control run is required.

Details of the control run are given in the next section which is followed by a brief section outlining the runs. Discussion of the results takes up the bulk of the chapter in section 8.4 and a conclusion is given in 8.5.

Included at the end of the chapter is an adjunct in which model results are used to calculate the values of the various aggregate trade elasticities such as the mean (or total) price elasticity of demand for imports. These values are then compared against other estimates and inserted into the Marshall-Lerner equation as a test of their plausibility and as a test of the general structure of the model as it relates to trade theory.

8.2 Control Run Preliminaries

Chapter 7, section 3 dealt with the procurement of a control run for 1990, against which (in section 4) other runs were compared. This 'contemporaneous analysis' framework is also used here and, but for a few modifications, is based on the same control run as used in 7.4.

The first modification is the revision of the exogenous balance of trade constraint from a deficit of $-136m (see 7.3 item 5) to a surplus of $109m. The reason for this change is that as a result of feedback from the NSP paper[1] the balance of payments constraint in the Haywood Macro Model was tightened from a 3.5% deficit-GDP ratio to one of 2%, with unchanged assumptions about net factor payments.

Secondly, all the tariffs and tariff equivalents were completely updated to more closely match current (around 1984) levels of protection. Naturally these revisions are not the final word on the profile of protection in New Zealand. Aggregation errors and measurement errors are probably rife and even without these one should remember that import licences do not generally translate into unique tariff equivalents. Hopefully, however, one's approximations are free of any systematic bias.

Thirdly, the Allen elasticities of substitution between imported and domestic goods have been set at 2.0 for all competitive imports except Clothing and Transport Equipment (mostly CBU and CKD vehicles) for which values of 4.0 and 3.0 respectively have been assumed.

These three changes yielded a revised base run from which the implicit shifts in the export demand curves were (again) determined. However, to obtain a reference run which would better serve the objectives of this exercise two further changes were introduced, but without recalculation of the export demand curve shifts.

Firstly, because most of the analysis here is concerned with the pure allocational effects of protection, exogenous levels of capital utilization and employment need to be specified. The precise levels chosen are not particularly important since, as shown in Chapter 7.1, model results are not sensitive to the overall level of macroeconomic activity - a statement which will be further tested below. Thus one may

[1] Haywood et al [49]

as well assume full employment of both resources, namely $72870m of real (1976/77) capital and 1,595,000 people, (see 7.3 items 1 & 2).

Secondly, to counteract the effect full employment would have on implied GDP growth between now and 1989/90, in the light of the poor economic growth to 1984, technological change rates were revised downward to zero from 1986 to 1990 with estimated actual rates for 1977 to 1985. This compares with a mean rate of 1% pa for 1980-1990 used before.[2]

The new control run, designated run 8C, is presented in table 1. A comparison of this run with the previous control run is not relevant to this exercise.

8.3 Specification of Runs

The schema of runs is illustrated in figure 1. The two groups of five runs listed horizontally explore the macro effects of alternative protection regimes; the first group under the assumption of flexible wage rates with fixed employment and the second group under the assumption of fixed real wage rates with employment free. In all runs the balance of trade in ('nominal') world prices, total real gross investment and real government consumption are held constant.

The sensitivity of results from two runs of the former group is then tested against various assumptions about elasticities of substitution, sectoral wage rate differentials, and so on. Discussion of sectoral effects is generally confined to those two runs; 8Z and 8N.

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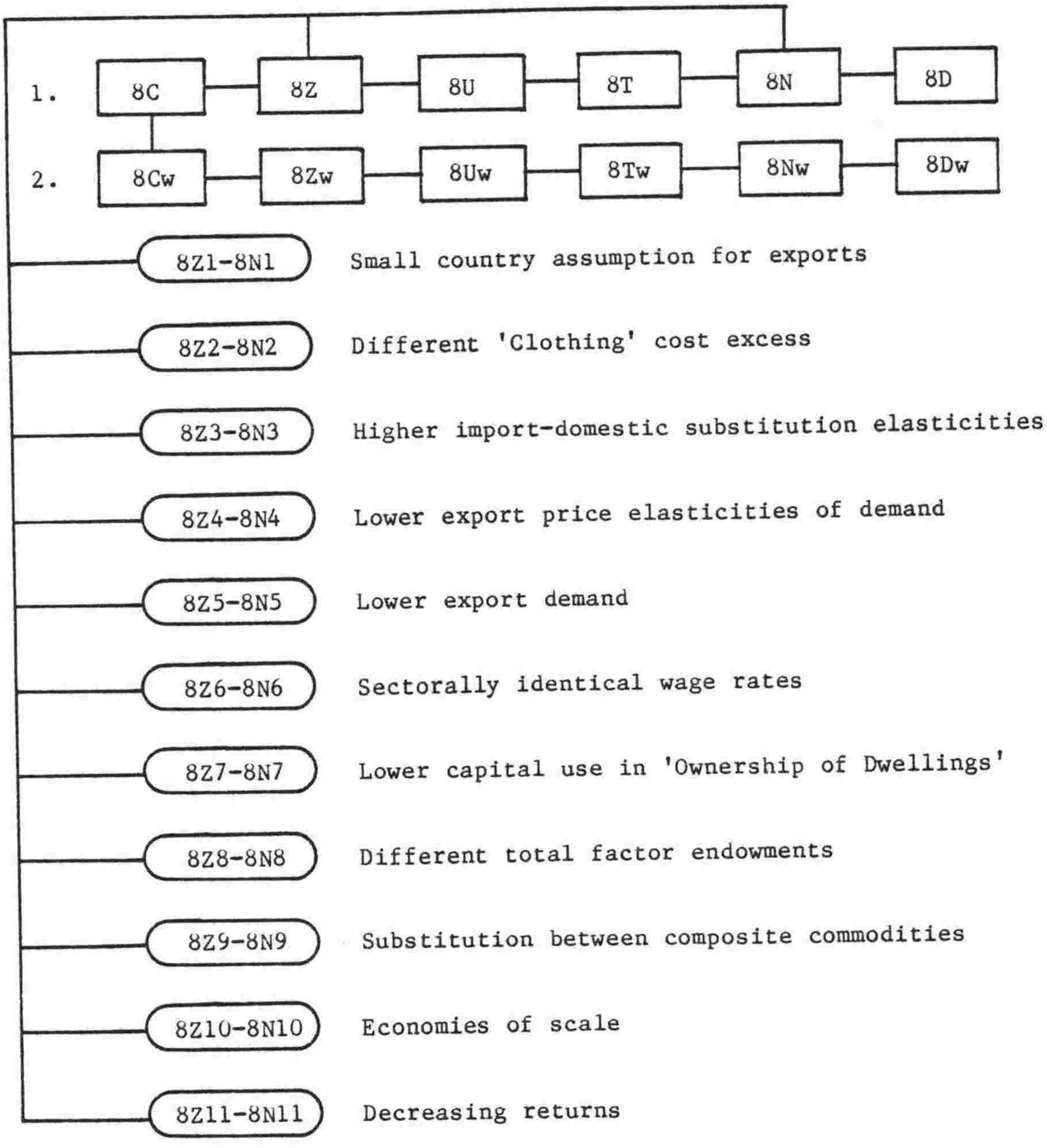
[2] One is aware that this adjustment seems redundant given the assertion in the previous paragraph. Strictly speaking it is, but personal experience has shown that no matter how many times that assertion is repeated, model results are received with less suspicion if the control run is a plausible projection of the horizon year.

Figure 1

Schema of Runs

C Control run, existing protection
Z Zero protection or free trade
U Uniform protection of 25%
T reduction of 'Tall poppies' - all tariff equivalents currently above 25% lowered to 25%, others unchanged
N as in U but exempting Non-competitive imports
D as in U with duty Drawback for exports

Group 1 runs have flexible wage rates and fixed employment.
Group 2 runs have fixed real wages and employment free.



8.4 Results

One should say at the outset that conventional calculations of the costs of protection based on the competitive neoclassical model yield rather small numbers; generally less than 2% of GDP. (See for example Boadway and Treddenick [8] or Dixon et al [30].) After firstly presenting the alternative protection scenarios, some of the reasons for these low figures will be investigated from which it will hopefully be possible to judge their reliability.

Starting with the results given in table 1, it may be seen that the differences between the best of these runs (run 8D) and the worst run (run 8C) is $140m in Private Consumption and $169m in Effective GDP, or 1.4% and 1.0% respectively. Both values are of the expected order of magnitude.

Complete free trade yields an increase in welfare compared to the present mix of protection (8Z v 8C) but a uniform tariff of 25% on all imports is better still, due to the terms of trade gain. These rise by 3.6 percentage points between 8Z and 8U. Thus whilst it is true to say that New Zealand's protection profile is generating a welfare loss, the unevenness of it is more at fault than its average rate (which is about 18%).

Run 8T in which the 'tall poppies' are reduced to a maximum of 25% protection produces an improvement on control but is still below both runs 8Z and 8U indicating that unevenness is still a significant problem, although cutting down the tall poppies yields over half the benefit that accompanies complete protection removal. That is, PriCon and Effective GDP in 8T are more than half way between 8C and 8Z.

Run 8N looks at the effects of a 25% tariff on imports judged (subjectively) as competitive or potentially competitive. This tariff protects the output of the import substituters and also holds down their costs by keeping imports of raw materials tariff free. Thus effective protection remains closer to nominal protection. The resultant levels of PriCon and Effective GDP are extremely close to the 8Z values although exports and imports are much less, being nearer to those in 8T. So one asks: Given that 8U is the best result so far, can the gains from a uniform tariff be utilised whilst simultaneously preventing cost increases in export industries? Run 8D looks at this question by

Table 1

Macro Results

($m 1976/77)

	8C	8Z	8U	8T	8N	8D	8Cw	8Zw	8Uw	8Tw	8Nw	8Dw
Private Consumption	10014	10084	10109	10054	10083	10154	9535	10057	9524	9712	9854	9685
Exports	4902	5520	4776	5076	5150	4910	4706	5508	4547	4932	5051	4719
Imports	4876	5346	4787	5010	5068	4931	4749	5338	4638	4917	5003	4807
Gross Domestic Product	17372	17606	17443	17455	17511	17483	16782	17572	16697	17034	17226	16907
Effective GDP	17447	17534	17555	17491	17530	17606	16926	17504	16889	17120	17280	17096
Employment ('000)	1595	=	=	=	=	=	1481	1588	1458	1513	1540	1484
Real Exchange Rate	0.998	0.938	1.006	0.980	0.966	1.044	1.021	0.940	1.035	0.996	0.976	1.068
Terms of Trade	1.015	0.987	1.023	1.007	1.004	1.025	1.031	0.988	1.042	1.017	1.011	1.040
Real Wage Rate	0.976	1.036	0.962	0.994	1.009	0.977	1.040	=	=	=	=	=
M/GDP ratio (%)	28.1	30.4	27.4	28.7	28.9	28.2	28.3	30.4	27.8	28.9	29.0	28.4

Note: (1) The real exchange rate is the GDP deflator divided by the cif import price index (1976/77 = 1.000).

(2) The terms of trade is the fob export price index " " " " " " " "

(3) The real wage rate is the 'nominal' wage rate index divided by the CPI (1976/77 = 1.000).

(4) Employment is held constant at the 8C value in the first set of runs.

(5) The real wage rate is held constant at the 8Cw value in the second set of runs.

allowing exporters a drawback of the duty they pay on imports. (This is modelled via a commodity specific subsidy equal to the percentage difference in unit export prices between runs 8Z and 8U.)

Private Consumption rises by another \$45m on run 8U and exports rise by \$134m. But at \$4910m they are still well below 8Z exports of \$5520m, since the terms of trade are still at about the run 8U level indicating a substantial cancellation of the export subsidies from increases in factor prices, as these are bid up by exporters.

Listing the above runs in order of decreasing Private Consumption gives:

	1	2	3	4	5	6
Fixed Employment	8D	8U	8Z	8N	8T	8C
Fixed Real Wage Rates	8Zw	8Nw	8Tw	8Dw	8Cw	8Uw

- with the order for the fixed real wage rate runs given underneath.[3] The ordering here is markedly different. Free trade is best and uniform protection is worst, by a large margin; 5.5% in PriCon, 3.5% in Effective GDP, and 130,000 in employment. Even the present protection regime is superior to uniform protection, though not by a significant amount. In fact with the exception of run 8Dw which has tariff negating export subsidies, the ordering here corresponds exactly to a ranking of runs in order of increasing mean protection. Thus in contrast to the first set of runs, the unevenness of protection is now not important.

The logic here is that the lower is protection, on average, the lower is the CPI so the more nominal wage rates must fall in order to prevent real wages from rising, as they did in 8Z compared to 8U say. This yields substantial improvements in price competitiveness with the real exchange rate in run 8Zw being almost 10 percentage points lower than in 8Uw. Even the advantages bestowed by favourable terms of trade in run 8Uw are not sufficient to counter the greater and more diffuse negative impact of the real exchange rate appreciation. That is, from 8Z

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[3] The real wage rate (defined as the nominal wage divided by the CPI) is set at 1.040 on an index value of 1.000 in 1977 (and about 0.930 in 1985!). It was chosen so as to obtain some unemployment in all runs. Thus it had to be higher than the highest value in the first set of runs, namely 1.036 in run 8Z.

to 8U import substituters benefited on two fronts: protection of output from the tariffs and lower labour costs due to the fall in wage rates. But from run 8Zw to 8Uw this latter effect is absent. Thus between 8Zw and 8Uw exports fall more and import substitution (as measured by the import-GDP ratio) is less, than between 8Z and 8U. Hence the inverse relationship between welfare and protection under real wage rate rigidity.

This difference in results between the two sets of runs is not something which can be passed off as of academic interest only. Clearly, ignoring any 'externalities' such as efficiency gains, economies of scale, reciprocal protection changes and so on; if the New Zealand labour market is such that the level of employment is not significantly affected by government trade policy, whilst the resultant level of real wage rates is so affected, then uniform protection yields a small net benefit in terms of Private Consumption, particularly if duty remission for exporters is allowed. If on the other hand the real wage rate is something which is unaffected by government trade policy (that is, if it is set exogenously to the system, by wage negotiation say) and employment is endogenous, then free trade is definitely the best policy.

Ascertaining how the New Zealand labour market functions is beyond the ambit of this exercise. However, one can test the sensitivity of results to changes in various assumptions and parameters. Since runs 8Z and 8N are the closest of any two runs and since one admits of a predisposition to the fixed employment variant, these two runs are selected for further testing later on. Meanwhile, a more in-depth study of runs 8Z and 8N - both micro and macro.

8Z - 8N Macro Detail

Again, the closeness of runs 8Z and 8N in PriCon and Effective GDP presents a good opportunity to look at the way in which the gains induced by the improvement in the terms of trade offset the loss from protection. The changes in the macro aggregates from 8Z to 8N are as follows:

	($m)
Private Consumption	-1
Gross Investment	0
Stocks	-3
Government Consumption	0

Gross Domestic Expenditure	-4
Exports	-370
Imports	-279

Balance of Trade	-91
Gross Domestic Product	-95
Effective GDP	-4

The loss arising from protection, which is due to the economy operating at an inappropriate point on the production possibility frontier, may be measured by the change in GDP, namely $-95m. The gain from the terms of trade improvement is measured by the negative of the change in the volume of trade, namely $91m. Hence there is a net loss of $-4m in Effective GDP and identically, also in GDE.

Another way of looking at the change is to re-express the standard GDP identity as:

$$\begin{array}{lrcl} & GDP + M & = & C + I + S + G + E \\ \text{or} & \text{supply} & = & \text{demand} \\ \text{i.e.} & -95 + -279 & = & -4 + -370 \\ \Leftrightarrow & -374 & = & -374 \end{array}$$

So the total change in supply and demand is $-374m. The rest of the world demands $370m less of our exports but, because of the change in the terms of trade, supplies us with only $279m less of their products. Thus we gain $91m. Unfortunately the loss in efficiency causes a local supply shortfall of $95m, leaving a net reduction of demand and supply in New Zealand of $4m.

Whilst one has attributed the efficiency loss exclusively to the change in protection and measured it by the change in GDP, it actually has a direct and an indirect component. The loss which is due directly to the increase in protection is measured by the difference between the change in imports in constant c.i.f prices (as above) and the change in imports in constant purchasers' (c.p.) prices. The latter change here is $-371m so the difference is $-92m, (ie -371 - -279). Hence the indirect efficiency impact of the change in protection is $-3m, this being the amount by which GDP falls (ceterus paribus) due to the reallocation of production between sectors. That is, apart from the direct loss of having to substitute relatively high cost domestic goods for imported goods, there is also some substitution between composite goods, particularly in Private Consumption. If this type of substitution is not possible the additional direct efficiency loss would probably be larger than the $3m indirect efficiency loss.

The indirect efficiency loss is very small relative to the direct loss but this need not be the case. For example from 8C to 8U, Effective GDP rises by $108m. This is composed of a terms of trade gain of $36m and an efficiency gain of $72m, the latter having a direct component of $98m and an indirect component of $-26m.

One can see then that the closeness of Private Consumption and Effective GDP in runs 8Z and 8N is due to the terms of trade effect and the (total) efficiency effect being of roughly equal but opposite magnitude. The efficiency effect has two components which can be of oppposite sign or of the same sign, as determined not only by the nature (level, incidence, uniformity) of the change in protection but also, as will become evident below, by the values of other parameters and variables.

8Z - 8N Sectoral Detail

Table 2 presents for runs 8Z and 8N, the changes in sectoral output, employment and capital, and the import and export ratios. These ratios are defined as:

$m = M/(X+M-E)$ & $e = E/X$ where M = real imports in c.p. prices
E = real exports
X = real gross output

The sectors which show the greatest gain from N style protection are Ceramics, Rubber, Clothing, Wood Products, and Plastics; whilst the biggest losers are N.Z. Steel Expansion, Air Transport, Base Metals, Chemicals, and Ore Mining. Other sectors show movements of less than 2%. All of the sectors which expand exhibit a move to capital intensity of about 0.11% whilst all those that contract lose about 0.11% more labour than capital. Thus all sectors become more capital intensive at the margin in response to the 0.11% fall in the rental rate - wage rate ratio (as shown in table 3), not surprising given the unitary elasticity of the Cobb Douglas production specification. The change in relative factor prices may seem small but one should not expect much else when employment of both factors is held constant. Indeed, given this factor employment invariance, how is it that all sectors can simultaneously become more capital intensive? One surmises that those sectors which expand into greater capital intensity are still sufficiently relatively labour intensive (on average) and those that contract into capital intensity are relatively capital intensive (on average). Checking this theory with the data from run 8Z confirms it with the group of expanding sectors being 10% more labour intensive than the contracting group.[4] In financial terms too, the expanding sectors are more labour intensive . A simple regression of output change (from 8Z to 8N) against the share of labour in value added (excluding the OWN and GOV sectors) yielded a positive slope, although with a correlation coefficient of 0.17 the relationship is certainly not well defined. However, the weighted mean labour share of value added in the expanding group is 6% higher than in the contracting group.

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[4] or 49% if the single factor sectors; Ownership of Dwellings and Government Services are excluded.

Table 2

Sectoral Results: Runs 8Z & 8N

Sector Name and Abbreviation		Run 8Z		Run 8N		% changes in:		
		m	e	m	e	X	L	K
Dairy & Beef Farming	DAB	-	0.21	-	0.19	-1.11	-1.15	-1.05
Sheep Farming	SHE	-	32.4	-	32.1	-0.39	-0.46	-0.36
Horticulture & Other Farming	HOR	6.38	27.9	6.19	27.2	-1.04	-1.07	-0.97
Forestry	FOR	-	5.97	-	5.61	0.98	0.92	1.03
Fishing & Hunting	FIS	13.5	23.3	8.87	21.6	0.89	0.85	0.96
Coal & Oil Exploration	COA	22.9	0.81	22.3	0.76	0.65	0.58	0.68
Ores, Lime & Minerals	ORE	-	34.6	-	33.5	-2.47	-2.52	-2.42
Meat & Poultry Processing	MEA	3.99	64.7	2.81	63.9	-0.62	-0.64	-0.54
Dairy Processing	DAI	0.64	64.6	0.39	63.8	-1.41	-1.45	-1.35
Food, Beverages & Tobacco (nei)	FBT	19.4	9.46	18.3	8.52	-0.42	-0.47	-0.36
Textiles & Carpets	TEX	67.7	62.1	62.0	57.1	1.42	1.40	1.51
Clothing & Footwear	CLO	30.0	19.6	20.1	15.3	2.88	2.85	2.96
Wood & Furniture	WOD	9.26	4.76	6.69	4.13	2.56	2.53	2.64
Pulp & Paper Products	PAP	20.1	27.3	15.1	24.3	1.48	1.43	1.53
Printing & Publishing	PUB	15.4	2.42	15.7	2.19	-0.23	-0.26	-0.16
Chemicals, Paints & Drugs	CHE	48.1	13.4	47.3	10.7	-2.53	-2.58	-2.48
Petroleum & Products	PET	46.5	0.08	46.4	0.07	0.77	0.69	0.80
Rubber	RUB	41.9	6.86	36.2	5.59	5.91	5.85	5.97
Plastics	PLA	45.6	19.2	43.0	17.4	2.55	2.50	2.61
Ceramics, Glass & Cement	CER	28.0	5.67	21.5	4.61	7.49	7.45	7.56

(pto)

Table 2 (continued)

Base Metals	BAS	54.2	44.0	49.8	37.8	-2.58	-2.64	-2.54
Fabricated Metals & Machinery	FAB	47.5	11.1	46.8	9.63	-0.70	-0.73	-0.62
Transport Equipment	TEQ	48.2	9.35	47.6	8.15	-1.60	-1.63	-1.53
Other Manufacturing	OTH	73.0	19.1	72.6	17.6	0.27	0.23	0.34
Electricity	ELE	-	0.32	-	0.30	0.90	0.83	0.93
Gas & Water	GAW	-	0.50	-	0.48	0.65	0.59	0.69
Construction	CON	-	0.28	-	0.23	0.03	-0.01	0.10
Wholesale & Retail Trade	TRA	8.41	9.65	8.49	8.89	0.17	0.12	0.22
Restaurants & Accommodation	RES	-	11.6	-	10.8	-0.35	-0.40	-0.30
Road Freight, Sea & Rail Trans.	FRT	9.44	28.7	8.72	27.0	-1.53	-1.57	-1.46
Road Passenger Transport	ROA	-	7.94	-	7.41	-0.48	-0.53	-0.42
Air Transport	AIR	56.4	55.2	56.3	53.1	-3.45	-3.49	-3.39
Communications	COM	-	4.59	-	4.23	0.89	0.86	0.97
Finance, Insurance, etc.	FIN	2.21	0.71	2.10	0.65	0.52	0.46	0.57
Ownership of Dwellings	OWN	-	-	-	-	0.55	-	0.55
Government Services	GOV	-	0.81	-	0.75	0.06	0.06	-
Leisure Services	LEI	-	0.43	-	0.40	0.31	0.28	0.38
Private Services	PRI	-	1.56	-	1.44	0.42	0.37	0.48
New Zealand Steel Expansion	NSE	-	52.0	-	48.1	-9.42	-9.49	-9.39
Synthetic Petrol & Methanol	SPM	-	-	-	-	0.77	0.67	0.77
Total		17.4	15.2	16.4	14.2	-0.09	0	0

Notes: m = M/(X+M-E) & e = E/X where M = c.p.p. imports in real 1976/7 prices
E = exports " " " " (producers')
X = gross output " " " "

Between runs 8Z and 8N only $370m or 1% of total gross output switches from exporting to import substitution. As a proportion of GDP this is just over 2% since trade ratios are about 31% in run 8Z and they change by about 7% between 8Z and 8N. Given that the expanding group is about 10% more labour intensive than the contracting group, the 0.11% (namely 10% of 1%) fall in the rental rate - wage rate ratio is not surprising. Thus (economies of scale and so forth aside) major gains or losses fron trade are unlikely, unless the factor price ratio changes by rather more than one tenth of one percent, which in turn requires a more pronounced difference in the relative capital-labour intensity of exporting versus import substituting sectors (or in the case of the standard two sector model: in traded versus nontraded sectors), or a larger change in the trade ratios. This in turn requires higher Allen substitution elasticities, assuming that the initial tariff equivalents are correct. These possibilities are analysed in four of the runs below.

The import and export ratios in table 2 show that the sectors which expand generally do so because of the demand switch away from imports whilst those that decline are generally forced to do so through lower export sales. Given that one is aware of these truths before the event, the directions of sectoral change, though not their magnitude, could in many cases be predicted in advance. There are, however, some instances where a little more thought is required. For example the Restaurant and Accommodation sector is generally considered to be a nontraded or sheltered sector which would gain indirectly from N style protection as New Zealanders switched away from holidays abroad. But since it is also heavily involved in tourism to New Zealand it feels the decline in tourism exports. Overall its output falls marginally. Forestry and Fishing both gain from protection even though their export propensity falls. The former responds directly to the positive changes in the Wood and Paper sectors and the latter obtains a larger local market share at the expense of imports.

Of interest also is the arrangement of winning and losing sectors in groups of 3 or 4 as one goes down the list in table 2, proving that each of the commonly defined broad sectoral types; primary, secondary and tertiary, has both winners and losers. Thus as the number of sectors becomes more aggregated the sizes of the observed sectoral changes become smaller as the negatives cancel the positives. Intersectoral movements are subsumed into intrasectoral movements. A given sector will usually comprise many different production functions so that intrasectoral changes will probably alter the 'mean' production function for that broad group. But with a highly aggregated model these sorts of shifts cannot be observed since the weighted mean production function is (naturally) assumed constant.

For example, the sectors Chemicals, Petrol, Rubber, and Plastics are aggregated into one Chemicals group in the standard 25 sector SNA classification. Between runs 8Z and 8N the output of the four sectors combined falls by 0.27% whilst inputs of labour and capital expand by 0.65% and 0.47% respectively - an obvious change in the mean production function. And compare also the total change in output with the individual figures which range from -2.53% to 5.91%. How much such aggregation affects the change in Private Consumption can best be ascertained by rerunning the model with the four sectors combined. Unfortunately this is not a small project and there are other factors (as noted below) associated with the aggregation question to be considered. Hence it will not be attempted here.

It should be safe to assert, however, that the greater the degree of sectoral disaggregation the greater (usually) will be the measured change in welfare associated with a change in protection. The point at which disaggregation reaches a 'reasonably' homogeneous commodity level clearly entails much more than 40 sectors, maybe thousands! And the finer the classification the more one needs to explicitly model intersectoral substitution and the greater become the potential rewards from economies of scale, which then also need to be modelled.[5]

Two of the runs below investigate with some hypothetical, but hopefully not too unrealistic numbers, intersectoral substitution in intermediate demand and economies of scale via specialization.

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[5] When the JULIANNE model was used as part of a study into the effects of trade liberalization on a group of textile and garment sectors (see BERL [10]), with the TEX and CLO sectors split into 5 sectors, the move from Z to N generated a rise in PriCon of $5m compared to the $1m loss recorded above. However, the TEX and CLO sectors are not that different, nor were any economies of scale modelled.

Sensitivity Tests

Eleven tests are considered as depicted in figure 1. Rather than present the results in level form and more in keeping with the spirit of contemporaneous scenario analysis, only the percentage differences are given. Thus in each case the figures represent the percentage changes in moving from a Z situation to an N situation. This cuts the amount of output data by 50% and makes for easier interpretation. The main macro results are given in table 3 with extra data being presented as the occasion demands it.

(1) Small country assumption for exports (8Z1-8N1)

The small country assumption on the import side is a standard feature of JULIANNE in that New Zealand cannot affect the world price of its imports. Here one also assumes that New Zealand faces a perfectly elastic export demand curve so that there can be no terms of trade gain from protection.

As expected the tariff now worsens the fall in real Private Consumption; from -0.01% to -0.68%. Without the terms of trade gain there is nothing to counteract the efficiency loss associated with protection. In fact, the efficiency loss increases since without the terms of trade rise imports must fall by more than between 8Z and 8N. Given full employment this necessitates a lower real appreciation than before and as shown in table 3, the real exchange rate rises by only one third of the increase between 8Z and 8N.

(2) Different 'Clothing' cost excess (8Z2-8N2)

A 20% lowering of the original mean cost difference on Clothing goods from 77% to 62% leads one to expect smaller gains from trade, or in other words, a smaller loss if protection (namely 25%) is 're-imposed'. In fact Private Consumption now rises marginally above the free trade run so this minor change to one tariff equivalent is enough to swing the original 8Z-8N PriCon difference from negative to positive. The efficiency loss is of course smaller than before. Thus the lower are the initial cost excesses, the stronger is the case for (uniform) protection.

Table 4 below shows the changes in the Clothing sector.

Table 3

Sensitivity Tests: Macro Results

(% changes)

	Private Cons.	Exports	Imports	GDP	Effective GDP	Wage Rate ÷ Rental Rate	Exchange Rate	Terms of Trade
8Z-8N	-0.01	-6.70	-5.20	-0.54	-0.02	0.11	0.028	0.017
8Z1-8N1	-0.68	-5.81	-5.91	-0.47	-0.45	0.55	0.009	0.000
8Z2-8N2	0.06	-6.64	-5.16	-0.51	0.01	0.06	0.027	0.016
8Z3-8N3	0.13	-9.45	-7.28	-0.76	0.08	0.19	0.038	0.024
8Z4-8N4	1.02	-7.31	-3.64	-0.53	0.55	-0.19	0.057	0.042
8Z5-8N5	0.22	-6.33	-5.06	-0.50	0.11	0.00	0.022	0.013
8Z6-8N6	-0.04	-6.83	-5.34	-0.60	-0.03	0.08	0.029	0.017
8Z7-8N7	0.08	-6.62	-5.22	-0.51	0.03	0.20	0.025	0.015
8Z8-8N8	0.01	-6.69	-5.22	-0.54	-0.02	0.19	0.027	0.017
8Z9-8N9	1.88	-7.51	-5.47	0.57	1.18	-0.65	0.037	0.024
8Z10-8N10	-0.25	-6.94	-5.41	-0.72	-0.19	0.28	0.026	0.017
8Z11-8N11	0.00	-6.67	-5.20	-0.53	-0.01	0.11	0.027	0.017

Note: The real exchange rate and terms of trade changes are absolute changes in their respective indices.

Table 4: Clothing Sector Results

	X	% change	m	e
Run 8Z	$590.8m		30.0%	19.6%
8N	607.8	2.88	20.1	15.3
8Z2	616.3		23.8	18.2
8N2	628.7	2.01	15.2	14.6

As expected output is lower in 8Z than in 8Z2 since in the former run the sector is faced with cheaper import competition. Accordingly the import share of the market is larger in 8Z than in 8Z2. The directions of these differences remain in the N runs but the output gain between Z and N is less when the initial cost difference is less, indicating that the protective effect of a given tariff is directly related to the size of the initial cost excess.

The export shares are higher in 8Z and 8N than in 8Z2 and 8N2 since the higher import penetration permits or forces output to be redirected from the home market to the foreign market.

(3) Higher import-domestic substitution elasticities (8Z3-8N3)

With a doubling of the Allen elasticity of substitution σ_{MD} between domestic and imported commodities (runs 8Z3 & 8N3), Private Consumption is higher than in runs 8Z and 8N. If one can more easily switch expenditure to cheaper goods, whether imported or domestic, then naturally welfare is enhanced. Table 5 shows that the trade ratios rise indicating that on balance imported goods are cheaper than domestically produced goods; hardly surprising.

Table 5: Macro Effects of Higher σ_{MD}

	PriCon	Exports	Imports	GDP
Run 8Z	$10084m	5520	5346	17534
8N	10083	5150	5068	17530
8Z3	10103	5873	5594	17548
8N3	10116	5318	5187	17562

As expected a higher substitution elasticity leads to a greater change in PriCon between the Z and N cases. But whether higher Allen elasticities should promote free trade or protection is not immediately obvious. It is only when one takes into account the results from the earlier runs which showed that protection can be beneficial if it is reasonably uniform and if export demand demand is not too elastic, that one can infer that greater flexibility as provided by the higher σ_{MD} should therefore promote protection. (Although 8Z is just ahead of 8N, run 8U is better still.) So the beneficial terms of trade effects of the tariff which in run 8N are not quite sufficient to counteract the efficiency loss associted with protection, are sufficient with the higher σ_{MD}. This is evidenced in table 6 which shows that the direct efficiency loss is now $-133m, naturally more than before, but the terms of trade gain is now $148m compared to $91m before. (The small improvement in the indirect efficiency loss is unimportant.) However, the gains in PriCon and Effective GDP are still very small, especially considering the magnitude of the shifts in trade; another 2-3 percentage points on the movements between runs 8Z and 8N.

Similarly, although not presented here, repeating run 8C with higher Allen elasticities and comparing the result with 8Z3 yields a bigger gain from free trade (0.99%) than between 8C and 8Z (0.70%).

Table 6

Dissecting the Gains and Losses from Protection

	8Z-8N	8Z3-8N3	8Z4-8N4	8Z7-8N7	8Z9-8N9
Change in GDE	$-4m	14	110	6	201
" Exports	-370	-556	-399	-396	-397
" Imports (cif)	-279	-408	-195	-294	-292
" Balance of Trade	-91	-148	-204	-102	-105
" GDP	-95	-134	-94	-96	96
Change in Imports (cpp)[6]	-371	-541	-267	-392	-392
=> " efficiency-direct	-92	-133	-72	-98	-100
indirect	-3	-1	-22	2	196
& Terms of Trade effect	91	148	204	102	105
= Change in Effective GDP	-4	14	110	6	201

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[6] constant purchasers' prices

(4) Lower export demand elasticities (8Z4-8N4)

We have looked at the effect of infinite price elasticities of demand for exports. What happens when lower elasticities prevail? In runs 8Z4-8N4 price elasticities of demand for exports of non-pastoral products are halved with rather interesting results. This is the first time in the this set of runs that Private Consumption changes by more than 1% between the Z and N runs.

It is apparent from the three tests just discussed and from the first set of runs, that the case for protection largely depends on an increase in the terms of trade. Raising the export price elasticities of demand lowers the terms of trade gain: A move to protection raises costs and thus lowers exports, leading to lower output and lower factor demand. But, given unchanged employment of factors this is not permitted. Thus factor prices must fall and the amount of the fall depends directly on the export demand elasticities. The higher they are (absolutely) the more factor prices must decline in order to maintain employment and hence the smaller is the gain in the terms of trade associated with the imposition of protection. Therefore a reduction in the elasticities is needed to reinforce the rise in the terms of trade, as may be seen in tables 3 and 6. Between runs 8Z and 8N the terms of trade rose by 1.7 percentage points whereas between 8Z4 and 8N4 the rise is 4.2 percentage points. This difference raises the beneficial terms of trade effect quite substantially from $91m to $204m.

Consequently exports fall by more than before (7.3% v 6.7) but imports fall by less (3.6% v 5.2%), the latter difference being consistent with the greater appreciation of the real exchange rate (5.7% points v 2.8% points) and yielding a smaller direct efficiency loss of $-72m compared to $-92m. Note also that the indirect efficiency loss is now more since the lower elasticities imply less flexibility in the pursuit of more efficient resource allocation.

(5) Lower export demand (8Z5-8N5)

Having just seen the effects of lower price elasticities of demand for exports. How do these compare with the effects of lower foreign income elasticities? This situation is modelled by shifting the export demand curves back toward the origin, as in Chapter 7.4. All the curves are moved back by 50% of their 1977-1990 shifts as determined from the control run, thereby simulating lower demand growth between the base year and the horizon year.

From the earlier sensitivity runs in 7.1, one does not expect significant differences between 8Z5 & 8N5 and 8Z & 8N, although the protected case should now be more favourable given that exporting has become more difficult. The results in table 3 confirm these expectations. Private Consumption in 8N5 is up 0.22% on 8Z5, in contrast to the -0.01% decrease recorded before. But, again the difference is not particularly marked. The changes in exports and imports are also not much different from those between runs 8Z and 8N.

Combining the demand curve shifts with the lower price elasticities yields a change in PriCon between the Z and N cases of 1.46% (not reported in table 3). Thus the two changes do not yield additive results but the benefits of N style protection are still small.

The actual levels of PriCon in runs 8Z5 and 8N5 are $9651m and $9672m, considerably lower than in runs 8Z and 8N, as may be expected. Therefore, <u>if</u> a move to free trade on New Zealand's part is reciprocated by our trade partners, which pushes out the export demand curves, the gain from free trade becomes much greater at 4.26%; the change in PriCon from run 8N5 to run 8Z. A 50% demand curve shift is undoubtedly too large, but determining the true size of such a shift is beyond the capabilities of the JULIANNE model. Nevertheless one can probably infer that multilateral free trade would be much more beneficial than unilateral free trade.

(6) Sectorally identical wage rates (8Z6-8N6)

A question of long standing interest is the extent to which the existing sectoral wage rate differentials might affect the gains from trade/protection. Runs 8Z6 and 8N6, where these differentials are removed, represent a preliminary look at this question. Admittedly the assumption of sectorally uniform (mean) wage rates is extreme but as such should provide some fairly strong evidence about the wage relativity effect.

As can be seen from table 3 the consumption and production differences between the Z and N runs are still very small. Of more interest is the direction of change which this time is in favour of free trade, and in the fact that PriCon in runs 8Z6 and 8N6 is higher than in

Table 7: Macro Effects of Uniform Wage Rates

	Pricon	Real Wage Index	Exports
Run 8Z	$10084m	1.036	$5520m
8N	10083	1.009	5150
8Z6	10186	1.006	5721
8N6	10182	0.979	5330

8Z and 8N - as may be seen from table 7. From the theory of the second best these changes are by no means guaranteed. That is, given a departure from perfect competition in one area of the economy, namely sectorally different wage rates, the removal of some other distortion, in this case protection, does not automatically generate a net increase in welfare. In fact, going from 8N to 8Z welfare does rise - just, and actually rises more between 8N6 and 8Z6. Running a simple regression of sectoral output change between 8Z and 8N against sectoral wage rate relativities yielded a slope of -0.56 and a correlation coefficient of -0.42 which, whilst not high, indicates that lower labour cost sectors fare better under protection. So it is not surprising that free trade should look better when the low wage rates are raised and the high ones are lowered.

Although we know that sectorally different wage rates are mainly due to occupational skill differentials, the model sees the labour force as completely homogeneous. Thus the higher PriCon in runs 8Z6 and 8N6 should be expected. And since costs are lower, as exemplified by the real wage rate index, exports are higher; as shown in table 7.

Perhaps the question one should be asking is: Would a change in protection alter sectoral wage relativities, whether by changing relative occupational demand and thus relative wage rates or (and) by changing the mix of occupations between sectors? Unfortunately one does not have the data with which to test equations that could then be incorporated into the model in order to explore this question. However, if a move to free trade engendered a greater sectoral uniformity of wage rates (a move from 8N to 8Z6), the gain from free trade relative to an N situation could be about 1%. Relative to the current protection mix (from 8C to 8Z6) the gain rises to 1.7%.

Of course one is not in a position where one can discount the possibility that a move to free trade would exacerbate sectoral wage rate differences. And, on a more fundamental point; how well do current occupational wage relativities reflect the true worth to society, in terms of maximizing welfare, of the occupations or persons concerned?

(7) Lower capital-output ratio in 'Ownership of Dwellings' (8Z7-8N7)

Between runs 8Z and 8N the amount of capital reallocated from the contracting sectors to the expanding sectors is $324m. The sector which absorbs most of this is Ownership of Dwellings, taking $110m. Electricity is next highest with $55m. Both of these sectors, especially the former, expand under protection because of the shift by consumers to nontraded goods. However, the large rises in capital are not due to large increases in output (as may be seen from table 2) but to the extremely capital intensive nature of these sectors. If the OWN sector was not so capital intensive would the freed capital generate a more favourable picture for N style protection by allowing more of the reallocated capital to go into 'productive' use?

In runs 8Z7 and 8N7 the capital-output ratio in OWN is halved. Private Consumption does become more favourable if only by a small amount. However, the composition of the gain in Effective GDP is interesting. Comparing the 8Z7-8N7 column of table 6 with the 8Z-8N column shows that the indirect efficiency change is now positive at $2m instead of $-3m and the terms of trade effect is also greater - by $11m. The accompanying table shows that exporters are more productive users of both factors but their comparative advantage lies in capital use.

	Exporters	Import Substituters
Marginal Product of Labour	15.93	12.19
" " " Capital	0.244	0.180
Ratio (MPL/MPK)	65.3	67.7

Thus more capital, which is the effective result when the K/X ratio in OWN is lowered, can be expected to raise exports. This does indeed occur with the export-GDP ratio of 31.4% in run 8Z rising to 31.9% in 8Z7. Because a larger proportion of GDP is now tied up in a more efficient use of resources the indirect efficiency loss associated with protection is less. In fact it is no longer a loss and, although the terms of trade gain from 8Z7 to 8N7 is smaller than from 8Z to 8N, it acts on a larger volume of exports thereby yeilding a greater beneficial terms of trade effect. These two favourable effects are strong enough to outweigh the larger direct efficiency loss to give a net gain in Effective GDP under the N protection regime.

Nevertheless the numbers involved are very small and the rise in PriCon over free trade at 0.08% compared to the 8Z-8N change of -0.01%, is especially insignificant when seen against the vast reduction in the OWN capital-output ratio. Other changes too are very similar to those between 8Z and 8N. Hence one must conclude that even if the capital intensity of the OWN sector has been substantially overestimated, any plausible error margin will not be so large as to significantly affect the projected gains or losses from free trade. And, given that is true for the Ownership of Dwellings sector, it will almost certainly hold also for the other sectors since the amounts of capital involved are much smaller.

(8) Different factor endowments (8Z8-8N8)

Following on from the last question, how are results affected if relative factor supplies are rather different from the control run projections? In particular let us take 10% less labour and, so as to approximately maintain GDP, 16.6% more capital. These differences may not seem very large but in each case represent about 40% of the projected growth in factor supplies between 1977 and 1990.

The well known Stolper-Samuelson theorem asserts that free trade raises the return to the relatively abundant factor, since a comparative advantage exists in the services provided by that factor. Conversely, protection will raise the price of the relatively scarce factor. From the detailed discussion of the 8Z-8N sectoral results it was evident that New Zealand's exports are relatively capital intensive and accordingly the rental rate fell relatively when protection was introduced. Thus when the supply of labour is reduced and that of capital raised, one expects an even greater fall in the relative rental rate - wage rate ratio when moving from Z to N. This does indeed occur as may be seen from table 3, with the ralative fall between runs 8Z8 and 8N8 being 0.19% compared to 0.11% between 8Z and 8N.

However, the change is still very small and this is reflected in the macro results which are virtually indistinguishable from the reference set (8Z-8N) with the change in endowments being just sufficient to swing the result from 0.01% against N to 0.01% for N, for the same reasons as those just given to explain the effects of a lower capital-output ratio in OWN, but with even smaller numerical magnitudes. The change in direction is not really significant, further confirming the conclusion from 7.1 that model results when expressed as relative differences between alternative contemporaneous scenarios are not sensitive to (relative) factor supplies. Or in other words; the comparative advantage of the New Zealand economy is not easily altered due to the rigidity of the relative factor intensities of exporting versus import substituting sectors.

(9) Composite commodity substitution (8Z9-8N9)

The runs presented so far have all been based on zero substitution amongst composite commodities in intermediate use. The other option in JULIANNE is to assume unitary elasticity so that for example, wood may substitute for metal, plastic for glass, or road transport for air transport. Unfortunately one may also be modelling the substitution of say rubber for meat products (with due allowance for some steaks being as tough as old boots!). Whether it is better on balance to allow no substitution or unitary elasticity substitution, in terms of minimising model bias, is an empirical question.

The results in table 3, runs 8Z9-8N9, depict quite a large gain (in relation to the other runs) from protection with PriCon rising by 1.88%. One of the reasons for this is the increase in the terms of trade which rise by about 50% more than the increase recorded between 8Z and 8N. Similarly the real exchange rate also appreciates more, which may seem peculiar given that the unitary substitution elasticity provides more opportunity for the use of lower cost inputs. But in a situation of fixed labour and capital a move towards greater import substitution exerts additional pressure on factor prices which therefore rise higher than before, negating the cost reducing benefits of being able to use more, now relatively cheaper, locally produced intermediate inputs.

However, the main way in which greater composite commodity substitution raises PriCon can be ascertained by examining the nature of the gain in Effective GDP using the analytical framework from table 6.

The greater appreciation of the real exchange rate causes a greater direct efficiency loss than between 8Z and 8N but it is only slightly worse. However, the indirect loss has become a substantial gain. This confirms one's suspicion, noted earlier with respect to runs 8Z and 8N that substitution between composite commodities minimises (or reverses) the direct loss due to protection. It is paradoxical that higher protection is needed to generate the relative price mix which realises the indirect efficiency gain. (At the same time it justifies one's labelling of the allocational effect as indirectly due to protection.) With the possibility of composite commodity substitution, protection directs some demand to those sectors where New Zealand has a comparative advantage. For example, even though protection may force demand away from cheap imported steel to domestically produced steel, it will also induce some buyers to purchase a competitive substitute product, say wood. The greater the shift to wood relative to the shift to expensive domestic steel, the more the positive indirect efficiency effect will outweigh the negative direct efficiency effect.

Overall then, as indicated in Chapter 7.1, the elasticity of substitution between composite commodities in intermediate use is quite an important parameter. A uniform change from zero to unity is not large and there are doubtlessly examples where the elasticity is much higher. It is certainly an area where further research is warranted, particularly when studying protection changes since the results here have shown that the welfare gains from intersectoral substitution can significantly affect the gains from trade.

The last test highlights the fact that none of the above parameter variations have been directly concerned with intrasectoral movements, although the extra intersectoral substitution allowed in runs 8Z9 and 8N9 has the same effect as intrasectoral substitution when sectors are more aggregated. The results from runs 8Z9 and 8N9 therefore reinforce the notion that the greater the disaggregation the greater is likely to be the measured change in welfare associated with a change in protection (whatever the direction), given appropriate allowance for intersectoral product substitution.

For runs 8Z and 8N export ratios and market share ratios were presented and the changes in these were also interpreted as representing intrasectoral shifts. Such data could of course be presented for all of the above runs but not much additional insight would be gained about intrasectoral changes. To study this issue more comprehensively involves an alteration to the production functions.

(10) Economies of Scale (8Z10-8N10)

Recall that in Chapter 6 an example was given of how non-constant returns to scale could be modelled. For increasing returns this involved adding a pseudo factor with a negative exponent onto the standard Cobb-Douglas production function. The negative exponent corresponds to the subsidy which is required to offset the loss which arises under increasing returns when factors are paid their marginal product. Consider the function:

$$X = L^{\alpha}K^{\beta}N^{\gamma} \qquad \text{where } \alpha+\beta+\gamma=1 \text{ and } \gamma<0 \qquad (8.1)$$

$$\Rightarrow MP_N < 0$$

- where N represents the number of commodities, or more accurately; the number of groups of commodities, where the commodities within a given group have very similar production characteristics (such as different makes and models of automobiles). The other variables and parameters are as usually defined.

As N increases, total output (which can be thought of as the number of commodities multiplied by the length of the production run) falls due to the loss in labour and capital efficiency that occurs as each factor is required to engage in more tasks. For production of a given number of commodities, increasing returns to scale exist with respect to labour and capital. Since γ, the total value of the subsidy is constant, expansion of L and K with given N implies that the per unit subsidy is less, as does diversification in production with given amounts L and K.

As we are interested in the relationship between economies of scale, specialization and protection, the following additional function is proposed:

$$N = f(p/q)$$

$$\text{with } f'(p/q)>0 \Leftrightarrow f'(q/p)<0$$

- where p is the price of a domestically produced good and q is the price of an equivalent imported good. A simple equation which will suffice here is:

$$N(p/q)^{\upsilon} = C \qquad \text{where } \upsilon>0 \text{ and } C \text{ is a constant} \qquad (8.2)$$

$$\Rightarrow \frac{dN/N}{d(p/q)/(p/q)} = \upsilon \qquad \Rightarrow \upsilon \text{ is an elasticity.}$$

Equation (8.2) says that specialization increases as the import price falls relative to the domestic price, such as when protection is removed. That is, a sector (or firm) must forego some product types if it is to survive, or at least not retrench.

It is possible but not (one personally believes) probable that the relationship between the price differential and specialization has the opposite sign, although it may well be that the variety of product is invariant to the price differential in which case $\upsilon=0$ - a possibility which will be considered later. Whatever the sign of υ one should note that equation (8.1) by itself is free of any bias, not favouring free trade or protection. For example if protection should encourage economies of scale by providing a greater local market share for given N, equation (8.1) will certainly allow this.

In the runs below, equations (8.1) and (8.2) are applied to four sectors: Textiles (TEX), Clothing (CLO), Fabricated Metal Products (FAB) and Transport Equipment (TEQ). The parameter γ is set at -0.3 in all sectors such that the scale factor is 1.3, and υ is set at -2.0 in all sectors. From the control run (indeed from any run or from base year data) it is possible to determine N for each sector. That is, output in the control run must satisfy simultaneously:

$$X = \theta L^{\alpha} K^{\beta} = \theta L^{\alpha'} K^{\beta'} N^{\gamma}$$

Now θ, X,L,K are known and one sets $\alpha'=1.3\alpha$ and $\beta'=1.3\beta$, thereby uniquely determining N. Increasing the labour and capital shares by the same proportion minimises the chance of results being corrupted by any relative factor intensity effects. It is of course quite conceivable that the original standard Cobb-Douglas production function could be misspecified with respect to only one factor. Once N is known the constant in equation (8.2) can be calculated since p and q are provided by the control run. For the four sectors N is: TEX - 32.2, CLO - 73.6, FAB - 169.7, TEQ - 72.3.

It can be seen that the numbers themselves do not mean much. They depend entirely on the above assumptions. And more fundamentally, even if one had measured α',β',γ and υ they would still (as usual) depend on the units of measurement. Nor is there significance in the their relative magnitudes. One cannot say that CLO and TEQ produce about the same number of groups of commodities. What is important is the proportionate changes in N as the price ratio changes.

Before presenting the results of this experiment it is worth reiterating that we are dealing with a hypothetical situation. The true values of γ are unknown but the chosen values are realistic and the true values of υ are even more uncertain but hopefully the chosen value is not absurd.

As before the percentage differences between Z and N are given in table 3. It will be seen that second to runs 8Z1 and 8N1, runs 8Z10-8N10 provide the biggest gain to free trade; 0.25% in PriCon and 0.19% in Effective GDP. As in many of the above cases, however, the differences are small. Of greater interest are the changes between 8C, 8Z and 8Z10. The relevant data is given in table 8.

Table 8: Free Trade & Scale Economies

	8C	8Z	8Z10
Private Consumption	\$10014m	10084	10207
Exports	4902	5520	5564
Imports	4876	5346	5387
Gross Domestic Product	17372	17606	17747
Effective GDP	17446	17533	17671
Real Exchange Rate (index)	0.998	0.938	0.940
Terms of Trade "	1.015	0.987	0.986
Real Wage Rate "	0.976	1.036	1.069
change in imports (cpp) on 8C		708	749
" " efficiency - direct		238	238
" " " ind.		-4	137
terms of trade effect		-148	-151
change in Effective GDP		86	224

Private Consumption rises by 0.70% between 8C and 8Z. and then by a further 1.22% between 8Z and 8Z10; 1.93% in total. This extra rise is wholly attributable to the reversal of the indirect efficiency change from a small loss to a significant gain, easily enough to counteract the slightly larger terms of trade loss. Specialization improves efficiency. Table 9 shows that the product range declines by between 24% and 62% in the four sectors, but all sectors now produce more output than in the control run. Note that the contraction of product types does not necessarily have to occur across all industries within a sector. It may instead involve a few industries or firms ceasing operation altogether.

Table 9: Sectoral Effects

		8C	8Z	8Z10	% change 8Z10 on 8C	8N10
Number of Products	TEX	32.3	-	17.3	-46.4%	22.2
	CLO	73.6	-	27.9	-62.1	37.4
	FAB	169.7	-	104.3	-38.5	109.4
	TEQ	72.3	-	54.8	-24.2	56.9
Output	TEX	$704.1m	687.4	733.1	4.12%	723.7
	CLO	651.3	590.8	711.0	9.17	677.3
	FAB	1793.3	1720.2	1796.2	0.16	1771.1
	TEQ	852.3	931.7	964.0	13.1	942.8

Run 8Z10 was repeated with $\upsilon=-1.0$ and $\upsilon=0$, and this yielded PriCon values of $10148m and $10082m; being increases on run 8C of 0.63% and -0.02% respectively. Thus there is an approximately linear relationship between the increment in PriCon (on 8Z) and the value of the elasticity of product range with respect to relative price.

Setting $\upsilon=0$ implies that N is fixed, therefore describing a situation where economies of scale are present but where these are not being enhanced by further specialization in production. Thus economies of scale without specialization do not significantly affect the gains from trade. Similarly, setting $\gamma=0$ but retaining equation (8.2) with $\upsilon<0$ which corresponds to specialization without scale economies, naturally has no affect at all on the gains from trade as (trivially) N effectively disappears from the production function. Hence neither economies of scale nor specialization by themselves are significant but if both exist simultaneously their effects are likely to be too important to ignore (in an analysis of protection changes).[7]

As the true values of the elasticities (υ) are unknown (although setting $\upsilon \leqslant 0$ seems reasonable), sensitivity tests are important. From the three values tested one can say that for not implausible values of υ the gains from free trade relative to the existing protection regime would rise rather markedly, especially if equations (8.1) and (8.2) had wider applicability; that is to more than the four sectors taken here.

However, between free trade and N style protection the gains are considerably less: 0.25% with $\upsilon=-2$ (from table 3), 0.15% with $\upsilon=-1$ and -0.03% with $\upsilon=0$. From the very first set of runs we saw how injurious the effects of uneven protection are compared to uniform protection. The type of inefficiency that jagged protection fosters is precisely that which accommodates the manufacture of many product lines in short production runs. In run 8N10 the N values are much closer to those in 8Z10 than to those in 8C - see table 9. At the same time the sectoral outputs in 8N10 whilst not as high as in 8Z10, prove that 'reasonable' economies of scale can be secured behind a properly designed tariff. Free trade is still better but other factors such as those studied in some of the above runs can reverse this ordering. In this connection the one other case which should be investigated is decreasing returns in agriculture.

(11) Decreasing Returns (8Z11-8N11)

The final test deals with the possibility of decreasing returns to labour and capital in the presence of a fixed factor (namely land) in the agricultural sectors Dairy & Beef Farming (DAB), Sheep Farming (SHE) and Horticulture & Other Farming (HOR). Equation (8.1) is also used here but now N represents land and $\gamma>0$; in particular γ is set at 0.20 in all three sectors such that $\alpha+\beta=0.80$. Further details of this method are given in Chapter 6.

Equation (8.2) is now redundant since N is not a variable. Its implicit value for each of the three sectors is determined from the

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[7] See Dixon [29] in this regard.

control run (as before) and the sum of these values then becomes the total land constraint. That is, the amount of land that can be used by each farming sector is not fixed, only the total. Again the implicit measurement unit of land has no meaning here but that is of no consequence.

The macro results (in table 3) are virtually no different from the 8Z-8N runs. Directionally, the outcome in 8Z11-8N11 is now relatively more favourable to N style protection, a result which conforms with prior expectations since under decreasing returns in agriculture the expansion of agricultural exports induced by free trade is less beneficial. That the effects of the decreasing returns are so small numerically should not be too surprising given that between 8Z and 8N total gross output in the three agricultural sectors changes by about 0.8% - see table 2. With fixed land now constituting 20% of agricultural value added about one fifth of that change (0.16%) disappears, assuming no compensating extra use of labour and capital, although this would then have to come from elsewhere in the economy. This 0.16% of gross output corresponds to \$2.5m - \$3m, a mere 0.015% of GDP.

The result also mirrors the variant of 8Z10 and 8N10 tested above, where increasing returns without specialization (that is with $\upsilon=0$ in equation 8.2) yielded a difference between Z and N of 0.03%.

Even between runs 8Z and 8U the total change in agricultural output is not more than 1.5% so a significant impact of decreasing returns on the effects of changes in protection appears unlikely. Where policies are directed specifically at agriculture such as the recent Supplementary Minimum Price scheme, the presence of a fixed land constraint coluld well have profoundly more significant effects.

8.5 Conclusion

The first collection of results showed that the gains (or losses) from trade are very small when total factor use is held constant, in accordance with other results from competitive neoclassical models. However, when real wage rates are fixed (and presumably also if real rental rates are fixed) the gain from free trade becomes quite large, being over 5%. If real wage rates are inflexible with respect to trade policy, free trade is clearly best. But if the level of total employment is independent of trade policy, a reasonably uniform protection regime may be optimal, but not by much. Whether it is or not depends on many other conditions (as investigated later in the chapter), particularly on the trade elasticities, the composite commodity elasticities, and the potential for specialization induced economies of scale. The higher are the import-domestic substitution elasticities and the composite commodity elasticities, and the lower are the export demand elasticities and the possibility of economies of scale arising out of specialization; the stronger is the case for protection.

By contrast it was also shown that the case for or against free trade (under fixed employment) does not depend significantly on relative factor supplies (varied within realistic limits), on relative sectoral wage rates, on the existence of decreasing returns in Agriculture, or on the presence of economies of scale without specialization.

Unfortunately the important variables are also those about which least is known, especially as regards the composite commodity elasticities and the specialization elasticities. The problem is compounded by the fact that higher composite commodity elasticities promote protection whilst higher specialization elasticities promote free trade, so that if both elasticities have plausible non-zero values, their respective effects will be mutually antagonistic. Hence even the direction of welfare change is difficult to ascertain, let alone its magnitude. The only really certain conclusion is that any evening out of the existing protection profile, perhaps via a T type run, will be beneficial.

The major reason for the small differences in the constant factor use runs is the low degree of curvature of the production possibility frontier, as deduced from the small changes in the factor price ratio between alternative scenarios. This in turn is due the small difference in relative capital-labour intensity between exporting and import substituting sectors.

If, however, by departing from the strictly competitive model it can be demonstrated that very significant economies of scale induced by specialization do occur as protection is removed, then free trade will be the optimal policy by a significant margin, even given the almost linear production possibility frontier. One believes that the model's trade elasticities are reasonably accurate and that the average composite commodity elasticity of substitution is unlikely to exceed unity (although the significance of a large range of such elasticities cannot be deduced from the above results). Thus the scale economies issue is the only remaining argument with the potential for substantially advancing the case for free trade, unless of course real wage rates are inflexible in which case free trade is virtually a certain winner.

Assuming that the New Zealand labour market does not fit clearly into either the flexible wage rate or the flexible employment mode (always with respect to trade policy), a game theory approach would probably suggest that the optimal policy would be a low level of quite uniform protection which exempts raw materials. A flat 25% uniform tariff is too disastrous if wage rates tighten but free trade can be bettered if they become more flexible. If under such a protection regime major economies of scale begin to materialise, a move to complete free trade may well become appropriate.

Adjunct to Chapter 8

Aggregate Trade Elasticities

The runs presented in this chapter can be used to ascertain various macroeconomic trade elasticities such as the mean (or total) price elasticity of demand for imports. Aggregate parameters of this type are never inserted exogenously into the model - they cannot be. Rather their values are built up from the many sector specific parameters which are exogenous; import-domestic substitution elasticities being the foremost example.

After calculation of these macro trade elasticities they are assessed against other estimates and used in the Marshall-Lerner framework as an aid to model vaildation.

(i) Income elasticity of demand for imports

(a) In run 8Z: GDP = 17060 (all values in $m 1976/77)
Imports = 5346
Real exchange rate = 0.938

(b) Mean of runs 8Z8 and 8Z6: GDP = 17851 (17873 & 17828)
Imports = 5436 (5419 & 5454)
Real e = 0.938 (0.942 & 0.933)

Because tariffs do not change between (a) and (b) the constancy of the real exchange rate implies that relative import-domestic prices between (a) and (b) are also unchanged. Thus there is no price effect in the change in imports. Hence the income elasticity of demand is:

$$\frac{\%\Delta\ M}{\%\Delta\ GDP} = \frac{1.68}{1.39} = 1.21$$

Similarly, using runs 8N and the mean of runs 8N8 & 8N6 yields a value of 1.19. Thus:

YED for imports = 1.2

(ii) Price elasticity of demand for imports

(a) In run 8N: GDP = 17511
Imports = 5068
Real e = 0.966

(b) In run 8N4: GDP = 17515
Imports = 5165
Real e = 1.005

Again, because there is no change in tariffs between (a) and (b) the change in the real exchange rate mirrors the change in relative import-domestic prices. Since GDP is virtually static between the two runs the price elasticity of demand is:

$$\frac{\%\Delta\ M}{\%\Delta\ e^{-1}} = \frac{1.91}{-3.88} = -0.49$$

Similarly, using runs 8Z5 and an unreported run which combines runs 8Z5 and 8Z4 yields a value of -0.60. Thus:

PED for imports = -0.55

Testing these two values to the changes between runs 8Z and 8N:

change in GDP = -0.54%
change in imports = -5.20%
change in relative import-domestic price = 6.18%

- this price being measured here as the mean domestic import price over the mean gross output price.

Therefore the predicted change in imports is -4.21%, which is (absolutely) below the actual change by about 20%. But a 20% margin on the elasticities is quite plausible especially taking into account that a tariff regime which exempts non-competitive imports is bound to yield an implicitly greater mean PED.

Between 8Z and 8U the change in GDP is -0.92%, in imports it is -10.5% and in relative prices it is 20.9%. Thus the predicted change in imports is 12.6% which is a 20% over estimation.

Other evidence on these elasticities is provided in a review by O'Brien [67] who cites average values for the income elasticities of 1.0 to 1.2, although higher values of up to 2.5 were recorded for estimation periods prior to 1970. Average values of -0.4 to -0.7 are given for the price elasticity. Haywood [48] obtains a relative price elasticity of -0.57 and an income elasticity of 1.31 but this rises to 2.88 when an intercept term is included in the equation, which emerges with a negative sign. This is attributed to import substitution over and above that induced by relative price changes. Perhaps import restrictions are to blame.

The value of 1.2 calculated from the JULIANNE runs could conceivably not be a pure income elasticity. It is possible that when income rises it has a distributive or weighting effect which biases the calculation of a pure income elasticity. In particular, Haywood's results are consistent with a shift away from import intensive goods as the structure of the economy became more manufacturing oriented. However, this seems rather unlikely and there is certainly no such shift in the JULIANNE runs. Thus the value of 1.2 does not appear to be corrupted by this type of effect. Indeed the value of 2.88 could be the incorrect estimate if, as Wells et al [100, p15] suggest, there is a degree of covariance between the intercept and the GDP variable (in Haywood's equation) due to the former proxying for a growth in long term capacity utilization. In JULIANNE capacity utilization is always 100% in which case the YED is a pure elasticity.

(iii) Price elasticity of demand for exports

(a) In run 8Z: Exports = 5520
fob export price = 1.061

(b) In run 8N: Exports = 5150
fob export price = 1.083

As competing world prices do not change, the (relative) price elasticity of demand for exports is -3.23%. Runs 8Z and 8U yield a value of -3.19%. Thus:

PED for exports = -3.2

Foreign income elasticities of demand for New Zealand exports are not explicitly modelled; the demand functions are shifted exogenously as appropriate. Export and import elasticities of supply are also not relevant, the former because they are not defined for constant returns production functions, effectively being infinity since supply always adjusts to satisfy any given demand. Import supply elasticities are assumed to be close to infinity as New Zealand is an insignificant buyer on the world market thereby having no effect on prices.

The two macro price elasticities can be combined into one equation; the Marshall-Lerner conditions for an improvement in the balance of trade, for a given change in the exchange rate. More detail on this is provided in Chapter 3 with the equation (for infinite supply elasticities) being given simply by:

$$dB = de\big(X\varepsilon_x - M(1-\varepsilon_m)\big)$$

- where B is the balance of trade, X is the value of exports, M is the value of imports (all in domestic prices), e is the exchange rate and ε_x & ε_m are the absolute price elasticities.

In run 8Z the nominal value of exports and imports are \$5858m and \$5749m respectively. The change in the real exchange rate between 8Z and 8Z5 is -10.8%, which is a devaluation or a rise in e. (The M-L equation is usually applied to a nominal exchange rate change, excluding any subsequent domestic price effects. But allowing for these with the appropriate relative price elasticities is a better application of the M-L formula in medium term analysis.) Thus from the equation dB is \$1744m. However, in these JULIANNE runs the nominal balance of trade is fixed so any induced change must instead emerge as a change in domestic absorption of the opposite sign. Between runs 8Z and 8Z5 the value of domestic absorption falls from \$17657m to \$15847M, or \$-1810m.

A similar analysis using runs 8N and 8N5 yields a predicted value of \$-1698m and an actual value of \$-1887m.

In both cases the predicted value is slightly too small (absolutely) but is within a tolerance margin given the range of variability in the elasticity values. The income effect of the exchange rate change which the M-L equation does not encompass is probably not significant here as real GDP is virtualy unchanged between runs 8Z & 8Z5 and between 8N & 8N5, due to the fixed factor usage, which also prevents a significant income redistribution effect.

Recall that runs 8Z5 and 8N5 are the low export runs where the export demand curves are shifted back towards the origin. As expected the model responds with a (real) devaluation so as to increase exports and lower imports. Normally this would improve the trade balance given the satisfaction of $|\varepsilon_x|+|\varepsilon_m|>1$ but again this is here translated into a reduction in absorption.

From the above analysis one can draw two conclusions:

(1) That the majority of the many sectoral and commodity specific elasticity values should be fairly reasonable, given the confirmation of the resultant macro elasticities by other external evidence and the satisfaction of the Marshall-Lerner equation, (not to forget the results obtained in Chapter 7, section 2).

(2) That model results as a whole accord with accepted theory in this area and, in relation to the sentiments expressed at the end of Chapter 3, its many parameters and equations are not interacting in some intractable manner.

9

THE `JULIANNE´ DYNAMIC MODEL

CHAPTER 9

THE 'JULIANNE' DYNAMIC MODEL

9.1 Introduction

This chapter presents the dynamic or intertemporal version of the JULIANNE snapshot model. The snapshot objectives of contemporaneous scenario analysis and the procurement of projections of the economy over the medium term are still relevant here but one is now also concerned with tracking the path of all the endogenous variables (macro and micro) year by year from the base year to the horizon year, as determined by the equilibrating structure of the model and the year by year changes in the exogenous variables.

As with the snapshot version the role of the dynamic model is not to exactly track the decision making processes of thousands of individiual economic agents or groups of agents, in order to obtain a picture of the economy a few years hence, in response to this year's policy actions and a given set of exogenous shocks. That is the role of a (reduced from) forecasting model. JULIANNE dynamic is a structural model designed to develop and study alternative time path scenarios, given certain boundary conditions and using certain known or testable quantitative relationships which can simulate the outcome of many influences and decisions, both discrete and interdependent.

The advantages of the dynamic model over the snapshot version are primarily concentrated in two areas. Most obviously, it is possible to acquire knowledge of the time paths of variables, which is certainly superior to having to make implicit assumptions about steady rates of growth between the base year and the horizon year. Secondly and as a consequence of knowing the time profiles, it is possible to analyse the trade-offs between static and dynamic considerations. The argument about protection is a well known example.

One might suppose that issues such as this could be adequately analysed by simply varying the horizon year of a snapshot model. Some insights could no doubt be gained by this method, but both theoretical and practical criticisms exist against such a rudimentary approach. On theoretical grounds it is difficult to ensure proper intertemporal consistency, particularly if the model is not solved for each successive year. Even then, there are differences between the medium or long term and the series of short terms which constitute it. This is discussed further in the next section. On practical grounds the human and computer time required to repeatedly solve a snapshot model is substantially more than is required to solve an integrated dynamic model, especially since the dynamic algorithm does not have to re-read the base input data for each period.

The next section sets out in more detail the theoretical foundations of the dynamic model, both in relation to the snapshot model through its neoclasical and general equilibrium structure, and as an entity in itself. The remaining 4 sections of this chapter comprise the equations, a discussion of the intertemporal linkages, and (two sections on) the solution procedure.

9.2 Theoretical Foundations and Considerations

The essence of the dynamic model is that last period's output becomes this period's input. But as will become evident throughout the model description, such intertemporal connectivity entails more than merely consecutive solutions of the snapshot model. Numerous snapshot equations have been changed to reflect the theoretical and behavioural differences between modelling some horizon year related by one leap from the base year and modelling an horizon year which is the last in a series of years, where each intertemporal link is explicitly formulated and stated from the beginning to the end.

The foremost example of this type of theoretical difference is with regard to investment. In the snapshot model the usual horizon year specification of a sector's (net) investment is as a function of the total change in that sector's capital stock during the entire model period, the time profile of that change being irrelevant. For reasonably distant horizon years such a specification is generally considered to be a useful and not too serious an abstraction. In a time staged model, however, one must recognise that investment in one year may not become operational capital until a subsequent year and that the amount of investment by any given sector may depend on profitability, expected demand for output, finance availability and so forth. These factors may not combine to yield anything like a steady rate of capital accumulation, or a steady rate of growth of anything. Very different results from those produced by a snapshot model could therefore be expected when dealing with shorter term horizons, say three or four years.

Because the chronological links of a dynamic model are what drives it, there is a major theoretical issue to be solved when designing this kind of model. That issue is whether to formulate a development planning model which has as many endogenous variables as practical so that the solution represents a long run intertemporal equilibrium growth path, or alternatively; to maximise the applicability of the model to current real world issues by admitting the existence of institutional rigidities, persistent wage and profit differentials between sectors, imperfect foresight and so on, all of which are anathema to pure neoclassical general equilibrium theory and to maximum efficiency in long term resource allocation.

The answer depends on whether one desires a model which solves optimal development and planning type questions, or whether one desires a model which answers questions of the type; "what would happen year by year if such and such were to occur in one year, or year by year over time"? The emphasis in this model is on the latter. Again, in snapshot models the distinction is less lucid since the adjustment paths are not delineated, and as long as one believes that in the long term intertemporal efficiency does exert some kind of 'von Neumann gravitational pull' on the system, the distinction is less relevant as well.

Perhaps the most fundamental difference between the intertemporal equilibrium (IE) development planning type model and the sequential equilibrium (SE) alternative scenario type model, is in the importance accorded to the base year. In the former the base year is of little consequence. A model which consists of equations that describe intertemporal efficiency and optimality to the exclusion of the rigidities, externalities and market imperfections mentioned above, is most unlikely to be able to simulate or yield the base year situation since that year is usually incompatible with a long run equilibrium growth path. If one forces that type of model to reproduce the base year, it is mathematically equivalent to imposing a highly arbitrary set of boundary conditions. In the following period the model may only be able to attain the optimum growth path by absurd means such as negative outputs and prices. It is then probable that the model will 'explode' or become unsolvable as it attempts to incorporate these negative entities.[1]

The JULIANNE dynamic model does include some intertemporal equilibrating forces and most of the intratemporal adjustment processes are neoclassical, as in the snapshot version, so that the pull of efficiency and optimality is certainly not absent. But under the present specification it is unlikely that the model would ever reach a long run steady growth path, let alone one that was optimal. The model exhibits continual but incomplete movements towards some dynamic equilibrium which itself is constantly changing, partly in response to non-steady variations in the exogenous variables. It is believed that this is a

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[1] This has been experienced with the JULIANNE dynamic model when various equations were altered to secure a more optimising structure.

much better portrayal of real world dynamics than the steady state phenomenon. Furthermore, the JULIANNE dynamic model deliberately includes the base year as irrefutable history. All alternative future scenarios induced by policy actions or exogenous shocks must proceed from that date or from some more recent year that is itself anchored to the base year, taking into account the momentum and market imperfections inherent in the system. One cannot then discover the optimal growth path but one can compare and evaluate the relative optimality of various alternatives in the context of the actual state of the economy as it currently exists. Hopefully therefore, the sacrifice in theoretical harmony and paradigmatic aestheticism (which seems to be a dominant concern of current policy makers!) is made in the name of added realism and applicability.

Lastly it should be noted well that in the model, equilibrium or market clearing is achieved each year without lags (except for the lags in investment and capital use) and without any disappointment of expectations.[2] This means that even apart from the existence of events that are completely outside the framework of the model such as demographic changes, the model cannot be expected to historically replicate the economy on a year by year basis. If reaction lags in the actual economy are of the order of one to three years, the model will only capture triennial trends. Results are therefore best interpreted as three year moving averages. Equally, when projecting forward, the yearly results can really only indicate the pattern and level of activity around each given year, and delineate how activity can be expected to change over time.

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[2] Disequilibrium in nominated markets can of course still be modelled.

9.3 The Equations

Rather than present the complete set of equations for the dynamic model, which has a substantial overlap with that of the snapshot model, only those equations which differ from those of the snapshot version are given. The format of Chapter 4 is retained here with the same equation numbering but with a D prefix to indicate the dynamic model specification of the corresponding snapshot equation. An equation without the D prefix implies a new equation and the absence of a time subscript means that the variable pertains to the current year.

Production Functions

(D1.1) $$X_j = e^{\nu t}\theta_j L_j^{\alpha} K_{j(t-1)}^{\beta} \qquad (\alpha+\beta=1)$$

Output in a sector j, in any given year, is a Cobb Douglas function of the current year's labour input, the capital stock put in place in the previous year and an efficiency parameter.

The CRESH and reduced form production specifications used in the snapshot model have not at this stage been included. (Work on incorporating the latter is underway.)

Factor Demand

(D2.1.1) $$l_j \equiv L_j/X_j = p_j^{*}\alpha_j/w_j$$

Profit maximization yields the per unit demand for labour as a function of the value added price (p^*), the wage rate and the share of labour costs in net output value.

The demand for capital is not relevant as its supply in any year is fixed and full utilization is normally required.

Intermediate Input Demand

The equations for intermediate input demand are structurally unchanged from those in JULIANNE snaphot. All references to the base year are simply replaced with references to the previous year (t-1), so that for each year the previous year effectively becomes the new base year. The parameter (π) which *was* defined as the extent to which potential import substitution or encouragement is thought feasible over the model's planning period, now incurs a more restricted interpretation since the planning period is now always only one year. This necessitates the yearly recalculation of the S parameter, the long run proportion of imports which are classed as potentially competitive since, for example, if there is some import substitution in one year which reduces the overall import coefficient the new competitive proportion must be lower. Hence the addition of equation (5.1) below.

(D3) $$m_{ij} = h_{ij}m^{C}_{ij} + m^{NC}_{ij}$$

(D5) $$m^{C}_{ij} = m_{ij(t-1)}\pi_i S_{ij}$$

(5.1) $$S_{ij} = \left((S_{ij(t-1)} - 1)\left(\frac{m_{ij(t-2)}}{m_{ij(t-1)}}\right)\right) + 1$$

In period t=1, the S_{ij} are exogenous and equal to the values in the snapshot version. More details are given in section 9.4 and in Appendix A of this chapter.

The expressions for the domestic component of the composite intermediate input coefficients are unchanged from the snapshot model equations (6.2).

Prices

(D7) $$p^{*}_{j} = p_j(1-v_j) - \sum_i q_{ij}m_{ij} - \sum_i p_i d_{ij}$$

$$= p_j(1-v_j) - \sum_i \rho_{ij}a_{ij}$$

Value added prices or net prices equate to gross output prices less per unit taxes and intermediate domestic and imported inputs. (Note that the usual definition of value added includes tax payments.)

Stock Change

(16.3) $$S_i = S_{i(t-1)}\hat{X}_i/X_{i(t-1)}$$

$$= S_{i(t-1)}X_{i(t-1)}/X_{i(t-2)}$$

(16.4) $$\sum\rho_i S_i = \phi^S Y$$

Investment in stocks by each sector in a given year is equal to that in the previous year multiplied by the expected change in the volume of sales. This expected rate of change is simply equal to the actual rate of change in sales between the previous two years.

To prevent explosive or shrinking stock accumulation, total stock change is still subject to an overall constraint which limits it to some proportion (ϕ^S) of income (Y), as in the snapshot model. Each S_i has a domestic and an imported component such that:

(D16.1) $$S_i^D = \zeta_i\rho_i S_i/p_i$$

(D16.2) $$S_i^M = (1-\zeta_i)\rho_i S_i/q_i$$

$\hat{X}$ expected level of output

ζ_i domestic share of the value of S_i

Investment

(17.3) $$\sum I_i = \sum I_j \equiv I = \alpha + \beta P + \gamma I_{t-1} + \delta\left(\sum C_j + G + S\right)$$

Total real gross investment is expressed as a function of an overall investment goods price index, the level of real gross investment in the previous year and the current year's real value of the remaining components of gross domestic expenditure; namely private consumption (summed over its eight Household Expenditure Survey categories), government consumption and stock change. This function has been econometrically estimated, the details of which are provided in Appendix B of this chapter.

The above function represents the standard equation for determining total investment in any year but one is naturally not forced into using it. By simply changing the coefficients on the variables in the equation exogenously, one could for example, fix investment to be some proportion of real GDE (less investment) or one could specify some rate of increase over time. The latter option is useful when studying questions of steady growth. Other options are also possible.

Whatever method is chosen to determine total investment, the implicit assumption is always made that the total level of investment is determined independently of its composition, at least in a direct sense. Indirectly, different sectoral compositions of investment may yield a different overall investment goods price index which affects total investment if $\beta \neq 0$. The sectoral composition of gross investment is determined thus:

$$I_j/I = (I_j/I)_{t-1}\left(1 + \lambda(r_{j(t-1)} - \overline{r}_{t-1})/\overline{r}_{t-1}\right) \tag{17.4}$$

Each sector's share of total investment in the curent year is equal to its share in the previous year plus an adjustment for its relative profit rate. That is, for example, if its profit rate is higher than average it will capture a higher share of total real investment than it had in the previous year. The size of the change will depend on the value of λ which may be interpreted as a sectoral investment mobility parameter. The greater is the responsiveness of investment funds to profit rate differentials, the higher will be its value.[3]

There is no guarantee that the sum of the shares will equal unity so all shares may need to be adjusted uniformly up or down as appropriate. This is done automatically within the solution programme.

Separating the determination of total investment from the determination of its composition is considered valid for this type of model. The Government does exert a major influence on total investment, particularly through the number of dwellings built, which is usually

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[3] In a similar equation de Melo and Dervis [18, pp. 156 & 160] (and see also Chapter 2) suggest a value of 0.10 for such a parameter. It is conceivable that a high value could cause the right hand side of equation (17.4) to become negative for some sector. However, no such occurrence has yet arisen and the solution programme will produce a warning message if it does.

also exogenous. To do without a total investment constraint in some form would mean that the specification of sectoral investment would need to be extremely accurate and well tested econometrically. It is unlikely that this could be accomplished since investment patterns are amongst the most volatile of economic magnitudes, varying not only from sector to sector but also from industry to industry and indeed from firm to firm. The model can be run without equation (17.3) but destabilising investment cycles may result. At times this may be exactly what one wishes to model but their reliability would be dubious. Thus the standard (and safer) option is to include some sort of total investment constraint.

The equations here hopefully simulate reasonably well the net outcome of a multitude of factors which determine the level and composition of investment. Certainly, the investment functions here are a major improvement on those in the snapshot model (which is not to imply that the snapshot equations are not suited to that sort of model). Most obviously they do not imply or require the assumption of steady growth but are nonetheless flexible enough to handle questions about steady growth as well as permitting many variations in the specification of investment behaviour that do not necessarily yield steady growth rates and which are not necessarily confined to reflect a particular economic paradigm.

As in the snapshot version of the model, the supply of investment goods is related to the demand for investment goods by sector of destination via a capital input-output matrix.

A standard capital updating equation is used to keep track of the accumulation of capital.

$$K_j = (1-\delta_j)K_{j(t-1)} + I_j \tag{17.5}$$

P price index of investment goods

r_j profit rate in sector j - as defined below

$\bar{r}$ mean profit rate

$\alpha\ \beta\ \gamma\ \delta$ coefficients in aggregate investment equation

δ_j physical depreciation coefficient in sector j

λ investment mobility parameter

Profits

(18.1) $$\Pi_j = (p^*_j X_j - w_j L_j) + (1-\delta_j) P_j K_{j(t-1)} - P_{j(t-1)} K_{j(t-1)}$$

Sectoral profits equal the value added accruing to capital, plus the value of the now depreciated capital stock, less the value of capital at the end of the previous year. Expressing profit as a rate:

(18.2) $$r_j = \Pi_j / (P_{j(t-1)} K_{j(t-1)})$$

$$= \frac{p^*_j X_j - w_j L_j}{P_{j(t-1)} K_{j(t-1)}} + \frac{P_j - P_{j(t-1)}}{P_{j(t-1)}} - \frac{\delta_j P_j}{P_{j(t-1)}}$$

The terms on the right hand side are respectively; the rental rate of capital, the rate of capital gains and the financial rate of loss due to depreciation. Profit rates are in general not equal across sectors although movements toward equality could be expected over time depending on the value of the investment mobility parameter.

Π_j	profits in sector j
P_j	price of capital goods to sector j

Income - Expenditure Identity

(D28) $$Y = \sum p^*_j X_j + \sum p_j v_j X_j + \sum_i\sum_j t^*_{ij} q_{ij} M_{ij} - \sum s_j p_j E_j + N$$

$$= \sum p_j C_j + \sum \rho_i I_i + \sum \rho_i S_i + \sum \rho_i G_i$$

As in the snapshot model national income is defined as the sum of payments to factors of production or value added, plus revenue from taxation and tariffs, less export subsidies, plus net capital inflows. It must also be equal to gross domestic expenditure.

This completes the list of equations specific to the dynamic version of the JULIANNE model. Equations for Private and Government Consumption and Exports, and the usual balancing identities are exactly the same as those in the snapshot version as given in Chapter 4. More details of the dynamic linkages are presented in the next section.

9.4 Intertemporal Connectivity

The major dynamic links in the model are as follows.

(i)

The production functions (equation D1.1) which use the capital stock formed in the previous year as input into the curent year's production.

(ii)

The total investment equation (17.3) which relates current year investment to the level of investment in the previous year.

(iii)

The capital updating equation (17.5) which ensures that the only way a vector can increase its capital stock is by new investment. No intersectoral mobility of capital is permitted so that capital is both heterogeneous and sector specific.

The equation could easily be altered to accommodate gestation lags of more than one year.

(iv)

The sectoral allocation of investment equation (17.4) which places major emphasis on the previous year's allocation. The equation deliberately does not (necessarily) specify an optimal allocation of investment. Conversely it does ensure that the recorded base year has a strong but progressively declining influence on future year allocations. These two options are generally mutually exclusive unless the base year is on a long run optimal growth path. But one can nevertheless shift the emphasis of the model from one option to the other by varying the value of the investment mobility parameter.

(v)

Equation (5.1) which explicitly reduces/increases the share of imports classed as potentially competitive (for the current period) in response to the reduction/increase in imports between the last period and the period before that. For example, in some given year a certain type of import may be classed as 60% competitive. If in the following year these imports are reduced by 10%, the new competitive portion must be lower, namely 56.56%.

Within each year one may alter the proportion of the maximum potential competitive share of imports which is substitutable in that one year, by varying the factor π in equation (D5). This is useful when exploring the effects of policies which promote import substitution or encouragement.

The equations discussed above describing intertemporal connectivity are considered standard, in the sense that one only needs to supply the base year information along with a few parameter values and the model will do the rest. These equations with the possible exception of equation (17.3) are seldom varied from one model application to another. They are the essence of the dynamic model specification.

There are numerous other intertemporal links, the behaviour of which is very much more user specific or issue specific. One needs to make assumptions about the time paths of certain variables such as the rate of growth of government consumption where that is exogenous, the rate of growth of house building, total investment, nominal wage rates (or real wage rates or employment), world import prices, the export demand curve shift parameters, and so on. The exact nature of the issue under study will determine which variables are in that list and what their time profile should be. Generally a steady growth rate is assumed or else absolute values are inserted exogenously into each time period when a steady growth path is considered inappropriate. Virtually any specification is possible.

9.5 The Dynamic Model Solution Procedure

As with the discussion on the snapshot solution procedure it is useful to split the procedure for the dynamic model into two parts; the solut**ion strategy and the solution algorithm. The former will be seen to be similar to the strategy used for the snapshot version of the model, discussed in Chapters 4 and 5. This was always the intention. The strong similarity exists despite the fact that the strategy can no longer be classified as a factor market strategy. For reasons which will be explained below, it is now a combined product market - factor market strategy, but one where the number of major iterations needed to solve the model is less than the number of sectors (at least for 22 or 26 sectors which are the only dynamic model sizes constructed to date). Thus the strategy is better than the standard product market strategy which requires at least as many iterations as there are sectors, just to evaluate the Jacobian of partial derivatives.

The expanded income equation which forms the core of the snapshot solution strategy is equally important to the strategy of the dynamic model. Its derivation was presented in Chapter 4 and thus need not be repeated here. The only significant difference between the strategies is that by the time the expanded income equation is solved in the snapshot strategy, product market equilibrium (for that iteration) is assured. This is possible because product prices can be obtained from knowledge of only factor prices and cost functions. For the dynamic model the presence of the lagged capital stock term in the sectoral production functions means that this approach is no longer viable. That is, because the lagged capital is immobile once it is installed, the ex-poste production functions exhibit decreasing returns. Thus product prices are not independent of the level of output.

An overview of the approach adopted then, is that firstly, quantity demanded is calculated from an initial estimate of value added (or net) prices using the expanded income equation (just as in the snapshot model); secondly, net supply prices are calculated from profit maximization conditions on the assumption that quantity supplied equals quantity demanded; and thirdly, these are then compared with the initial (demand) prices. If the two sets of prices are not identical to within some specific error margin, the demand prices are adjusted by the algorithm and the procedure repeated until convergence is achieved.

Within this major loop there is a sub-loop to equate labour supply and demand, should employment be an exogenous variable. The dynamic model solution procedure solves these two loops simultaneously as is shown in figure 1. Because one loop is not nested inside the other (as occurs in the snapshot model solution strategy), it would be misleading to classify the strategy as either a factor market one or a product market one. Also, it requires more iterations for solution than there are factors but less than the number of sectors. Hence the dual classification.

An initial set of value added prices (based on information from the previous year's solution or from the base year) yields an estimate of gross output prices via equation (D7). These determine domestic and imported input-output ratios via equations (D3) & (6), from which, when combined with an assumption about wage rates, net prices may be recalculated, again using equation (D7). If these new net prices do not equal the original net prices, the new values are used to repeat the process. Convergence of this simple progressive substitution process is almost always achieved in two iterations. Once this occurs the algorithm proceeds to the next stage which is to calculate quantity demanded using the now established gross and net output prices, the expanded income equation and equation (23). Again this step is just as in the snapshot model solution procedure. The algorithm then forks into two branches, one of which calculates the demand for labour using equation (D2.1.1) and adjusts wage rates accordingly if labour demand differs from labour supply. This branch then rejoins the main branch to again recalculate net prices, this time from the supply side using equations (D1.1) and equation (7) of this section (9.5), on the assumption that producers supply the quantity demanded. If equal, the algorithm proceeds to the following year, updating all the relevant variables as described earlier. If not, the vector of net demand prices is adjusted and the process is repeated from the beginning.

The actual adjustment which is made to net prices depends on the number of iterations that have thus far occurred. Counting the first pass through the main loop as the first iteration, the new demand prices for the second and third iterations are set as functions of the previous iteration's prices:

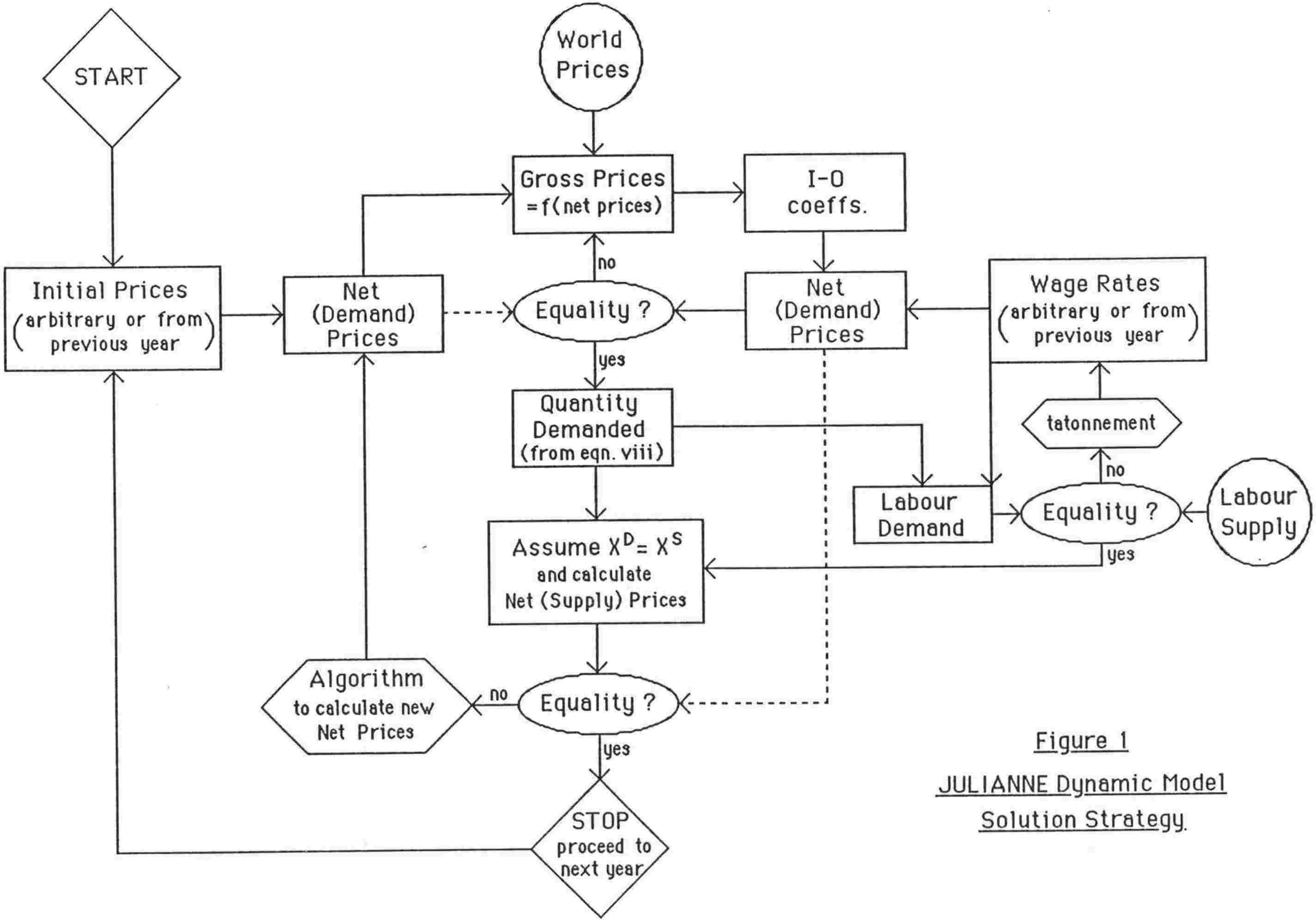


Figure 1

JULIANNE Dynamic Model Solution Strategy.

$$p_2^D = \lambda p_1^S + (1-\lambda)p_1^D \qquad (1)$$

$$\& \quad p_3^D = \lambda p_2^S + (1-\lambda)p_2^D \qquad (2)$$

- where D and S denote whether the price is used to determine quantity demanded or is determined by quantity supplied, and λ is a damping factor such that $0.5 < \lambda < 1$. Assume for the moment that its value is unity. Note also that all the p variables are n×1 vectors and that the subscripts denote the iteration count. (One apologises to the reader for not using superscripts for this purpose as in the explanation of the snapshot algorithm.)

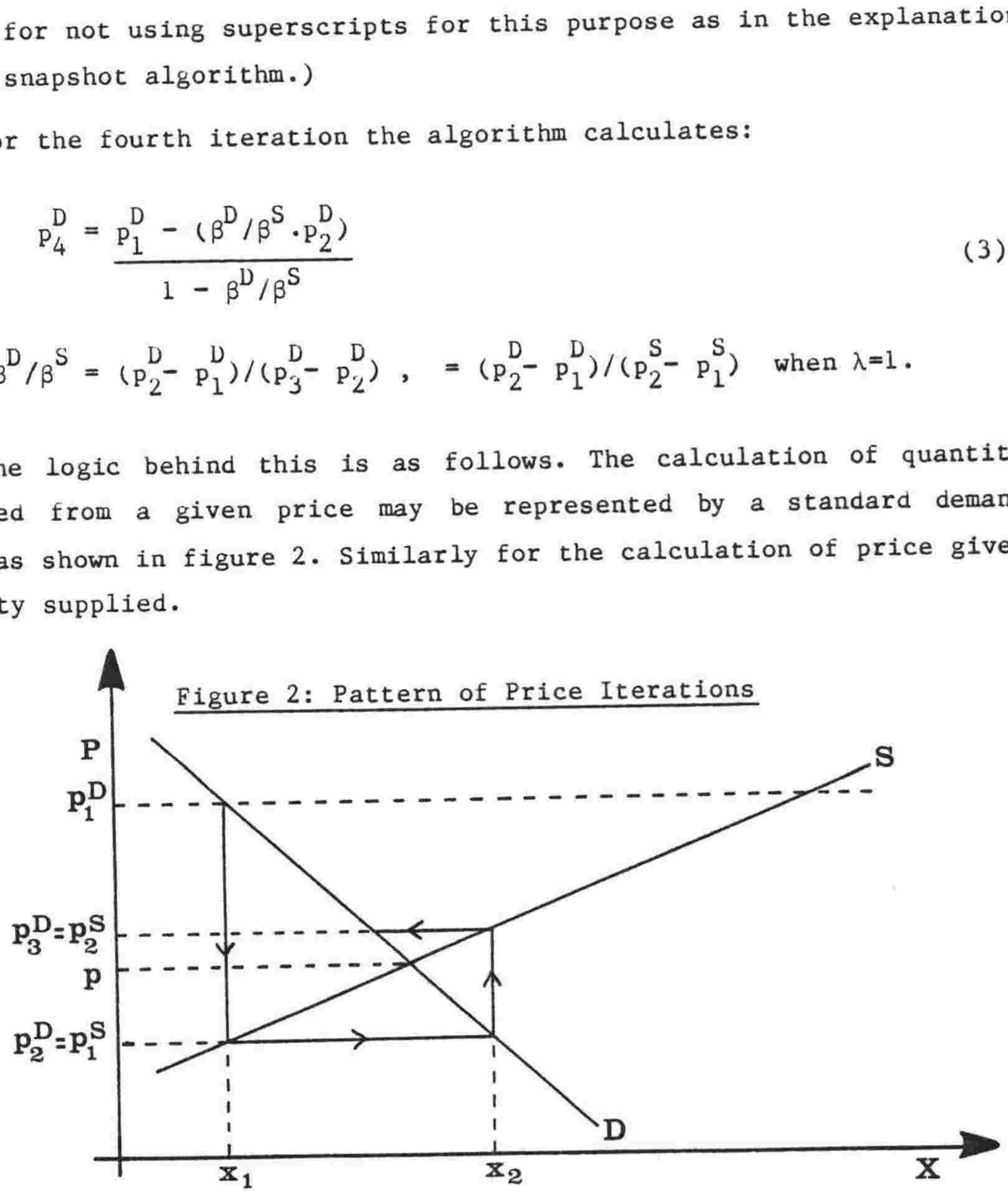
For the fourth iteration the algorithm calculates:

$$p_4^D = \frac{p_1^D - (\beta^D/\beta^S . p_2^D)}{1 - \beta^D/\beta^S} \qquad (3)$$

where $\beta^D/\beta^S = (p_2^D - p_1^D)/(p_3^D - p_2^D)$, $= (p_2^D - p_1^D)/(p_2^S - p_1^S)$ when $\lambda=1$.

The logic behind this is as follows. The calculation of quantity demanded from a given price may be represented by a standard demand curve as shown in figure 2. Similarly for the calculation of price given quantity supplied.

Figure 2: Pattern of Price Iterations



In the first iteration a price p_1^D is selected, from which a point X_1 on the demand curve is calculated. But suppliers would only produce this quantity if the price were p_1^S. However, at this price the quantity demanded is given by X_2. (With $\lambda=1$, $p_2^D = p_1^S$.) Again the supply response would then entail a price of $p_2^S = p_3^D$. At this point there is enough information to determine the slopes of the curves and their intersection. That is:

$$\beta^D = (p_2 - p_1)/(X_2 - X_1) \qquad \text{(omitting the D superscripts)}$$

$$\& \qquad \beta^S = (p_3 - p_2)/(X_2 - X_1)$$

$$\Rightarrow \beta^D/\beta^S = (p_2 - p_1)/(p_3 - p_2)$$

Thus the intersection is given by equation (3) with p^* substituted for p_4^D. This equation holds no matter where one begins.

The rate of convergence of the algorithm depends on the linearity of the curves. But, more fundamentally, whether the algorithm converges at all depends on the relative slopes of the curves, as in familiar cobweb theory. These two matters will be analysed in their logical order.

Condition for Convergence

A sufficient condition for convergence given that the demand curve is sloped negatively and the supply curve positively,[4] is that:

$$(dp/dX)_S < |dp/dX|_D \tag{4}$$

What does this condition require of the actual model equations? Equation (4) may be rewritten as:

$$(dp/dX)_S < \frac{1}{|dX/dp|_D} \tag{5}$$

So in terms of the steps in the algorithm, the change in the supply price which occurs for a given change in quantity, should be smaller than the reciprocal of the (absolute) change in the demand price which activated the change in quantity. Can this be checked?

---

[4] Perversely sloped curves are not relevant in the JULIANNE model.

The demand for output from a sector i is not exclusively a function of its own price. That is, the term dX/dp in equation (5) is really an abbreviation for :

$$\sum_{j=1}^{n} (\partial X_i/\partial p_j)$$

Normally, and certainly in the JULIANNE model, it will be true that $\partial X_i/\partial p_j \geqslant 0$ unless $p_j = p_i$. Thus for the algorithm to converge the matrix of dX/dp should be sufficiently diagonally dominant to ensure that:

$$(dp_i/dX_i)_S < \frac{1}{|\partial X_i/\partial p_i + \sum_{j\neq i} (\partial X_i/\partial p_j)|_D} \qquad \forall i \tag{6}$$

It is not very practicable to calculate the analytical derivatives of the $(dX/dp)_D$ since the change in output which is caused by the change in prices is the net result of virtually an entire algorithm iteration, involving the sequential solution of numerous equations and sub-loops. On the other hand $(dp/dX)_S$ which is unaffected by changes in p_j, where $j\neq i$, is readily derived from equation (7).

$$p = X^{(1-\alpha)/\alpha}\left((e^{\upsilon t}\theta)^{-1/\alpha} w\alpha^{-1} K_{(t-1)}^{-\beta/\alpha}\right) \tag{7}$$

- omitting the usual i subscripts. This equation results from substituting equation (D2.1.1) into equation (D1.1).

$$\Rightarrow dp/dX = (1-\alpha)/\alpha \; X^{(1-2\alpha)/\alpha}(\quad) \tag{8}$$

$$\geqslant 0 \quad \text{for } 0<\alpha\leqslant 1, \qquad \text{(always true in JULIANNE)}$$

Hence (one of) the major factors determining the value of dp/dX is likely to be the exponent $(1-2\alpha)/\alpha$, since as $\alpha \to 0$, $(1-2\alpha)/\alpha \to \infty$.

Thus the algorithm is less likely to converge for sectors where labour accounts for a small proportion of value added. Excluding the Ownership of Dwellings sector which does not have a Cobb-Douglas production function, the Water, Petrol and Electricity sectors have relatively low α values. Experience has revealed that only the Water sector is apt to be problematic, no doubt due to the combination of a low α value and a very high capital-output ratio. The algorithm has never not converged for this sector but large (although naturally damped) oscillatory movements often did cause it to be intolerably slow. In terms of figure 2 the curves would be of almost identical absolute slope. The standard tolerance margin is 0.005% but for the Water sector a more lax margin of 0.05% is usually permitted. Under these criteria convergence is typically achieved in 12-17 iterations where iterations 4,7,10,13.... use equation (3) with the information required to solve it coming from the immediately previous 3 iterations. The looser tolerance margin for Water has an insignificant effect on the results and allows one to dispense with essentially superfluous iterations.

Rate of Convergence

Given that convergence is possible, it would be achieved after only 4 iterations using equation (3) if the demand and supply curves involved were as linear, and the arrowed lines as orthogonal, as drawn in figure 2. Naturally this is not necessarily the case, as is certainly evident for the supply curve from the nonlinear equations (7) and (8), and from the right hand side of figure 1 which shows that the wage rates used in the calculation of a set of demand prices are not necessarily those that are used to determine supply prices, thus destroying the orthogonality. As regards the demand curve the lack of linearity is caused not only by the intrinsic nonlinearity of the model's equations but also by the sub-loop which iterates on gross prices, input-output coefficients and net prices. The execution of this loop will generally mean that a set of demand prices as determined by the algorithm on the left of figure 1, is not the same set which is used to calculate the demand for output.

Convergence problems in these two loops have never been serious enough to prevent the algorithm as a whole from converging. Furthermore it is unlikely that they ever will do so, since the sub-loops themselves trace out well behaved adjustment paths. Their main effect along with the general nonlinearities of the model is to slow down the rate of convergence by causing the arc estimates of the slopes (β^D & β^S) to be only approximations to the slopes at the point of intersection. This linearization error is analogous to that which occurs in the snapshot model solution algorithm, where the Jacobian is estimated by functional evaluations along a secant. As the solution point is approached the aproximation becomes progressively better.

One improvement which is incorporated to speed up the rate of convergence is the inclusion of a damping factor (λ) as shown in equations (1) and (2). This is generally useful because the movement to equilibrium is one of damped oscillations (as depicted in figure 2) and it is thus always true that:

1. The equilibrium price will lie between two 'adjacent' prices. For example, from figure 2, p^* is between p_1 and p_2, then between p_2 and p_3, and so on.

2. p^* is closer to p_2 than to p_1, closer to p_3 than to p_2 etc.

Hence as in equation (1) setting

$$p_2^D = \lambda p_1^S + (1-\lambda)p_1^D \qquad \text{with } 0.5<\lambda<1.0 \tag{1}$$

- yields a p_2^D which is closer to the equilibrium than simply setting $p_2^D = p_1^S$, as done for diagrammatic clarity in figure 2.

The optimal value of λ is obviously a function of the relative slopes of the curves, namely:

$$\lambda = \frac{|\beta^D/\beta^S|}{1 + |\beta^D/\beta^S|} \tag{9}$$

Thus after the first three iterations, enough information is available to set λ optimally for each sector. These values are used for the fourth, fifth and sixth iterations after which they are re-evaluated for the seventh, eighth and ninth iterations, and so on. For the first three iterations λ is usually set at 0.50 for all sectors and this value is retained as a lower bound at all times. That is, if equation (9) yields a value of λ less than 0.50, that value is set equal to 0.50. Similarly there is an upper bound of unity. Such a safeguard is necessary to ensure convergence especially at the beginning of the iterative sequence when the estimated slopes may not be very accurate.

It is easily shown that for iterations 4,7,10.... equations (1) and (9) collapse to equation (3), since that is when the slopes are re-evaluated. One could of course programme the algorithm to re-evaluate the slopes at every iteration from the fourth onwards so that equations (1) and (9) always collapse to equation (3). This option has been tested but did not perform as well as the procedure described above. Investigation of the iterations suggested that the vicissitudes of the slopes away from the solution point are such, that constantly changing the λ values slows down the rate of convergence toward the solution 'neighbourhood' whilst only speeding up the rate marginally within the neighbourhood.

In conclusion one cannot claim that the solution procedure for the dynamic model is the best technique possible. But as with the snapshot model solution procedure, it has thus far proved satisfactory. As far as one can determine from a search of the literature on procedures for solving nonlinear dynamic economic models, the product - factor combination strategy used here is unique. Thus there are no (obvious) improvements that one can glean from others.

About 18 seconds are required by the programme to read the database (which it does just once) with each year requiring about 30 seconds, corresponding to an average 15 iterations, for solution. (This is using SAS on an IBM 4341 computer.) The technique therefore compares very favourably with those that entail evaluating the full Jacobian of partial derivatives, which are generally efficient algorithms in many applications; as in the snapshot version of JULIANNE.

9.6 The Solution Procedure and Market Adjustment

In Chapter 5 on the snapshot solution procedure the economic parallels of the mathematics were discussed in the context of the Walrasian notion of tatonnement. Accordingly, how does the dynamic version of JULIANE compare with the Walrasian tatonnement process? Is it a better representation of actual market adjustment?

Because JULIANNE dynamic is a sequential equilibrium model rather than an intertemporal model,[5] it uses (as we have just seen) essentially the same algorithm as the snapshot version to solve for each period. As Leijonhufvud [57, p75] says, we can: "...conceive of tatonnement as.... taking place between innings of a period model."

As with the snapshot model no false trading occurs but expectations and imperfect information do cause adjustment lags. For example, desired stock change in each sector is calculated on expectated sales and investment funds are attracted, subject to a one year lag, to sectors with relatively high profit rates on the expectation that these will continue. Strictly speaking none of this generates false price trading since all transactions occur using only one set of (equilibrium) prices. But they are not those prices that would prevail if different (or perfect) adjustment mechanisms were specified. That is, the adjustment mechanisms in the model which to an extent simulate myopic preferences and reactions, and reflect known institutional rigidities, affect the nature of the equilibrium solution more than they affect the path of its attainment. (In an intertemporal equilibrium model the solution process is even further removed from actual market adjustment.)

In the JULIANNE dynamic model the information held by market participants is deliberately far from total, since perfect foresight is not assumed. This generates a model solution path which is not intertemporally efficient, although it may at times be reasonably stable. Such a result is hardly surprising given that the yearly equilibria are not Pareto efficient. As was said earlier in section 9.2: "The model exhibits continual but incomplete movements towards some dynamic equilibrium which itself is constantly changing."

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[5] Elaboration of this distinction was provided in Chapter 2 and in section 2 of this chapter.

Hence some of the characteristics of disequilibria are present without purporting to accurately portray true market adjustment processes; this being beyond the ambit of the JULIANNE model.

Thus in general, and in terms of the amount of information attributed to market agents, the snapshot version of the model has more in common with tatonnement than does the dynamic version. In terms of actual market behaviour the dynamic version is more realistic. But a significant difference still exists between the model's solution procedure and market adjustment. This is aptly illustrated by a classic example which also elucidates the central position of investment decisions in the tatonnement process. What happens if there is a rise in the mean savings ratio - if current consumption is forgone for future consumption?

Ideally, and as could occur if futures markets existed, current consumption goods would become cheaper with future consumption goods becoming more expensive, thereby negating some of the switch whilst rendering investment to supply future consumption more profitable. More likely the switch in consumption would be perceived by producers as a fall in demand, leading to excess capacity followed by a cut in investment, lower production, lower employment, and hence lower demand; and so on in the familiar Keynesian cycle. Producers' expectations about future demand do not yield the correct investment decisions.

In the model a reduction in the propensity to consume in a given period is, for a given level of resource inputs, automatically translated into an increase in investment in the same period since excess capacity is not generally permitted. So it is as if a futures market is operating. The increase in investment will raise sectoral capital stocks in the following period and thereby allow greater future consumption. Market adjustment operates smoothly. The difficulty in modelling excess capacity is in determining the appropriate degree of price versus quantity response. Indeed, this is the essence of disequilibrium modelling, the heart of market behaviour based on the imperfect information that is held by market participants.

The future refinement of the JULIANNE dynamic model through the inclusion of better disequilibrium behavioural mechanisms is a possibility. However, one believes that any accurate simulation of market adjustment processes is unlikely to remain accurate for any length of time other than the short term and JULIANNE is not a short term model. There are no universal market adjustment laws which merely await identification, as some theorists would appear to believe. A general theory of disequilibrium dynamics good enough to yield predictions is an impossibility as long as the economic system, as personified by the out of equilibrium actions of its participants, defies the logic of mathematical rigour. It is not always even easy to mathematically describe equilibrium behaviour.

As a concluding thought one might consider that rather than attempting to model the existing economy exactly as is and travelling ever further up the ogee-shaped 'effort-reward' curve, it may be more beneficial if some form of indicative planning arrangement was implemented in order to reduce some of the uncertainty of market participants and hence facilitate adjustment to disequilibria.

Appendix A

Import - Domestic Substitution in JULIANNE Dynamic

In section 9.3 it was stated that the values of the S_{ij}, the long run potential maximum degree of import substitution of product i in activity j, are adjusted between periods in response to import substitution or encouragement in the immediately previous period. The updating equation is given as:

$$(5.1) \qquad S_{ij(t)} = \left((S_{ij(t-1)} - 1)\left(\frac{m_{ij(t-2)}}{m_{ij(t-1)}}\right)\right) + 1$$

where t=2...n, and when t=1 the S_{ij} are exogenous at their base year values.

In a one year model or in a snapshot model the horizon year import coefficient is given by:

$$dm/m = \varepsilon\pi S.d\rho/\rho \quad \text{(dispensing with i \& j subscripts)}$$

where ρ is the ratio of the price of a domestic good (p) to the price of an equivalent imported good (q).

$$\Leftrightarrow \quad (m_1-m_0)/m_0 = \varepsilon\pi S\left((\rho_1-\rho_0)/\rho_0\right) \quad \text{where subscripts denote time}$$

$$= \varepsilon\pi S(\rho_1-1) \quad \text{as } p=q=1 \text{ at } t=0$$

$$\Rightarrow \quad m_1 = \left(\varepsilon\pi S(\rho_1-1) + 1\right)m_0$$

$$\Leftrightarrow \quad m_1 = \left([\varepsilon(\rho_1-1) + 1]\pi S + (1-\pi S)\right)m_0$$

Hence for a dynamic two period model one has:

$$m_2 = \left(\left[\varepsilon\frac{(\rho_2-\rho_1)}{\rho_1} + 1\right]\pi_1 S_1 + (1-\pi_1 S_1)\right)m_1$$

$$= \left(\left[\varepsilon\frac{(\rho_2-\rho_1)}{\rho_1}+1\right]\pi_1\left[(S-1)\frac{m_0}{m_1}+1\right] + 1 - \pi_1\left[(S-1)\frac{m_0}{m_1}+1\right]\right)m_1 \qquad \text{by eqn(5.1) with } S \equiv S_0$$

$$= \left(\left[\varepsilon\frac{(\rho_2-\rho_1)}{\rho_1}+1\right]\pi_1\frac{[(S-1)m_0+m_1]}{m_1} + 1 - \pi_1\frac{[(S-1)m_0+m_1]}{m_1}\right)m_1$$

$$= \varepsilon\frac{(\rho_2-\rho_1)}{\rho_1}\pi_1[(S-1)m_0 + m_1] + m_1$$

Substituting for m_1, with $\pi \equiv \pi_0$:

$$\Rightarrow m_2 = \varepsilon\frac{(\rho_2-\rho_1)}{\rho_1}\left(\pi_1(S-1) + \pi_1\left\{\left[\varepsilon\frac{(\rho_1-\rho_0)}{\rho_0}+1\right]\pi S + (1-\pi S)\right\}\right)m_0 +$$

$$\left(\left[\varepsilon\frac{(\rho_1-\rho_0)}{\rho_0}+1\right]\pi S + (1-\pi S)\right)m_0$$

Writing $\varepsilon\frac{(\rho_2-\rho_1)}{\rho_1}$ as ε_2, $\varepsilon\frac{(\rho_1-\rho_0)}{\rho_0}$ as ε_1 and simplifying:

$$\Rightarrow \frac{m_2}{m_0} = \varepsilon_2(\pi_1 S - \pi_1 + \pi_1\pi S\varepsilon_1 + \pi_1\pi S + \pi_1 - \pi_1\pi S) + [(\varepsilon_1+1)\pi S + (1-\pi S)]$$

$$= \varepsilon_2(\pi_1 S + \pi_1\pi S\varepsilon_1) + \varepsilon_1\pi S + 1$$

$$= (\pi_1\varepsilon_2 + 1)(\pi\varepsilon_1 + 1) + (1-S)$$

$$\Rightarrow \frac{m_2-m_0}{m_0} \equiv \frac{dm}{m} = (\pi_1\varepsilon_2 + 1)(\pi\varepsilon_1 + 1)S - S$$

It can similarly be shown that for n periods:

$$\frac{m_n-m_0}{m_0} \equiv \frac{dm}{m} = \prod_t(\pi_{(t-1)}\varepsilon_t + 1)S - S$$ where $\prod_t$ denotes the product from $t=1$ to $t=n$

Assuming ε_t and π_t to be the same $\forall t=1\ldots n$, or taking their mean values:

$$\Rightarrow \frac{dm}{m} \simeq \left(\pi\varepsilon.\frac{d\tilde{\rho}}{\tilde{\rho}} + 1\right)^n S - S$$ where $\tilde{\rho}$ is the mean $\Delta\rho$ per annum

$$= \left(1 + n\pi\varepsilon.\frac{d\tilde{\rho}}{\tilde{\rho}} + \frac{n(n-1)}{2!}\left(\pi\varepsilon.\frac{d\tilde{\rho}}{\tilde{\rho}}\right)^2 + \ldots\ldots\right)S - S$$ using a Taylor series expansion

$$\Leftrightarrow \frac{dm}{m} \simeq (1 + n\pi\varepsilon.\frac{d\tilde{\rho}}{\tilde{\rho}})S - S$$

$$\Rightarrow \frac{dm}{m} \equiv \frac{m_n - m_0}{m_0} \simeq \pi\varepsilon S.\frac{d\rho}{\rho} \equiv \pi\varepsilon S\frac{(\rho_n - \rho_0)}{\rho_0}$$

which is an expression of the same form as that given at the beginning for a one period model. That is, a given elasticity ($\varepsilon\pi S$) yields approximately the same change in an import coefficient when applied to consecutive per annum price changes as when applied to one equivalent overall price change which occurs over the whole model period, because the S values are progressively updated over time by equation (5.1).

The degree of accuracy of the approximation will improve with:

(i) Smaller price changes so that the second and higher order terms in the Taylor series expansion tend to zero.

(ii) A greater uniformity of ε values across time so that the mean ε value is less a function of the weights $(d\rho/\rho)_t$ which may not be equal.

(iii) A greater uniformity of π values; reasoning as for ε.

The value of S is unambiguous being the potential maximum degree of import substitution as defined in the base year, that is S_0.

Appendix B

Estimation of Equation (17.3)

Equation (17.3) is:

$$I = \alpha + \beta P + \gamma I_{t-1} + \delta(\textstyle\sum C_j + G + S)$$

variable	estimated coefficient	t-statistic
constant	-620.8	2.40
P	-0.777	5.19
$I_{(t-1)}$	0.570	5.32
(C+G+S)	0.262	4.81

mean of dependent variable: 2716.7 ($m 1977)

R^2: 0.936

F-statistic (3,16): 77.7

D-W statistic: 1.59

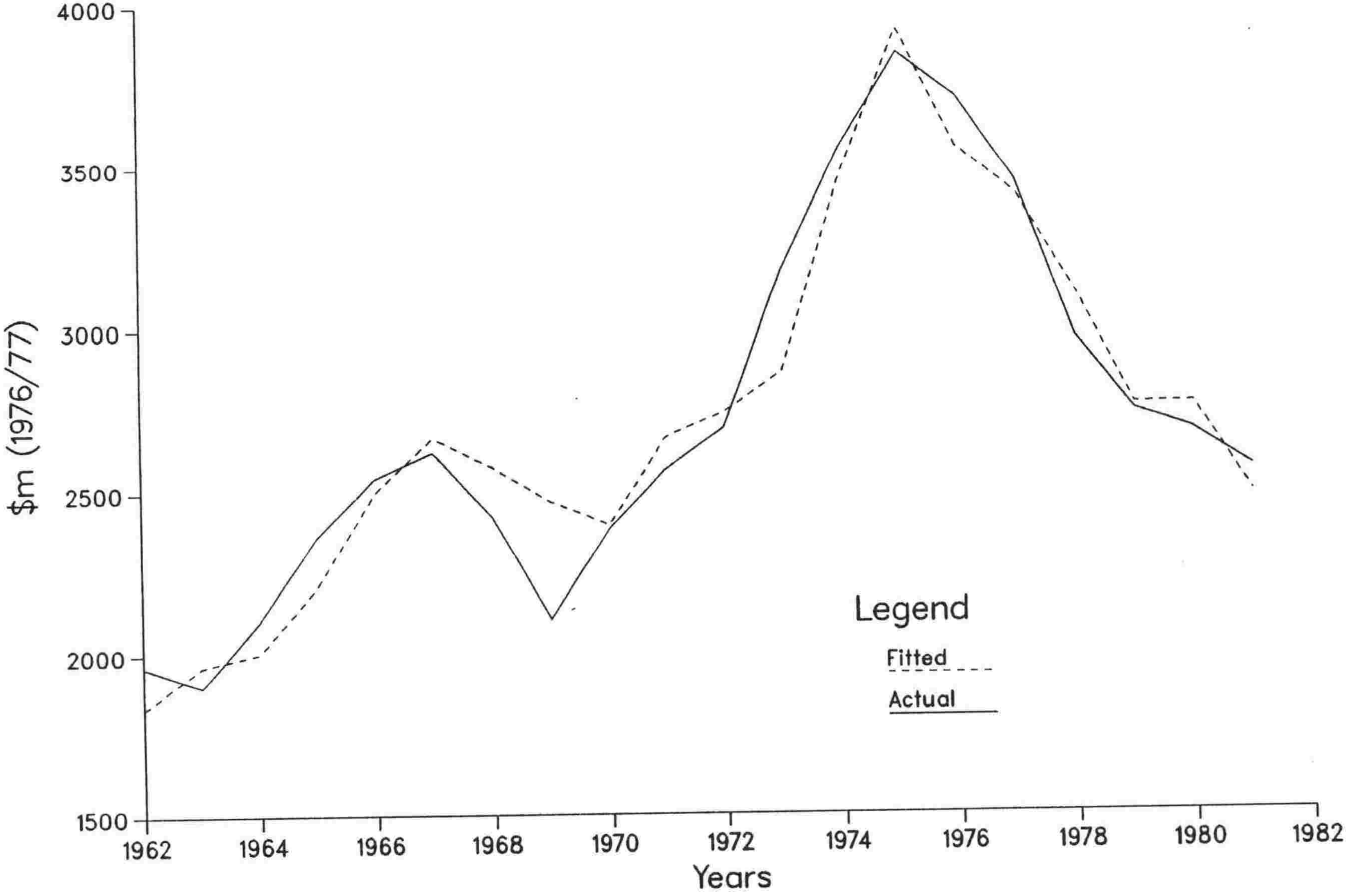
sample range: 1961/62 - 1980/81

The results are both satisfactory and self explanatory with the signs of the coefficients conforming to prior expectations. A good picture of the overall goodness of fit is given in figure B1.

The Durbin-Watson statistic is in the uncertainty range for the characteristics of this regression. However, when tested using a first order autoregressive estimation procedure, an autocorrelation coefficient of only 0.23 was obtained with a t-statistic of 0.94. The parameters changed to -0.717, 0.576 and 0.243 respectively. On the basis of this stability and the non-significance of the autocorrelation coefficient the hypothesis of no serious autocorrelation is accepted.

Again as stated earlier, equation (17.3) does not have to be used with the estimated coefficients; they be altered as desired.

Figure B1
Real Gross Investment



10

APPLICATIONS OF 'JULIANNE' DYNAMIC

CHAPTER 10

APPLICATIONS OF JULIANNE DYNAMIC

Three applications of the dynamic version of JULIANNE are presented in this chapter, beginning with an historical simulation of the period 1982-85. This section is the dynamic equivalent of section 7.2. The second section outlines a control run projection to 1990 - the dynamic analogue of section 7.3. And the third section looks at a few alternative protection regimes for that period, comparing them with the snapshot model results from Chapter 8. A brief overall conclusion is given in section 10.4.

10.1 Historical Simulation 1982-85

Introduction

Recall from section 7.2 that the simulation of a known time period is a useful way, probably the principal way, of testing or validating a CGE model. The objective is not to obtain an exact replica of the past as this has never been an intended attribute of CGE models, belonging more to econometric forecasting models. Rather the objective is to obtain a reasonable simulation that can then be used as a control run against which one can compare alternative scenarios of that time period or from which one can project forward and study alternative future scenarios. In securing such a control run it is possible (indeed unavoidable) to assess the realism of model assumptions such as profit/utility maximization, the sensibility of parameter values and the importance of economic events which have no counterparts in the list of model variables. In principle, if the model should manage to accurately track known history one would conclude that its assumptions and parameters, taken holistically, are defensible and that events outside the framework of the model are either unimportant or can be allowed for through the model's standard list of exogenous variables.

In practice the methodology is complicated by data problems in the sense that a good simulation could conceivably be the result of elusive but beneficial interaction between untestable assumptions, model exogenous events and data deficiencies. These problems are discussed in more detail below, with the actual enumeration of the input data forming a separate sub-section.

Practical issues in Simulation with a Dynamic CGE Model

Two major problems arise when using a (dynamic) CGE model such as JULIANNE in a simulation type experiment.

1. There are exogenous variables in the model which require information that is not available in the form of consistent time series, or at least is very difficult to obtain and often unreliable. This is especially true of sector specific information.

2. Events occur in the real economy which have absolutely no corresponding variables or sets of equations in the model that encompass or describe the relevant relationships.

With regard to the first point, if the model is to be used to simulate the past then ideally the time profile of all the exogenous variables and time dependent parameters should be known. Fortunately most of the major exogenous variables are reasonably well documented even if not always in official statistical publications. But disaggregated data on such variables as world price movements is rather scant with (not surprisingly) no estimates at all being available of the shifts in the export demand curves between 1982 and 1985. Similarly with changes in commodity specific export subsidy rates and tariff-equivalent rates.

The second difficulty associated with using a dynamic CGE model in a simulation context is conceptually more serious. There are many real world events which affect the pattern and level of economic activity but which have no corresponding variables in the model that can be exogenously adjusted, or no corresponding sets of equations. For example the model does not incorporate:

(a) Expectational behaviour such as may have been the reason for the splurge in imports in 1984/85. (See table 5 and figure 1.)

(b) Government action such as price freezes.

(c) Finance market actions such as restrictions on mortgage loans.

(d) Changes in tastes and demographic characteristics which, for example, will not be tracked by the model's consumer demand functions.

(e) Disequilibrium situations: Expectational behaviour such as that mentioned in (a) also has a more subtle effect in that the disappointment of expectations over time may lead to incorrect price and output decisions, unintended stock changes and so forth. Whilst JULIANNE dynamic does not incorporate the perfect foresight assumption, the actions of all the various economic agents represented in the model are determined by a set of equations which do not include adjustment periods should expectations be disappointed. The model knows nothing about expectations except for their very rudimentary modelling in investment allocation and stock change. This implies that the model cannot be expected to yield exact historical year by year replications, even if all of the other problems mentioned above were absent.

These sorts of problems do not occur in the normal contemporaneous comparative analysis of future years for which the JULIANNE model and other CGE models are designed where (as demonstrated in Chapters 7 and 8) one is concerned with examining the implications of alternative assumptions in a laboratory experiment type situation, with events outside the framework of the model being assumed unchanged across scenarios. Unfortunately the recorded past is replete with events which confound the logic and abstraction of a CGE model, but which need to be allowed for somehow, if one is to secure a simulation which can be used as a control run and as a general validation of the model.

Input Data

The input data is presented in tables 1 to 4 and in most cases no further elaboration is necessary. The exceptions are given below. Note that the model version used here consists of 22 sectors and is based on the 1981/82 input-output tables.

The sectoral technological change rates given in table 2 result from a four step adjustment procedure applied to the rates calculated from Nana [64]. The four steps are (for each sector):

1. The per annum rates of technological change were averaged.
2. All those less than zero were set at zero.
3. All those greater than five were set at five
4. These adjusted averages were then scaled up or down uniformly by the change in the economy-wide rate as given in table 1.

The import price data in table 3 comprises only nine series due to the lack of more appropriately disaggregated series being given in table 21.10 of the Monthly Abstract of Statistics (MAS). Hence the need to apply some indices to more than one JULIANNE import category. It is assumed that the mean c.d.v. import price index mulitplied by the change in the value of the margin between c.d.v. and c.i.f. imports (calculated from MAS tables 11.02 and 21.10) is a reasonable proxy for a service import price index. The index for Chemicals is taken as the average of the Petroleum index and the All Groups index, from table 21.10.

Exports

Recall from Section 7.2 where the JULIANNE snapshot model was used in a simulation experiment, that export volumes were set exogenously due to the lack of information on demand curve shifts. That information shortage is now compounded three-fold. However, a new approach is attempted here with export values being set exogenously leaving the model to solve for prices and quantities.

The goods figures are calculated from MAS tables 11.01 and 11.03 using March year ended data wherever possible but falling back on 1/4-3/4 interpolation of June year figures where necessary. Service exports are calculated by subtracting total goods exports from the total of all exports given in MAS table 20.03.

Table 1: Exogenous Variables

	1981/82	1982/83	1983/84	1984/85	Sources & Comments
	actual	estimated and actual			
1. Total real gross investment (% of GDE)	20.61	22.39	22.84	21.78	BERNZ/Infometrics: various issues of the Statistical Bulletin [11]
2. Real housing investment ($m)	1088.8	916.5	1158.7	1246.1	MAS Table 9.01
3. Real govt. social investment ($m)	625.1	744.6	771.6	715.3	BERNZ/Infometrics
4. Real govt. consumption ($m)	5332.0	5173.3	5220.3	5272.6	" & NZIER Quarterly Predictions
5. Trade balance ($m)	-918.7	-1138.0	-221.0	-992.0	MAS tables 19.01 & 20.03, BERNZ
6. Stocks/(Stocks + PriCon) (%)	91.41	90.96	93.94	89.72	" " " " NZIER
7. Total employment ('000)	1283.8	1262.9	1276.8	1333.1	Nana [64]
8. Mean Solow-Denison residual (%pa)	---	0.96	1.34	5.16	"
9. Exchange rate ($NZ/$F)	1.000	1.051	1.114	1.311	MAS table 18.07
10. Allen substitution elasticity	---	1.0	1.0	1.0	cf. medium term values of 2.0-4.0

Notes: (1) $F indicates a foreign dollar unit.

(2) MAS is Monthly Abstract of Statistics.

(3) BERNZ is Berl Econometric Resources New Zealand.

Table 2: Solow-Denison Residuals

(% pa 1982-85)

AGR	Agriculture	2.10	FAB	Fabricated Metals	5.00
FIS	Fishing & Hunting	0.75	OTH	Other Mfg.	2.73
FOR	Forestry & Logging	0.00	EGW	Elect., Gas, Water	0.90
MIN	Mining & Quarrying	5.00	CON	Construction	1.80
FBT	Food, Bevs., Tobacco	0.02	TRA	Trade & Accom.	3.08
TEX	Textiles & Leather	2.62	TRN	Transport	5.00
WOD	Wood & Wood Products	5.00	COM	Communications	4.28
PAP	Paper & Products	5.00	FIN	Finance etc.	1.67
CHE	Chemical Products	0.00	OWN	Own. Dwellings	0.00
NOM	Non-Metallic Prods.	3.58	PRI	Private Services	1.15
BAS	Base Metal Products	4.92	GOV	Govt. Services	0.00

Table 3: Trade Prices

(1981/82 = 1.000)

	'83	'84	'85
Imports:			
AGR FIS FBT	1.123	1.233	1.478
FOR WOD PAP	1.104	1.209	1.445
MIN NOM	1.113	1.208	1.425
TEX	1.096	1.163	1.471
CHE	1.101	1.127	1.326
BAS	1.068	1.117	1.380
FAB OTH	1.090	1.215	1.468
EGW	1.106	1.186	1.411
CON → GOV	1.120	1.208	1.439
Exports:			
DAIR	1.129	1.123	1.166
MEAT	1.026	1.092	1.127
WOOL	0.967	1.082	1.329

Table 4: Export Values

($m 1981/82)

	'83	'84	'85
DAIR	1321.8	1151.3	1376.8
MEAT	1761.8	1885.7	2005.8
WOOL	967.4	1114.2	1404.7
FISH	258.7	384.4	352.5
HORT	218.3	343.0	455.5
OFBT	426.6	495.2	798.3
TEXT	459.0	531.5	681.1
WOOD	170.2	203.8	284.3
PAPR	331.1	397.3	482.6
CHEM	319.3	364.6	657.8
ENGY	20.5	25.4	155.7
MINE	45.6	49.2	64.2
CERA	42.2	47.1	66.4
BASE	427.4	645.3	889.9
MAEQ	240.5	284.6	360.2
OMFG	213.5	163.1	199.5
SERV	1527.0	2583.8	2831.2

Note; Export abbreviations explained in table 6.

Dairy, meat and wool exports are treated slightly differently since their world market prices are notoriously volatile. The model cannot be expected to simulate this volatility so prices are set exogenously along with values. Thus volumes and subsidy rates (which capture SMP's) are endogenous, with the subsidies acting as an accommdating buffer so as to allow selling prices to differ from the price dictated by production costs.

Subsidy rates for the remaining export commodities are left unaltered in 1983 and 1984 from their 1982 rates which averaged 2.6% (excluding SMP's). In the 1984/85 year the July 1984 devaluation had the effect of suddenly raising New Zealand returns to exporters above production costs. To simulate this effect in the model export subsidies are reduced by a uniform 5% (which converts some of them into net taxes) so as to raise (NZ dollar) export prices relative to production costs and relative to the prices of similar goods sold on the domestic market. Thus the subsisies are again acting as a wedge between selling prices and production prices. In reality this (temporary) price difference effected by the devaluation is absorbed by exporters as super-normal profits, which of course is inconsistent with the neoclassical pricing hypothesis used in JULIANNE. Hence the modelled reduction in export subsidies may be thought of as being returned to exporters via lower income taxes.

If the devaluation is not modelled in this manner, the devaluation induced rise in export values, which are exogenous here, will yield overstated volume figures since the model's export prices would be too low. In reality, once the devaluation feeds through into domestic prices the super-normal profits will disappear. Indeed at the time of writing the appreciation of the exchange rate and domestic inflation have negated any remaining benefits of the July 1984 devaluation.

Clearly, the export and import data is far from ideal which implies that the probability of the model accurately tracking annual sectoral changes is less than it potentially could be, quite apart from the problem of events which are completely outside the model's framework, as discussed in the previous section. Consequently, whilst reasonably good macro results can be expected from a simulation such as this, sectoral results will be subject to a much higher error margin which cannot then be attributed to the structure of the model.

Results

The macro results are given in table 5 and illustrated in figure 1, where actual series are suffixed 'A' and model results are suffixed 'M'.

It can be seen that the model tracks the general movement in the macro aggregates rather well, yielding GDP above actual in 1983 and 1985, and below actual in 1984. The biggest absolute difference is about $500m in 1985 although one suspects that the actual estimate could be somewhat on the low side, given the higher MAS estimate of GDP as shown in footnote 3 of the table. Correspondingly, Private Consumption (PriCon) is overstated and imports are understated.

The model fails to capture the drop in imports in 1984 and the (consequent) surge in 1985. Given the overstatement of both GDP and prices this indicates that forces other than real income changes and relative price changes were responsible for those oscillations; not really surprising.

Export volumes are slightly above actual in all three years, so the method of exogenous values, exogenous agricultural prices and exogenous non-agricultural subsidy rates works quite well, even for some of the individual commodities as shown in table 6. This is in spite of the quite marked divergence between the model's GDP price index and the true index, although the total change from 1982 to 1985 is close to actual. That is, the endogenous agricultural subsidies ensure that there is an accommodating wedge between production costs and selling prices for agricultural exports. But for manufactures and service exports this is not the case, suggesting that in reality export prices rose under the 1982-84 price freeze (as they were entitled to do) above domestic prices generally. Thus the model's GDP deflator could be providing some indication of what inflation would have been like without the freeze, although the 1983 result can hardly be so interpreted!

Some of the individual commodity export results are rather out of line. In the case of Fishing and Other Food the discrepancies are mutually offsetting, being due to a classification difference. But the other major discrepancies, notably those in Wood and Minerals, are (presumably) due to model-external events such as product changes and to the uniform 5% export subsidy adjustment factor, which ideally should be commodity specific.

Table 5: Macro Results

($m 1981/82)

	Actual / Estimated[1]				Model Simulation		
	'82	'83	'84	'85	'83	'84	'85
Private Cons.	16952	16577	16922	17677	16449	16799	18029
Govt. Cons.	5332	5173	5220	5273	5173	5220	5273
Investment	6197	6714	6892	7052	6704	6848	7078
Stock Change[2]	1592	1692	1114	2025	1612	1115	2116
Exports	7991	8147	8917	9756	8257	9208	9773
Imports	8910	9156	9075	10136	8987	9212	9924
Trade Balance	-919	-1009	-158	-380	-730	-4	-151
G.D.P.	29155	29147	29990	31647[3]	29209	29979	32344
Real Exch. Rate	1.000	1.017	1.004	0.904	0.965	1.014	0.948
GDP Deflator	1.000	1.123	1.188	1.278	1.062	1.199	1.343
Terms of Trade	1.000	0.967	0.967	0.954	0.963	0.980	0.944

Notes: 1. Values from BERNZ, Infometrics and NZIER.

2. 1982/83 - 1984/85 values are residuals.

3. MAS estimate is $31933m.

Sectoral net output changes between 1982 and 1985 are given in table 7 and illustrated in figure 2. The largest discrepancies between model and actual are in FFM (Forestry, Fishing Mining) where the model value is too low, and in CON & TRA where the model values are too high.

The former is probably due to the failure of the model to pick up the rapid expansion of output of natural gas as part of the major projects programme, although the official estimate always rises when oil exploration activity falls since intermediate expenditure falls without a corresponding fall in gross output. (In runs with the snapshot version of the model numerous coefficients were exogenously adjusted so as to incorporate the effects of the major gas based projects such as the synthetic petrol plant and the CNG/LPG conversion programme. The same sort of changes will also be incorporated in the dynamic model for runs beyond 1985.)

Figure 1
1982–85 Macro Variables

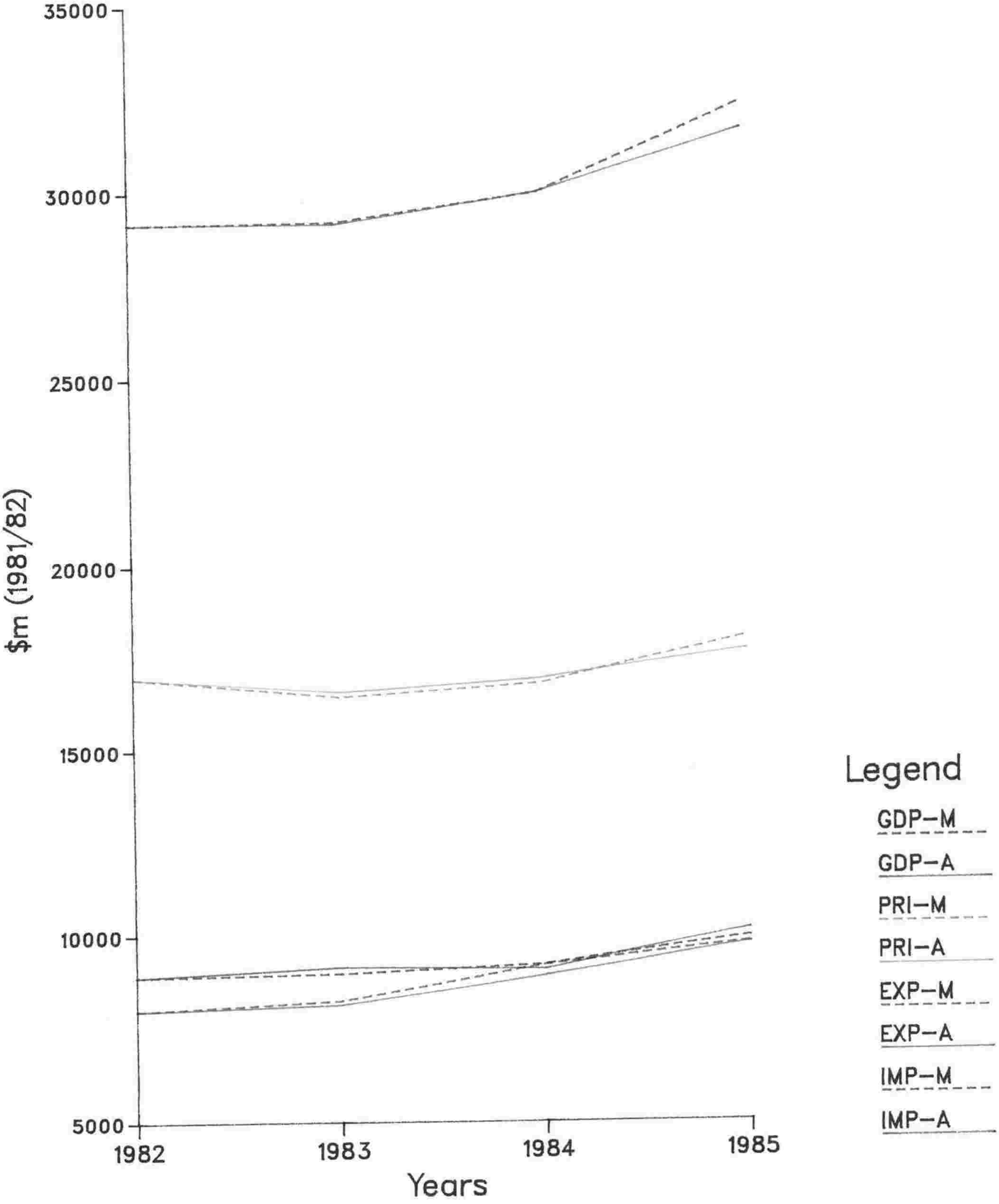
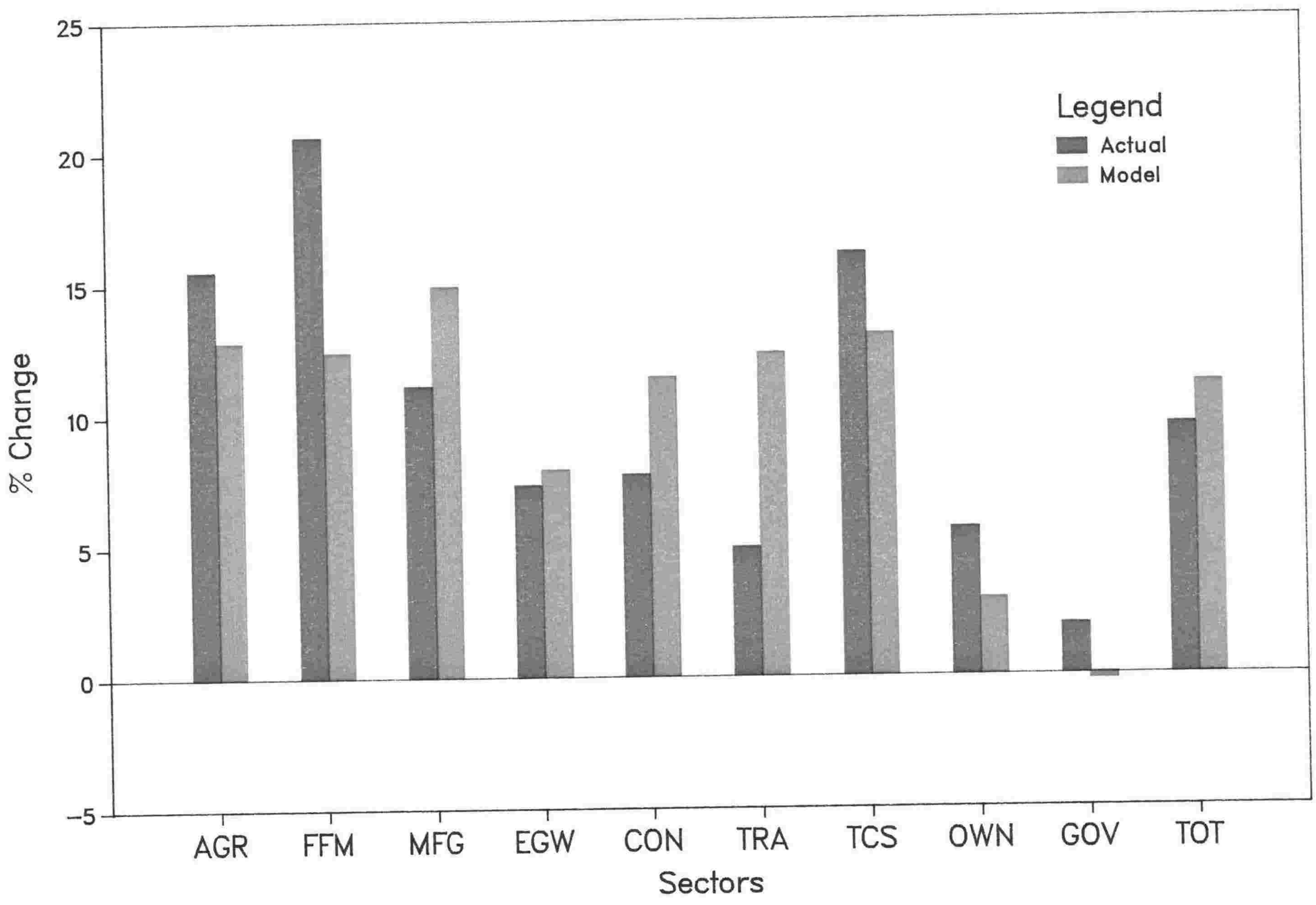


Figure 2
1982–85 Real Net Output Changes



On examination of the time profile (not shown here) of the changes in Construction output it is evident that the reason for the model's overstatement occurs in 1983 when actual output fell by 1% and model output rose by 3%. Whilst the model is undoubtedly at fault to some degree, the official measurement of net and gross output in the Construction sector is subject to wider error than in other sectors as it varies with the degree of subcontracting - a practice which is pervasive in that sector. (See Dept. of Statistics [22, p41].) Thus actual changes in real output can easily be overstated or understated.

Of the 7% points overstatement in Trade sector output, two-thirds occurs in 1984/85. But without more official data relating to that year it is difficult to ascertain why. Note, however, that the total change in Trade sector output at 12.3% is close to the total change in manufacturing output at 14.9% whereas the actual figures are 4.9% and 11.1% respectively. Given that the output of this sector is mostly margins on goods, one would expect its output growth to be reasonably close to the growth of manufacturing output, unless of course retail and wholesale markups have changed, something which the model cannot capture. One can only speculate that this may have happened in 1984/85.

Table 6: 1982-85 Export Growth

($m 1981/82)

		1981/82	1984/85	% change	
				model	actual[1]
Dairy	DAIR	1068.0	1180.8	10.6	11.6
Meat	MEAT	1547.8	1568.3	1.32	1.10
Wool	WOOL	908.0	1057.0	16.4	14.8
Fishing	FISH	204.9	248.3	11.9	30.2
Horticulture	HORT	211.9	322.3	52.1	66.0
Other Food etc.	OFBT	336.4	560.2	66.5	60.4
Textiles	TEXT	385.9	471.3	22.1	15.0
Wood Products	WOOD	177.2	204.4	15.3	2.80
Paper "	PAPR	365.3	354.8	-2.87	-6.30
Chemicals	CHEM	274.4	479.4	74.7	72.6
Energy	ENGY	94.1	111.5	18.5	25.5
Minerals	MINE	41.4	45.5	9.90	36.6
Ceramics	CERA	40.0	51.1	27.8	25.0
Base Metals	BASE	380.8	650.4	70.8	86.1
Machinery & Equip.	MAEQ	259.4	261.1	0.66	10.8
Other Mfg Goods	OMFG	124.7	142.6	14.4	32.8
Services	SERV	1571.0	2064.1	31.4	25.5
Total		7991.4	9772.8	22.2	22.1

[1] Source: New Zealand Planning Council, National Sectoral Programme working papers - publication forthcoming.

Table 7: Sectoral Net Output

($m 1981/82)

	1981/82	1984/85	% change	
			model	actual[1]
AGR	2425.8	2736.4	12.8	15.5
FIS	90.0	100.2	11.3	
FOR	316.5	351.2	11.0	
MIN	248.4	284.6	14.6	
FFM	654.8	736.0	12.4	20.6
FBT	1499.5	1632.9	8.9	
TEX	787.9	897.0	11.4	
WOD	507.3	593.7	17.0	
PAP	801.6	886.8	10.6	
CHE	636.7	743.9	16.8	
NOM	312.3	356.8	14.2	
BAS	216.7	289.4	33.5	
FAB	1870.8	2221.2	18.7	
OTH	85.4	95.9	12.3	
MFG	6718.2	7717.6	14.9	11.1
EGW	857.9	925.9	7.9	7.3
CON	1460.7	1627.8	11.4	7.7
TRA	6107.1	6860.9	12.3	4.9
TRN	1422.5	1697.1	19.3	
COM	732.1	814.0	11.2	
FIN	2841.6	3181.4	12.0	
PRI	1272.3	1392.4	9.4	
TCS	6268.5	7084.9	13.0	16.1
OWN	650.9	670.0	2.9	5.6
GOV	3734.9	3726.4	-0.2	1.9
Total	28878.8	32085.8	11.1	9.5

[1] Source: Monthly Abstract of Statistics

Conclusion

As was the case with the snapshot model, the sectoral results do not accord with actual values as closely as do the macro results. But this should not be surprising given the relative dearth of sectoral input information. Once again then, one can have some confidence in the general structure of the model and in the parameter values taken as a whole, whilst admitting that some sector specific parameters may well be in need of refinement.

Complicating any judgement, however, is the problem of events which are completely external to the model. Government monetary policy or general elections for example, cannot be directly tracked by the model. Their effects are fortunately captured to varying degrees by such variables as the technological change parameters, but this has an unfortunate side-effect in that it camouflages and consequently extenuates the (apparent) significance of such events. Nor can the model be expected to track temporary phenomena such as changes in the distribution of factor income as induced by the price freeze or the devaluation, or negative changes in the value added of Mining whenever oil and gas exploration increases without any associated new output.

These events render a proper test of the model extremely difficult, especially on a year by year basis. Thus the caveat given at the end of section 9.2 regarding the tracking ability of JULIANNE is vindicated; namely: Model results must be interpreted as indicating the pattern and level of activity <u>around</u> each given year. Exact annual tracking with a CGE model is too ambitious.

The fact that there are differences between the model's economy and the true economy justifies the existence of a control run. If the model could replicate everything a control run would not be necessary. Few, if any models, especially CGE models, are that powerful. Consequently if one wishes to ask 'what if' type questions one must begin with a control run so as to prevent any distortionary effects that a model's abstractions and conclusions might have on the issue under consideration. For example, if an alternative counter-factual run with protection removed were to show GDP in 1985 to be $32500m, a comparison with the actual 1985 GDP of $31647m instead of the control run value of $32344m, would grossly overstate the change.

10.2 Control Projection to 1990

Introduction

As with the snapshot version of JULIANNE, the dynamic model requires a control run before it can be used in a contemporaneous comparative analysis framework. The simulation run obtained in the previous section can be this control run for alternative counter-factual scenarios of 1982-85, but space and resource limitations (and personal preference) have prompted one to opt instead for a similar analysis pertaining to the 1985-90 period.[1] In particular one is interested in how the snapshot model results from Chapter 8 are affected by the length of the time horizon. For this purpose one needs a 1986-90 control run projection, for which the 1982-85 simulation from the previous section can act as a foundation.

The methodology is very similar to that used for the snapshot 1990 projection as described in section 7.3, with most of the data again coming from the (now revised) database of the NZPC National Sectoral Programme (NSP) - as shown in tables 8 and 9. Further constraints comprise:

1. All export subsidies are removed for all five years - the NSP policy assumption.

2. All tariff equivalents on non-competitive imports are removed in 1985/86 and those on competitive imports are reduced to a maximum of 25% by 1989/90 in five equal steps from their 1984/85 levels - the NSP policy assumption. (In terms of the Chapter 8 nomenclature this is a combination of N and T type runs.)[2]

---

[1] Counter-factual simulations with an older 1976/77 based version of JULIANNE dynamic are reported in Stroombergen and Philpott [90] and [91].

[2] Recall that N denotes a uniform 25% tariff on competitive imports with all non-competitive imports exempt, whilst T denotes a lowering of all protection currently above 25% tariff equivalent to 25%.

Table 8

(i) Exogenous Variables

	1985/86	1986/87	1987/88	1988/89	1989/90	Sources & Comments
1. Investment - GDE ratio (%)	21.0	20.0	20.0	20.0	20.0	2 yr adj from 1985 to NSP values
2. Real housing investment ($m)	1248.9	1251.8	1254.6	1257.4	1260.3	interp. from 1985 to NSP 1990 "
3. Real govt. social inv. ($m)	722.5	729.7	737.0	744.3	751.8	1% pa from 1985 - NSP
4. Real govt. consumption ($m)	5378.1	5585.6	5595.3	5707.2	5821.4	2% " " " "
5. Trade balance ($m)	126.0	341.0	369.0	217.0	28.0	NSP
6. Stocks/(Stocks + PriCon)	0.90	0.91	0.92	0.92	0.92	3 yr adj from 1985 to NSP values
7. Total employment ('000)	1360.4	1389.7	1421.4	1453.1	1483.2	NSP
8. Mean Solow-Denison resid. (%pa)	0	0	-- endogenous --			'86 & '87 based on BERL [11]
9. Allen substitution elasticity	3.0	3.0	3.0	3.0	3.0	cf. '83 - '85 values of 1.0

(ii) Projected NSP Export Growth Rates 1985 - 1990 (% pa)

DAIR	0.87	OFBT	15.0	CHEM	12.0	BASE	3.80
MEAT	0.20	TEXT	13.6	ENGY	2.00	MAEQ	22.1
WOOL	-3.05	WOOD	4.00	MINE	12.4	OMFG	14.1
FISH	10.0	PAPR	6.29	CERA	12.1	SERV	6.45
HORT	20.5						

Table 9: Solow-Denison Residuals

(% pa 1985-90)

AGR	Agriculture	1.50	FAB	Fabricated Metals	3.40
FIS	Fishing & Hunting	1.00	OTH	Other Mfg.	2.30
FOR	Forestry & Logging	1.70	EGW	Elect., Gas, Water	1.00
MIN	Mining & Quarrying	4.00	CON	Construction	0.20
FBT	Food, Bevs., Tobacco	0.40	TRA	Trade & Accom.	0.50
TEX	Textiles & Leather	3.90	TRN	Transport	2.00
WOD	Wood & Wood Products	0.10	COM	Communications	4.00
PAP	Paper & Products	2.30	FIN	Finance etc.	0.00
CHE	Chemical Products	2.70	OWN	Own. Dwellings	0.00
NOM	Non-Metallic Prods.	1.90	PRI	Private Services	0.00
BAS	Base Metal Products	2.80	GOV	Govt. Services	0.00

3. All the import substitution of the major projects (as documented in section 7.3) is assumed to come into effect in 1987/88, at full 1989/90 potential.

4. World import and (competing) world agricultural export prices are held at their 1984/85 levels, whilst the 1984/85 world prices for exports of manufactures and services are reduced uniformly by a factor of 1.5%. This adjustment ensures consistency with the NSP where the mean world import price and the mean world export price for manufactures and services are assumed to maintain their 1981/82 relativity. That is, the 1984/85 mix of trade prices (as recorded in table 3 in the previous section) is such that the terms of trade excluding agricultural exports rose by 1.5% between 1981/82 and 1984/85, an increase which needs to be offset to restore the desired trade price relativity.

Of course there is nothing sacrosanct about the NSP assumptions but if one is appealing to them in areas where it is convenient one should be consistent and utilise them also in other areas, even though doing so may be somewhat specious.

Since the model is homogeneous of degree zero in all quantities and relative prices there is no point in endeavouring to predict, or in inserting, a world inflation rate. It was useful for the 1982-85 simulation so that one could compare the model's price indices with actual indices.

5. The procedure for modelling exports is identical to that used for the NSP model runs, namely: Export growth for Dairy, Meat and Wool is set exogenously according to data provided by the NSP sectoral survey. For non-agricultural exports which includes major project exports, the survey data is interpreted as representing shifts of the demand curves so that exporters are free to move along the demand curves, although exports of Minerals and Wood cannot rise above the survey figures. The survey data is given in the lower part of table 8.

Results

As the aim of this section is to secure a control run for contemporaneous comparisons, not too much space and discussion will be allocated to an intertemporal comparison between 1985 and the years to 1990. Per annum macro results are given in table 10 and sectoral real gross output growth rates over the whole five years are shown in table 11, together with a breakdown of real import growth by (sectoral) type into final consumption and intermediate consumption.

Gross Domestic Product Growth averages 3.25% per annum over the quinquennium to 1990 compared with 3.52% per annum from 1982 to 1985. The relatively slow growth in the first two years is due largely to the assumption of zero growth in efficiency for those years, although presumably the easing of the required rate of increase in the trade surplus (from the NSP database as given in table 8) in 1987/88, also provides a small boost to growth.

The level of imports in that year is virtually unchanged from 1986/87 due to the coming on stream of the major projects which save about $650m (from table 8c in section 7.3). Domestic prices rise due to the expansionary effect of the major projects, exports decline and the terms of trade improve. Without this improvement the reduction in the real balance of trade surplus between 1986/87 and 1987/88 would not have occurred and thus the volume of exports could not have declined.

Table 10: Macro Results
($m 1981/82)

	84/85	85/86	86/87	87/88	88/89	89/90
Private Cons.	18028	18235	19187	20460	21523	22675
Exports	9772	11003	11329	10873	11192	11528
Imports	9923	10299	10588	10560	11163	11833
Gross Domestic Prod.	32342	33274	34103	35201	36533	37958
% Δ on previous year		2.88	2.49	3.22	3.78	3.90
Real Exch. Rate	0.948	0.910	0.925	0.969	0.991	1.015
Terms of Trade	0.944	0.944	0.956	0.995	1.011	1.028
Import-GDP ratio (%)	30.7	31.0	31.0	30.0	30.6	31.2

Obviously this 4% drop in exports in 1987/88 is unrealistic. Presumably the actual effect of the major project's import substitution would be an improvement in the balance of trade, which could certainly be incorporated into the model if one was willing to depart from the NSP constraint set. For a control run such as this it does not really matter, but clearly the major project phase-in would need to be modelled more carefully if one wanted to obtain a 'most likely' projection to 1990.[3]

This export anomaly reminds one (again) that a dynamic CGE model is not capable of, and is not designed for, annual projection work.

Looking now at the sectoral data in table 11, it is interesting to see that with the exception of Mining, Textiles and Fabricated Metals, the fastest growing sectors are the service sectors. Income elasticities are one reason for this but the main reason is price elasticities. The demand for local manufactures falls relative to the demand for imported manufactures which incur (often substantial) reductions in protection. It can be seen from table 11 that imports of each type expand faster than the corresponding domestic sector in nearly all cases. Furthermore, imports into final demand (mostly private consumption) expand on average

[3] In fact, if the 5-year balance of trade profile is altered to ($m) -500, 0, 1000, 500, 100 (which leaves the total over the 5 years unchanged), the export profile is more realistic.

Table 11: Sectoral Results

($m 1981/82)

	Gross Output		% pa change	% pa change in imports[1]		
	1984/85	1989/90		final demand	interm demand	total
AGR	5898.2	6738.7	2.70	3.71	3.06	3.41
FIS	242.1	275.0	2.58	6.17	2.61	4.51
FOR	615.1	668.4	1.68	--	1.97	1.97
MIN	651.3	1196.5	12.9[2]	32.3	8.40	9.16
FBT	6840.0	7495.0	1.85	8.15	2.47	5.86
TEX	2983.2	3500.9	3.25	10.4	3.62	5.91
WOD	1575.1	1787.8	2.57	7.92	3.39	3.55
PAP	2272.3	2424.2	1.30	6.07	2.85	4.08
CHE	3662.4	3913.2	1.33	10.2	-2.02[2]	-0.32
NOM	748.9	825.7	1.97	10.3	2.47	4.13
BAS	1151.5	1294.0	2.36	3.16	0.27	0.28
FAB	5703.7	6878.8	3.82	5.00	4.42	4.76
OTH	221.7	237.8	1.41	13.9	3.26	11.6
EGW	1776.6	2027.0	2.67	26.9	2.42	20.5
CON	5656.1	6058.8	1.39	--	1.89	1.89
TRA	11252.6	13488.9	3.69	8.03	3.65	3.86
TRN	3819.5	4522.1	3.43	8.19	3.52	6.67
COM	941.5	1126.5	3.65	5.17	3.48	3.57
FIN	4854.6	5769.8	3.51	9.93	4.54	4.63
OWN	1589.6	1819.9	2.74	--	--	--
PRI	2841.3	3575.5	4.70	8.11	4.04	5.81
GOV	5505.6	6126.6	2.16	--	--	--
Total	70803	81751	2.92	6.94	1.60	3.67

1. Imports are here measured in constant purchasers' prices
2. The effects of the refinery expansion and the synthetic petrol plant.

over four times faster than intermediate imports. This is not really surprising given that consumer imports are generally more competitive than imports into intermediate use which include a substantial amount of raw materials that were not highly protected in the first place. Thus the complete removal of duty and licences does not have much affect here. Conversely there are numerous non-competitive consumer imports which did incur high protection (such as some toys, cameras, sound and visual equipment, babywear etc.), so that when this is dismantled there is a further boost to the growth of consumer imports that already occurs with the lowered protection on competitive imports. (Note that the expansion of competitive imports displaces domestic production whilst the expansion of non-competitive imports does not - at least not directly.)

The only instances where the growth of imports is significantly less than the growth of the corresponding domestic product, namely in Mining, Chemicals and Base Metals, are all attributable to the import displacement of the major projects.

There are naturally many more results that could be discussed such as shifts in sectoral factoral intensity over the quinquennium, changes in relative profitability and so forth. But intertemporal comparisons between <u>an actual</u> past year[4] and some series of future years, are not the object of this thesis and, as should by now be well understood, they are not where the strength of CGE models lies. Moreover, the run reported here cannot be considered as a most favoured projection of the years to 1990, but it is realistic enough to serve most adequately as a control run for the contemporaneous comparative analysis, to which we now turn.

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[4] That is, as opposed to a model <u>simulation</u> of some past year, not including the base year where the distinction is irrelevant.

10.3 Alternative Protection Regimes

Introduction

This section is really an extension of Chapter 8, but on a much smaller scale since the repetition of all of the Chapter 8 runs is superfluous, given that the basic theoretical structure of the dynamic version of JULIANNE is much the same as that of the snapshot model. The main point of interest here is whether the gains (or losses) from trade vary over time and if so, how. The time period under consideration is the five years 1985/86 to 1989/90, compared to the thirteen year snapshot horizon of 1976/77 to 1989/90 used in Chapter 8. Also the mean cost excess in 1977 was 17.5% whereas in 1985 it had fallen to 15%.

Since the underlying set of cost excesses used in the model has not been altered, this reduction is due to weighting changes. More subtly, however, the aggregation from 40 to 22 sectors reduces the unevenness of the cost excesses, something which the analysis in Chapter 8 revealed could be more important than the mean level of cost excess. These differences (the shorter time horizon, the lower mean cost excess, and the lower spread of cost excesses) can all be expected to lower the percentage differences between the alternative runs investigated here, compared to the corresponding snapshot runs in Chapter 8. Nevertheless, these considerations do not compromise the complementarity between the conclusions of Chapter 8 and those that may be drawn here from a comparison which is purely between alternative dynamic model runs. That is, contemporaneous comparative analysis which normally applies to a single (snapshot) year is now quite consistently applied to a series of years.

Analysis

Retaining the nomenclature system from Chapter 8, two variations around the control run (run 10NT) are considered: zero protection or free trade - run 10Z, and 'existing' 1982-85 protection - run 10E. Both regimes apply from 1986 onwards. Factor employment, the investment-GDP ratio, consumption and investment by government, housing investment and the nominal balance of trade, are fixed across runs.

Table 12 gives a comparison of the macro results for each of the five years, expressed as the percentage differences that occur in moving from run 10E to 10Z and from 10NT to 10Z. Given also are the corresponding numbers from Chapter 8.

It is quite apparent that the gains from trade as measured by either PriCon, GDP or Effective GDP, increase over time and that if it were not for the dips in 1987/88 the increases would be monotonic. The same pattern of change is also evident in exports and imports. It will be recalled from the previous section that 1988 is the year in which the import substitution of the major projects comes into effect. Now these projects are more capital intensive than the economy as a whole, both directly and indirectly. In run 10NT in 1988; the share of capital in value added is 6.7% higher than in an identical run (not reported here) without the major projects, the economy-wide capital-GDP ratio is 0.5% higher, and the capital-gross output ratio is 1.5% higher. The analysis in Chapter 8 showed that exporting sectors are capital intensive compared to import substitution sectors. Thus a move to more trade as induced by the dismantling of protection is hindered by the presence of the major projects which compete for the same resource - capital.

However, since sectoral capital stocks are fixed from the previous year's investment, sectors must compete for variable inputs, namely labour and to a lesser extent, intermediate inputs. As the major projects are exogenously forced in; that is, output from the relevant sectors must be forthcoming, those sectors take precedence in the demand for resources. Accordingly, the export expansion which is evident in 1985/86 and 1986/87 is curtailed. This naturally constrains import growth thereby reducing the gains in efficiency associated with free trade, as manifested by the smaller gains (or greater losses) in PriCon, GDP and Effective GDP. From 1988/89 onwards there are no additional major projects so the reallocation of resources into exporting can proceed as before, with the gains from trade increasing over time.[5]

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[5] Note that if the additional major project investment before 1987/88 had been explicitly modelled, the competition for resources in 1987/88 would not have been so sudden.

Table 12: Macro Results

(% differences)

	10E - 10Z					8C-8Z	
	'86	'87	'88	'89	'90		
PriCon	-0.76	-0.67	-1.60	-0.15	0.15	0.70	
Exports	8.10	8.41	7.90	9.23	9.59	12.6	
Imports	5.59	5.91	5.41	6.35	6.76	9.64	
GDP	0.47	0.52	-0.27	0.82	0.99	1.35	
Eff. GDP	-1.86	-0.39	-1.03	0.00	0.25	0.50	
T/T	-0.023	-0.024	-0.025	-0.028	-0.027	-0.028	
Real e	-0.050	-0.052	-0.044	-0.058	-0.058	-0.060	
	10NT - 10Z					8N-8Z	8T-8Z
PriCon	-0.31	-0.26	-1.37	-0.01	0.13	0.00	0.30
Exports	3.95	4.07	3.26	4.21	4.22	7.18	8.75
Imports	2.68	2.82	2.17	2.88	2.98	5.49	6.71
GDP	0.25	0.28	-0.60	0.40	0.47	0.54	0.87
Eff. GDP	-0.23	-0.20	-0.96	0.00	0.11	0.02	0.25
T/T	-0.012	-0.012	-0.011	-0.013	-0.012	-0.017	-0.020
Real e	-0.022	-0.023	-0.012	-0.024	-0.023	-0.028	-0.042

Notes

(1) The directions of change are measured from 10E to 10Z, 8C to 8Z etc.

(2) T/T is the Terms of Trade.

(3) Real e is the Real Exchange Rate.

- both of these are absolute changes in the ratios, not percentage changes.

Comparing the dynamic model results with those of the snapshot model as given in the last columns of table 12, reveals that the five year period is not sufficient for the gains from trade to match those recorded with JULIANNE snapshot over a thirteen year period. The time difference together with the other two differences noted above, are undoubtedly the reason for the apparent divergence in results between the two model versions.

If one extrapolates the export changes over another eight years the resultant change is 12.6%[6] - exactly the figure obtained with the snapshot model between runs 8C and 8Z (!). Extrapolating the import changes yields 9.13%, also very close to the snapshot model result. But extraploating the changes in any of the welfare indicators; PriCon, GDP or Effective GDP, yields numbers which are far too high. There is little doubt, however, that the relationships involved are eventually asymptotic and that the welfare gains probably approach their respective asymptotes rather quicker than the trade changes approach theirs. That is, the trade share of GDP may continue to increase for some time but the resultant increments to welfare will be progressively smaller, as indeed one would expect from the law of diminishing returns. Also, if the production possibility frontier is close to linear, as seems to be the case from the analysis in Chapter 8, quite large changes in the trade ratios will yield only small changes in welfare.

De Melo and Dervis [18] investigate the dynamic versus static effects of trade liberalization using a simple 3-sector sequential equilibrium model (as reviewed in Chapter 2) which is theoretically similar to JULIANNE. Their model is run over 40 years which enables them to carry out a discounted evaluation of the gains and losses from trade. Unfortunately the five year period used here is not long enough for such an appraisal; the protected path is superior on a cumulative discounted basis even with a discount rate of zero. Presumably at thirteen years out the free trade path would dominate at some plausible discount rate. But whether over an even longer period of time the gains would keep on increasing toward some asymptote, or whether they might reach some (local) maximum and then decline again and perhaps even become negative (as in some of de Melo and Dervis's experiments), cannot be known with certainty. However, the former outcome seems more plausible.

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[6] That is: $(1.0959/1.0810)^{12/4} \times 1.0810 = 1.0126$

Table 13 gives the changes in sectoral gross outputs in 1990 from runs 10E to 10Z and from 10NT to 10Z. Given also are the directions of change from runs 8N to 8Z, taken from table 2 of Chapter 8. The two single asterisked sectors are where the direction of change between runs 8N and 8Z is opposite to that between 10NT and 10Z, but where the 8N - 8Z change is itself composed of changes of opposite sign. For example, in the 40-sector version of JULIANNE the Paper sector is split into two sectors, one of which expands and one of which declines. Likewise with the Trade sector. The three double asterisked sectors are where the direction of change is again opposite but where the sector definitions are identical between the two model versions.

Table 13: Sectoral Changes

	10E-10Z	10NT-10Z	8N-8Z		10E-10Z	10NT-10Z	8N-8Z
AGR	0.51	0.24	+	FAB	1.07	0.77	+
FIS	0.49	0.19	- **	OTH	-5.22	-0.50	-
FOR	1.57	0.05	- **	EGW	-0.82	-0.42	-
MIN	0.17	0.05	+	CON	-0.37	-0.25	-
FBT	-0.09	0.03	+	TRA	0.48	0.33	- *
TEX	0.58	-0.03	-	TRN	3.01	1.30	+
WOD	0.55	0.32	- **	COM	-1.23	-0.64	-
PAP	2.50	0.93	- *	FIN	-0.16	-0.02	-
CHE	0.16	0.18	+	OWN	-0.06	-0.07	-
NOM	-2.75	-1.96	-	PRI	0.36	-0.01	-
BAS	7.05	2.74	+	GOV	-0.10	-0.03	-
				Total	0.50	0.24	+

Not much need be said about Paper and Trade since it was ascertained in Chapter 8 (with respect to the total Chemicals sector) that the output change of the aggregated sector could easily be composed of markedly different and opposing changes in the output of its constituent (sub) sectors. This is not surprising but it means that where the subsectoral weights are not explicit (and probably different between 1976/77 and 1981/82) the observed output change in the aggregate sector could quite conceivably be in either direction.

As stated before the degree of spread in the cost differences is generally directly related to the size of the model and the relative compression of cost differences in the 22-sector dynamic model has already been cited as one of the reasons for smaller gains from trade being observed here. However, even if the spread of cost differences was not affected by aggregation, one would still expect the more aggregated model to yield smaller gains since the opportunities for specialization in products with the greatest comparative advantage are lost. That is, the greater the aggregation, the smaller the chance that the mean production function of each sector will remain constant when protection changes. (Again see the analysis of the Chemicals sectors in Chapter 8 - in the section labelled '8Z-8N Sectoral Detail' and the section on runs 8Z9 and 8N9.)

The results for the double asterisked sectors require some explanation.

Fishing: In the 1977 based snapshot model the share of the market held by imports in run 8N is about 9% but in run 10NT which is based on 1982, the share is less than 1%. Consequently the removal of protection has no significant negative effect on local market share and accordingly the gain in exports is sufficient to realise a gain in total output.

Wood: The mean tariff equivalent on Wood products fell from 35% to 30% between 1977 and 1982 due to an increase in the proportion of intermediate Wood product imports which are more competitive than consumer Wood products. Also, in run 10NT the mean tariff equivalent is 17% compared with 25% in run 8N. Thus the removal of protection in run 10Z does not lead to as large a decline in market share as between runs 8N and 8Z (1% compared to 3%) and so total output does not fall.

Forestry: What happens in the Forestry sector is determined primarily by what happens in the Wood and Paper sectors. Hence Forestry output expands just as it contracted between runs 8N and 8Z.

In summary then, the directions of sectoral change between run 10NT and 10Z (or 10E and 10Z) are consistent with those between runs 8N and 8Z. Quantitatively one can see from a quick glance down table 2 of Chapter 8 that the sectoral output changes are generally much larger than those observed here, but this should not be unexpected given that the macro changes are similarly related, the reasons for which have been expounded above. It is perhaps symbolic though, of the aggregation issue, that the total gross output change between runs 8N and 8Z is 0.09% whilst between 10NT and 10Z it is 0.24%. As the degree of disaggregation increases the significance (in terms of welfare gains) of the change in total output pales beside that of the diverse changes in its sectoral components.

Table 14 shows the changes in output and capital-labour ratios between runs 10E and 10Z, for each of the years 1985/86 to 1989/90. Of the 22 sectors there is an even split between those that show a larger increase (or smaller decrease) in output between 1985/86 and 1989/90, and those that show a larger decrease (or smaller increase). In aggregate, output expands over the five years with a temporary hiccup in 1987/88, a pattern of change which not surprisingly mirrors that in GDP and which occurs in virtually all sectors irrespective of whether they expand or contract. Note that the Fishing and Paper sectors show a declining trend over the five yaers, a result which is more consistent with the run 8N-8Z changes than the 1989/90 figures alone would suggest - see table 13. Whether the increments would ultimately become negative, however, cannot really be inferred from the given data.

The changes in the capital-labour ratios show a similar pattern to output changes although with less regularity. In 1985/86 the direction of change in the capital-labour ratios is in all sectors opposite to the direction of output change. With sectoral capital stocks fixed from the previous year the group of expanding (export) sectors can only do so by utilising more labour. Thus at the margin they reduce their capital-labour ratios, even though (as ascertained in Chapter 8) they are relatively capital intensive on average.

By 1989/90 five further sectors (TEX, WOD, FAB, TRA, PRI) show a gain in output and three (EGW, FIN, GOV) show a smaller reduction. Of those eight sectors, six become more capital intensive. Of the other two sectors, one is GOV for which the issue of relative factor intensity is irrelevant, leaving EGW where there is a clear move away from capital. All of the other expanding sectors (AGR, FIS, FOR, MIN, PAP, CHE, BAS, TRN) except FOR also show a continuing shift out of capital. Augmenting these results with those for the contracting sectors, provides the following picture in 1989/90, excluding OWN and GOV.

	capital intensity:		
	increasing	decreasing	
expanding set	6	7	13
contracting set	4	3	7
	10	10	20

Thus overall there is a slight dominance of decreasing capital intensity in the expanding sectors and a slight dominance of increasing capital intensity in the contracting sectors. In Chapter 8 the snapshot model results showed that under free trade all sectors became more capital intensive at the margin.[7] With the removal of fixed sectoral rental rate relativities in the dynamic model there is now no reason why all sectors should move in the same direction as regards relative factor intensity since the change in the factor price ratio is not the same for all sectors.

Over longer periods it is quite conceivable that a sector could reverse its relative factor intensity. Agriculture for example exhibits a definite trend to factor intensity reversal over the five years studied here. It is possible that the capability to model such changes could alter the measured gains from trade although the other snapshot model - dynamic model differences noted earlier such as the degree of sectoral disaggregation, appear to be more important. This accords with the Chapter 8 results which showed that a different mix of sectoral wage rate relativities did not significantly alter the results, although admittedly this is not quite the same thing as relativities changing <u>between</u> protection regimes.

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[7] Results in that chapter were actually expressed the other way around - all sectors became more capital intensive when protection was applied.

Table 14: Time Profile of Changes in Output and Factor Intensity

	Changes in Output (%)					Changes in Capital-Labour Ratio (%)				
	85/86	86/87	87/88	88/89	89/90	85/86	86/87	87/88	88/89	89/90
AGR	0.30	0.30	0.13	0.27	0.51	-0.52	-0.50	-0.97	-1.63	-2.56
FIS	0.85	0.83	0.30	0.64	0.49	-1.67	-1.71	-3.30	-5.27	-6.21
FOR	0.88	1.05	0.87	1.47	1.57	-2.05	-2.42	1.66	2.63	5.16
MIN	0.42	0.45	-0.35	0.23	0.17	-1.82	-1.86	-2.00	-2.29	-2.85
FBT	0.06	0.03	-0.28	-0.22	-0.09	-0.11	-0.09	-0.91	-2.06	-3.22
TEX	-1.19	-1.15	-1.00	-0.01	0.58	1.90	1.82	3.34	3.98	5.08
WOD	-0.96	0.16	-0.78	0.40	0.55	1.53	-0.33	-0.61	1.52	2.45
PAP	3.09	3.12	1.71	2.67	2.50	-5.06	-5.14	-4.29	-5.03	-4.89
CHE	1.01	1.17	-0.58	0.12	0.16	-1.60	-1.93	-1.40	-4.17	-5.58
NOM	-2.00	-2.08	-1.43	-2.61	-2.75	4.61	4.58	6.77	3.94	3.23
BAS	8.49	9.09	6.84	7.43	7.05	-12.2	-13.0	-11.5	-12.7	-12.8
FAB	-0.77	-0.33	-0.80	0.56	1.07	1.17	0.44	1.63	0.97	1.05
OTH	-5.20	-5.53	-6.14	-5.29	-5.22	10.1	10.9	12.0	11.4	11.6
EGW	-1.09	-1.02	-1.60	-0.79	-0.82	3.48	3.24	1.07	0.18	-0.83
CON	-0.04	-0.45	-1.22	-0.41	-0.37	0.03	0.58	2.10	3.22	4.41
TRA	-0.37	-0.45	-1.01	0.19	0.48	0.68	0.79	3.91	4.88	6.77
TRN	2.74	2.83	1.78	3.29	3.01	-3.79	-3.92	-4.78	-7.51	-8.47
COM	-1.21	-1.38	-2.01	-1.22	-1.23	1.68	1.93	1.86	0.48	-0.10
FIN	-0.57	-0.57	-1.99	-0.28	-0.16	1.27	1.14	-2.38	1.67	1.94
OWN	-0.06	0.70	-6.73	-0.10	-0.06	--	--	--	--	--
PRI	-0.27	-0.28	-0.53	0.16	0.36	0.39	0.40	1.84	1.97	2.71
GOV	-0.12	-0.12	-0.19	-0.10	-0.10	--	--	--	--	--
Total	0.16	0.21	-0.67	0.35	0.50	0.01	-0.03	-0.03	-0.07	-0.09

10.4 Summary

This chapter describes three progressive applications of the dynamic extension of the JUlIANNE model. The first application is a simulation of the period 1982-85 which serves two purposes; the broad validation of the model's parameter values and equation structure, and the procurement of a run that can be used either as a control for counter-factual scenarios of the 1982-85 period, or as the foundation for a realistic control run extension to 1990 which is then used for investigating alternative scenarios of the 1986-90 period. The latter option was pursued here and hence the other two model applications in this chapter deal with the projection to 1990 and the alternative 1990 scenarios.

The simulation is considered satisfactory since the macro results conform well with estimates of actual macroeconomic activity, and the sectoral results, whilst not as accurate, are quite good considering the lack of some important sector specific model input data and the occurrence of events that are completely outside the framework of the model. Partly because of this latter point and partly because one prefers to look forward rather than backward, the option of exploring alternative 'what could have been' scenarios was discarded. One cannot be sure whether model-external events that are now history, such as price freezes, would have been the same or had the same effects across alternative counter-factual scenarios. Invoking the 'ceteris paribus' or 'accommodating policy' assumption is also less comfortable than when one is dealing with alternative future scenarios where any such model-external events are still completely unknown. Finally, by looking forward one avoids to some extent the obvious criticism of backward looking studies, namely that the specifics of the problem have changed between the most recent year for which the required data was recorded (generally the year of the latest input-output table) and the current year.

As with the snapshot model the forward looking control run is based on National Sectoral Programme data wherever practical, which reduces the possibility of one subjectively influencing the outcome and contributes to the perceived realism of the alternative future scenarios. Again one stresses that the control run is not intended to be a best guess of the period to 1990.

The three runs to 1990 differ according to their protection regime: unchanged (1982-85) protection (E), 25% tall poppy tariff equivalent with no protection at all on non-competitive imports (NT), and complete free trade (Z). The results are consistent with those from the snapshot model as reported in Chapter 8 which, for fixed factor employment and flexible factor prices, showed that free trade is definitely superior to the existing protection profile and probably also to an NT situation, depending on the magnitude of various trade elasticities and other parameters. The additional insight gained from the dynamic version of the model is that the benefits of freer trade improve over time after starting negatively, although supposedly not indefinitely.

The time horizon here is really too short to derive the long run shape of the 'benefit curve'. Running the model over a longer period is certainly possible but as can be seen from section 10.2, the data requirements are formidable. Thus a smaller model may be appropriate but one is then compromising one of the major fortes of CGE models, notably their multisectoral approach. And it was ascertained in Chapter 8 with further proof coming from this chapter that the degree of sectoral disaggregation can be quite instrumental in the model's measurements of the gains from trade. Hence: a quandary for research at a later date.

11

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 11

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

11.1 Summary

The work presented here has covered the development and application of the JULIANNE computable general equilibrium model of the New Zealand Economy, a model which accents issues of trade and structure.

One of the first steps in the construction of JULIANNE was a thorough study of the literature on CGE models, leading in Chapter 2 to a review of a cross section of models selected for their capacity to portray (whether by omission or inclusion) the requisite features of a CGE model, especially one intended for the study of trade and structural problems. Those models also demonstrate some of the advantages and disadvantages of the various methods of solving CGE models. And the two dynamic models which were reviewed are excellent examples of the difference between intertemporal equilibrium (IE) models and sequential equilibrium (SE) models.

The following chapter extended the list of requisite model features and explained their relationship to some of the problems that arise in CGE modelling, such as indeterminacy and heterogeneity caused by the need to aggregate sectors and by the need to operate within a framework that is necessarily an abstraction of reality.

The JULIANNE model itself was presented in two stages; the snapshot model version as described in Chapter 4 and the extension to a dynamic version as described in Chapter 9. As the same underlying theoretical framework is common to both versions, only one chapter (Chapter 6) details the routines and features of the model. It may have seemed odd to the reader that the detailed explanation of JULIANNE was given before the dynamic version was presented. However, some features that are peculiar to the snapshot model, notably its investment routines, should obviously be explained prior to the presentation of the dynamic model whilst other aspects that are common to both model versions such as the modelling of import-domestic substitution are (one believes) easier to understand in the context of a snapshot model.[1] More importantly though, the dynamic model should be seen as a variant of the basic snapshot

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[1] as Appendix A of chapter 9 demonstrates.

model in much the same way as is say the CRESH production specification. It should not be seen as a separate model nor as the general model of which the snapshot model is a variant. But because it is a rather more substantial variant than the CRESH variant (or the scale economies variant suggested in Chapter 8), necessitating therefore rather more changes to the equations and the solution procedure than do the other variants, it merits a separate chapter and deserves the title of dynamic model rather than dynamic version. Nevertheless a version it still is, albeit a major one. Hence also the presentation of the snapshot model solution procedure (in Chapter 5) and applications of the snapshot model (in Chapters 7 and 8) before the statement of the dynamic model.

The applications of JULIANNE snapshot consist (in order of presentation) of some preliminary sensitivity analysis, model validation by 'simulation' of a year other than the base year, projection to a future year, and the comparative contemporaneous analysis (CCA) of: export subsidisation, occupational wage rate relativities (using the CRESH variant), and of most significance; alternative protection regimes. Model validation, projection, and a less extensive CCA of alternative protection regimes constitute the applications of JULIANNE dynamic, in Chapter 10. The conclusions of all this research are discussed below.

11.2 Conclusions

From the sensitivity analysis of section 7.1 it was ascertained that the elasticity of substitution between composite commodities is an important parameter in the analysis of protection changes. The import-domestic substitution elasticities and price elasticities of export demand are also important, but necessitated larger variation to generate given changes in results, relative to the effects of variation in the composite commodity elasticity. At the sectoral level the same sort of relativity prevails overall although there is nonetheless considerable diversity between sectors in their sensitivity to the various parameters.

An equally important conclusion from 7.1 was that the general level of economic activity as determined (primarily) by the amounts of labour and capital employed and by the technology of production, does not affect - anywhere near significantly - the differences between scenarios. This is both fortuitous and consequential, the latter because it implies that the control run for any CCA does not need to be an especially accurate projection of some, indeed any future year for the results of the analysis to be valid; the former because projection of the future is not something for which CGE models such as JULIANNE are designed. Of course one should still endeavour to obtain realistic control runs so as to further ensure the reliability of model results, even though this is no mean task as sections 7.3 and 10.2 have shown.

Admittedly the control runs described in 7.3 and 10.2 could have been secured with rather less fuss and less attention to detail, without endangering the reliability of the CCA results. But the space end effort devoted to these sections is justified when one recalls from the Introduction that the applied use (to date) of the JULIANNE model has been as much in projection work as in CCA work. Thus although a control projection run is primarily a prerequisite for CCA - the means to an end, it is also an end in its own right and a valid, if not preferred use of JULIANNE. The fact that there is a demand for CGE models to be used in projection work presumably indicates that (disaggregated) models designed specifically for medium term forecasting are not readily available, or are not much better. More on this later.

The conclusions from Chapter 7 regarding the three elasticities mentioned above and regarding the levels of factor use, were reinforced in Chapter 8 where it was further shown that in the evaluation of alternative protection regimes, the 'specialization elasticities' and the degree of potential scale economies could also be classed as important parameters. The analysis revealed that under flexible factor prices with fixed factor employment, the higher are the composite commodity substitution elasticities and the import-domestic substitution elasticities, and the lower are the export demand price elasticities and the potential for economies of scale arising out of specialization, the weaker is the case for free trade. It was also demonstrated under the same labour market assumptions, that the case for or against free trade is not significantly affected by either relative factor supplies, relative sectoral wage rates, decreasing returns in agriculture, or the presence of scale economies without specialization.

For the standard elasticity values used in JULIANNE the model shows little difference between free trade and low uniform tariffs, preferably exempting non-competitive imports. Although such exemption upsets strict tariff uniformity it does not directly distort the uniformity of protection given to domestic industries. Indeed the evidence from Chapter 8 suggested that the <u>uneveness</u> of protection probably has a greater deleterious effect on welfare than does the <u>mean level</u> of protection. However, under fixed real wage rates with flexible employment the case for free trade is fairly clear-cut. The lower is the mean level of protection the higher is the level of welfare, virtually irrespective of the degree of uniformity in the protection profile.

The results from the runs with the dynamic version of JULIANNE described in section 10.3 are consistent with the snapshot results and yielded the important additional information that the gains from trade increase over time, presumably within limits although the size of the gains in the long term of say 10 or 15 years has not been investigated. The dynamic model runs, all of which are in the fixed employment - flexible factor price class, also provided indirect support for the argument that removing the 'tall poppies' is more effective in increasing welfare than lowering all protection by some given amount.

One says 'indirect' because it appeared (in 10.3) that the differences between the snapshot results and the dynamic results could not all be attributed to the different model time horizons. The residual differences are consistent with the theory advanced in Chapter 8 that the higher the degree of aggregation,[2] the more uniform the perceived protection profile becomes and thus the smaller the measured gains from freer trade. Even without any differences in the uniformity of protection it still seems likely (again from Chapter 8) that the measurement of the gains from trade varies directly with the number of sectors identified in the model. Intuitively this inference is reasonable since the greater the degree of disaggregation the greater the opportunity to capitalise on comparative advantage. That is, industries which in a relatively aggregated model may be combined into one sector can, in a relatively disaggregated model, expand at different rates according to relative efficiency, the net outcome of which may not be identical to what happens to the total sector in the more aggregated model. The Chemicals sector provided an example of this in Chapter 8.

Thus the outstanding question is: What degree of disaggregation is necessary to abtain a reliable measurement of the gains from trade? And further, as the degree of disaggregation increases; how significant are economies of scale from specialization and where are the possibilities for substitution between composite commodities? These questions currently constitute the major problems in the debate on protection reform, as it has been quite well established that in the absence of scale economies, specialization, and inter-industry substitution; the gains from trade are only about 1%-2% of GDP and may well be negative in the large country case. Of course with fixed real wage rates the gains are likely to be rather larger but this is not a true allocational efficiency gain.

The small country - large country distinction is important not only in import protection analysis but, symmetrically, also in the analysis of export subsidisation (reflecting the optimal import tariff - optimal export tax argument). In section 7.4 it was concluded that the subsidisation of exports as a response to slow growth in foreign demand, is beneficial only when the price elasticity of demand is fairly elastic. Thus a subsidy on manufactured exports was shown to increase private consumption (or welfare) whilst a subsidy on agricultural exports did not. In other words, where the large country situation

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[2] Recall that the snapshot model in Chapter 8 has 40 sectors and that the dynamic model has 22 sectors.

applies it may be optimal to tax agricultural exports so as to secure terms of trade gains. Conversely, when agricultural exports are subsidised the associated decline in the terms of trade outweighs the effect of the higher volumes, yielding a net reduction in revenue.

In a partial analysis the critical elasticity would presumably be unity but the general equilibrium analysis of section 7.4 revealed that the critical value is in fact higher (absolutely) due to the upward pressure on prices exerted by the subsidies themselves; an effect which a partial analysis omits.

Labour market behaviour was also shown to affect the results. Of the two options considered; fixed employment with flexible wage rates and flexible employment with wage rates fixed relative to the exchange rate numeraire (and thus relative to world prices),[3] the latter provides a better environment for export subsisies, in that the subsidies yield a greater <u>increment</u> (or smaller decrement) in private consumption. However, the other conclusion from 7.4 is that in the face of declining export demand, irrespective of whether or not subsidies are granted, the <u>level</u> of consumption falls less under the former labour market assumption.

Given the importance of labour market behaviour the development of the CRESH version of the model can be seen to be a logical and justifiable extension of the standard model. Timing problems and conceptual differences, however, between the data sources for the CRESH version and the Input-Output based standard model, mean (unfortunately) that the application of the CRESH version to trade issues would not have been consistent with the analysis of Chapter 8 (or 10). That is, the cause of any differences between results could not be unambiguously known, as between data inconsistencies and true structural reasons.[4]

Of course it should not be forgotten that the JULIANNE model is not constrained to examine only trade issues at the expense of all else. The CRESH version in particular can be used to study a wide range of labour market questions, and one such application is presented in section 7.5 where the topic of interest is occupational wage rate relativities. Demonstration of method rather than derivation of conclusions, was the

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[3] The usual option is to fix real wage rates relative to the Consumer Price Index.

[4] This problem is currently being amended in the 1981/82 based 22-sector version of JULIANNE.

primary objective. Nevertheless, results showed that with the usual set of labour-labour substitution elasticities (which average 0.35), granting wage increases to particular skill groups has macro and occupational effects which depend considerably on the skill group concerned. This reflects not just the different elasticities of substitution but also the fact that factor demand is a derived demand.

In general one concluded that the substitution elasticities are certainly important but that the relevance of a multi-labour category production specification with different pairwise elasticities of substitution depends on whether, over the time horizon of the snapshot, it is legitimate to assume that the supply of occupational skills will match whatever demand may eventuate, given some profile of occupational wage relativities. If this assumption is not valid then clearly supply shortages would need to be allowed for and wage relativities between occupations (and probably also therefore between sectors) would need to be endogenous.

Another non-trade application of JULIANNE is its use in projection work. A projection of the medium term future is usually desirable as a control run for contemporaneous comparative analysis - be it of trade and structural issues or whatever. It was shown in section 7.1 that such a control run need not be particularly well researched, as long as it is realistic. However, there is also a strong demand for projections in their own right. These need to be more than just reasonably realistic, necessitating therefore much greater research into the values of the model's exogenous variables.

From experience gained so far it is evident that some form of macro model (formal or otherwise) is required to drive JULIANNE. Information on labour supply or employment, capital growth, sectoral rates of technological change, relative world prices, and the shifts of the export demand curves; all of which are exogenous to JULIANNE,[5] are crucial to the shape of the economy in some future year. Note that the last three of the items just listed actually entail disaggregated information which is not going to come from a macro model. The best one can hope for here is corresponding macro information; for example an economy-wide rate of productivity improvement or terms of trade index.

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[5] One can of course swap the exogenous / endogenous status of some variables. For example employment could be made endogenous and wage rates exogenised, but this does not lessen the informational requirement.

Other sources such as a survey of sectoral expectations need to be researched, the results of which can hopefully be reconciled with those of the driving macro model. Indeed, the use of JULIANNE in projection mode is the primary method of testing consistency between macro and micro information, a procedure which is essential in any projection work and one which is at the foundation of indicative economic planning.

Sections 7.3 and 10.2 only describe the final model runs of such a procedure. A full account is given in a 1983 New Zealand Planning Council paper by Haywood et al [49] although the multisectoral model used there is the VICTORIA model.[6] The latest in the series of National Sectoral Programme studies utilises the JULIANNE model, full details of which will appear in a forthcoming NZPC paper.

The projections described in 7.3 and 10.2 both have a 1990 time horizon. Thus the opportunity to test a projection against an actual outcome has not yet occurred. Official data for the 1985/86 year should be available in a few months and this could possibly be compared with the dynamic model's 1985/86 projection. However, a fairer evaluation of the model would be to compare it with an average of the three years centred on 1985/86. This is not only because most of the input data is derived from the Haywood [48] model which is based on 3-5 year moving averages, but also because the model is simply not designed for exact annual tracking.

A further problem in projection validation is the presence of events which have no corresponding equations or variables in the model, such as demographic shifts and election induced economic cycles. The former, for example, generate consumption patterns which cannot be explained purely by changes in income and relative prices. Thus even if the model's equations exactly described reality, they do not wholly describe it. In contemporaneous comparative analysis this is generally not significant in the sense of distorting model results but in an intertemporal comparison between an historical base year and some future year the potential for distortion is much greater. For events such as elections and stock cycles the problem can be (partly) overcome by the moving average interpretation of model results. However, there is no systematic way of dealing with demographic shifts and other non-cyclical phenomena such as long run climatic changes which may, for example, affect

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[6] See Philpott et al [72].

consumer energy demand or agricultural demand for irrigation.[7] These are events that may well be predictable with a different model, which could in theory be interfaced with, or even subsumed into, a CGE model. This would naturally enhance the projection ability of a CGE model but one should not forget that there will always be completely random events such as the massive oil price increases of the 1970's or serendipitous technological advances, for which there is no historical precedent and which no model can predict.

The extent of the significance of model-external events may be gauged from sections 7.2 and 10.1 which deal with simulation and validation. Simulation of a knowm year other than the base year is really a special case of projection, as the model's exogenous variables can be set at their actual values instead of at forecasted values - much like within sample prediction in econometrics. With perfect equations and parameter values the differences between the model's economy and the true economy could be attributed to model-external events. That at least is the theory. In practice, model imperfections mean that any such projection or simulation is as much a test or validation of the model as of the significance of model-external events. Indeed, sections 7.2 and 10.1 focus on the former rather than on the latter. Unfortunately, to add further complication, the list of exogenous data requirements is seldom (if ever) fulfilled and the effects of some model-external events may be subtly captured by standard exogenous variables. The technological change or efficiency parameter is an excellent such 'catch-all'.

The separation of the effects of deficient data, model-external events and model shortcomings is extremely difficult and conclusions must therefore be tentative. Overall the model simulations are quite good especially at the macro level, suggesting that the availability and quality of appropriate input data is important since it is at the sectoral level that data deficiencies are greatest. The major model-external events over the simulation periods considered (1977 to 1982 for the snapshot model and 1982-90 for the dynamic model) were general elections and the 1982-84 price freeze. Many, probably most of the effects of these events are captured by the technological change variable especially where enough information exists for sector specific

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[7] One could 'manually' adjust equations or parameters but that is hardly systematic.

values. (Of course there were other significant shocks such as the sharp increases in oil prices and substantial amounts of 'lumpy' investment in major energy based projects. These, however, are not model-external events since the model includes variables or equations which can be accordingly adjusted.)

From this evidence it was concluded, albeit somewhat tentatively, that the equation structure of the model and its parameter values appear reasonable and therefore validated - holistically speaking. There is always room for improvement particularly with regard to sector specific parameter values. Indeed the uncertainty surrounding the values of (crucial) parameters is the main reason for undertaking extensive sensitivity analysis. If the entire model could be validated by full econometric investigation as discussed in Shoven and Whalley [81, p1021], the size of Chapters 7, 8 and 10 could be much reduced. As this is not (yet) possible it is essential to attempt validation through simulation even though it seems destined not to yield precise answers, either in support of the model or against it.

Thus the relationship between the various applications of JULIANNE - validation, projection, and contemporaneous comparative analysis (CCA) - becomes evident. Given the necessity for validation by simulation, it follows that there is also a necessity for a control run (namely the simulation run) as the reference point for any counter-factual simulation of any year other than the model's base year.[8] That is for example, if one wished to study the effects of lower protection in 1985, a control run would be required so that the effects of lower protection could be divorced from the effects of model shortcomings and/or model-external events. If, as has been the procedure in this thesis, one elects to focus the CCA applications on some future year, a control run is still required. It is then called a projection rather than a simulation since the values for the model's exogenous variables are not documented history.

Finally, whatever CCA mode one selects (whether based on a simulation or on a projection), the analysis should incorporate enough model runs to enable some assessment of the sensitivity of model results to changes in assumptions and/or parameter values.[9] Like validation by

[8] Recall that the term 'counter-factual simulation is reserved for CCA which is focussed on some historically documented year, as opposed to a future year.

simulation, such sensitivity tests are crucial to an understanding of the model's deficiencies and thus to an appreciation of the reliability of conclusions drawn from model results.

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[9] It may, however, be possible to apply sensitivity tests from one model application to another. For example, it was ascertained in section 7.1 that the total levels of labour and capital did not significantly affect results from a CCA of protection changes. Thus it seems probable that this would also be true for changes in export subsidisation (as analysed in section 7.4).

11.3 Recommendations

Recommendations arising out of this study fall into two categories:

1. Applied recommendations - suggested economic policies as a result of model runs.
2. Theoretical recommendations - further model enhancements and improvements.

The former were covered in the preceding section. It is in the nature of this type of work that a distinction between the conclusions about economic policy drawn from the various model applications and the associated policy recommendations, is artificial. For example if one concludes that uniform protection is preferable to selective protection, then obviously the recommendation for policy is exactly that. Some recommendations for further work then, are given below.

Optimal Growth

The JULIANNE dynamic model is a sequential equilibrium model and thus is not directly suited to studying questions of optimal growth.[10] However, the alterations necessary to convert it into an intertemporal equilibrium model (such as that developed by Dervis [24]) are not too overwhelming , consisting largely of changing the equations and some associated changes to the solution procedure (which would unfortunately increase the solution time). But to address the topic fully also entails modelling the path by which the economy could move from its current position onto an optimal growth path - the von Neumann turnpike model. As far as one is personally aware no multisectoral model has yet been advanced that fulfils this challenging task. An interface with a short to medium term forecasting model is a possible alternative to a single overall model. Conversely, perhaps JULIANNE dynamic should be left fairly much as is and allocated to modelling the von Neumann 'on-ramp', with the optimising role being assigned to a linear programming model. However, some experiments with this option indicated that the procedure is likely to be very messy and cumbersome due to LP problems having to be specified in terms of activity analysis. More generally, from the rather loose interface between JULIANNE and the Haywood macro model described in section 7.3, one infers that two models should really be designed simultaneously if any formal interface is contemplated.

[10] See Chapter 2 in this regard.

Alternative Pricing

The neoclassical zero pure profit pricing equation in medium term applications of JULIANNE snapshot is considered reasonable. But for the annual time horizons of JULIANNE dynamic a (variable) mark-up pricing hypothesis may well be more realistic. The monopolistic pricing equation or the Eastman-Stykolt hypothesis where domestic price is set equal to foreign price plus tariff, are possible alternatives.[11] Note that the same pricing equation need not apply to all sectors.

Monetary and Fiscal Dimension

As with the pricing equation a case can be made for the inclusion of monetary and fiscal variables in JULIANNE dynamic, especially for the shorter term applications. The major relationships that would probably be included as part of a monetary dimension are; a money demand function, a money supply varaible, a selection of interest rates, and a savings/investment function relating the marginal efficiency of capital to interest rates. If the assumption of no money illusion holds the relevant mechanisms are fairly simple to incorporate into the model. But if the system is not homogeneous of degree one in nominally denominated variables (of degree zero in real variables) the solution procedure would require considerable alteration. Furthermore if some nominal variables are under exogenous control (as recently occurred in New Zealand with respect to interest rates) an equilibrium solution might not be possible. Of course a disequilibrium may well be a realistic outcome but one would need to ensure that the model outcome was not just a function of the order of operations in the solution procedure. See section 5.6 for further elaboration of this point.

The importance currently attached by policy makers to the size of the internal government deficit, who appear to promote it more as a target for economic policy rather than a policy instrument, means that it is desirable to be able to model the effects on the deficit of such measures as changes in tariffs, export subsidisation, sales taxes, stock tenders and so on. As regards a fiscal and tax dimension the specification of the appropriate equations is much easier, and the relevant variables more measurable than for a monetary dimension, although one can certainly not incorporate a complete fiscal dimension in isolation from a monetary dimension. Some work on the inclusion of

[11] See for example Harris [46].

taxation flows on JULIANNE has recently been carried out, although not in connection with this thesis.[12] It embodies personal income tax, company income tax, the usual array of indirect taxes, wage and salary income, profit income, benefit income (such as unemployment benefits and superannuation), and transfers from overseas. An expenditure function is specified for households and the government budget deficit is also modelled. Thus the foundation for a more complete fiscal dimension already exists.

Disaggregated Household Sector

No version of the JULIANNE model has yet identified more than one household sector. The 'representative consumer' has always been the personification of the final demand category, Private Consumption. As one's understanding of the likely changes in total welfare consequent upon (say) changes in protection improves, questions about the distribution of such welfare changes across different consumer groups (whether income classes, household type or whatever) gain more prominence. Is the total change significantly affected by the distribution of that change? How uniform is the distribution and can it be altered?

The theoretical extensions to the model required to incorporate more consumer classes are quite straightforward and much of the required date is available. Hence this is one model improvement where the reward per unit of effort is likely to be high.

Capital - Labour - Energy - Materials Substitution

In JULIANNE, factor substitution and intermediate input substitution are independently modelled. Substitution between these two categories has only been modelled with unitary elasticity. It is a logical extension therefore to incorporate better equations to capture this kind of interaction.

One particular combination of inputs which has undergone considerable (overseas) investigation is the KLEM model which distinguishes capital, labour, energy and material inputs. Given the uncertainty surrounding many of the parameter values in general equilibrium models, it would be expedient to utilise the KLEM framework in JULIANNE. Apart form the usual restrictions associated with

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[12] paper forthcoming

elasticities there is no reason why the functional form used in the model should be the same as that used to estimate the elasticities. A hierarchical structure could then be appended to this system for the modelling of substitution between various types of each input. For example the CRESH specification could be used to model substitution between labour types with the aggregate labour input being substitutable with capital, energy and materials at the level of the KLEM specification.

With many KLEM studies showing that capital and energy are complementary inputs, free trade is likely to emerge as even more capital intensive (relative to import substitution) than ascertained in Chapter 8, since the energy sectors are generally also relatively capital intensive. The inclusion of a KLEM specification in JULIANNE can thus be seen to be a high priority issue - one which would further enhance the protection analysis of Chapter 8.

Imperfect Competition

Probably the most obvious areas for model enhancement are those that directly affect the modelling of changes in protection. In a general sense the term 'imperfect competition' covers many of the desiderata, notably specialization leading to economies of scale and the ensuing procedure for determining prices. The estimation of parameter values is one avenue for further research. But there is also much scope for advancing the theoretical framework employed in Chapter 8, such as along the lines advocated by Harris [46]. One should also add the area of substitution between composite intermediate inputs to the list of factors which could substantially affect the measured gains from trade and which is therefore worthy of further study. As with scale economies the potential for this is likely to increase as the level of sectoral disagregation identified in the model increases.

As a concluding thought one offers the personal opinion that the modelling of scale economies, specialization and related phenomena, is crucial to the future esteem, even the future survival of (medium term) computable general equilibrium models concerned with trade and structure.

DATA APPENDIX

'JULIANNE' DATA APPENDIX

This appendix provides all the data that has not already been supplied elsewhere in the text, for the latest 22-sector 1981/82 version of JULIANNE. Most of the data for older model versions still exists and is available on request. There are four parts to this appendix, as follows:

1. Explanation of the abbreviations.
2. Description of the database.
3. Data in flows (usually dollars), presented in model output format and in fact produced by the model as a test for arithmetical error, programming error and internal consistency.
4. Supplementary matrices in coefficient form.

PART 1: NOTATION AND ABBREVIATIONS

Sectoral Abbreviations (22 Sectors)

AGR	Agriculture
FIS	Fishing & Hunting
FOR	Forestry & Logging
MIN	Mining & Quarrying
FBT	Food, Beverages & Tobacco
TAL	Textiles, Apparel & Leather
WOD	Wood & Furniture
PAP	Paper, Printing & Publishing
CHE	Chemicals, Petrol, Plastics & Rubber
NOM	Non-Metallic Mineral Products
BAS	Base Metals
FAB	Fabricated Metals & Equipment
OTH	Other Manufacturing
EGW	Electricity, Gas & Water
CON	Construction
TRA	Wholesale & Retail Trade, Restaurants & Accommodation
TRN	Transport & Storage
COM	Communications
FIN	Finance & Insurance etc.
OWN	Ownership of Dwellings
PRI	Private Services
GOV	Government Services

(All of the following dollar variables are in $m)

MACRO

CONSUM	Private Consumption
INVEST	Gross Investment
GOVCON	Government Consumption
STOCKS	Stock Change
EXPORT	Exports
IMPORT	Imports - (c.i.f. valuation)
GDP	Gross Domestic Product

NOMINAL	model's current values relative to the numeraire
REAL	real 1981/82 values
PRICE	NOMINAL divided by REAL

Prices

PEXG	Price of Exports received by producers
PIMG	Price of Imports to buyers (includes tariffs)
TT	Terms of Trade Index relative to 1981/82
PREL	Price Relativity - (GDP deflator / NZ cif import price index) - a measure of the real exchange rate
RW	Real Wage Rate Index - (MW / CONSUM price)
MW	Mean Nominal Wage Rate
MR	Mean Nominal Rate of Return on Capital

Totals

TL	Total Employment ('000 persons)
TK	Total Capital Utilization/Stock in real 1981/82 prices
TTAX	Total Net Indirect Taxation plus revenue from actual Tariffs and from the imputed Tariff Equivalents (as explained in Chapter 6), less Export Subsidies
BOT	Balance of Trade (nominal EXPORT less nominal IMPORT)
VO	Value of Total Gross Output
VL	Value of Total Labour Inputs
VK	Value of Total Capital Inputs

Private Consumption Split

FD	Food	TN	Transport
HG	Housing	TA	Tobacco & Alcohol
HO	Household Operation	OG	Other Goods
AP	Apparel	OS	Other Services

DOM	Domestically Supplied
IMP	Imported - (at constant purchasers' prices)

Sectoral Data

Q	Domestic Import Prices
P	Gross Output Prices
R	Capital Rental Rates
W	Wage Rates ($'000 per person)
TAX	Nominal Value of Net Indirect Tax Payments after the Tariff Equivalent adjustments have been subtracted -see Chapter6
GROSSM	Nominal Value of Gross Imports by Type
NETM	GROSSM net of tariffs (Note that import good types have the same classification as domestic goods/sectors.)
PE	Nominal Value of Exports by Sector
PEX	Domestic Export Prices by Type - in order listed below

X	Real Gross Output
L	Labour Employment, (total given by TL)
K	Real Capital Use, (total given by TK)
GJ	Real Gross Investment by Sector of Destination
GI	" " " " Type of Good, whether imported or domestically produced
DEP	Real Replacement Investment
ECOM	Real Exports by Commodity Type - in order listed below

OCC Employment by Occupation

PROF	Professional
SWC	Skilled White Collar
USWC	Semi & Unskilled White Collar
SBC-ME	Skilled Blue Collar - Metal & Electrical
SBC-B	Skilled Blue Collar - Building
SBC-O	Skilled Blue Collar - Other
USBC	Semi & Unskilled Blue Collar
RURAL	Rural workers
AS	Armed Services
O-NEC	Other - Not Elsewhere Classified

FINAL Inputs into Final Demand

D.CON	Domestically supplied into	Private Consumption
D.GOV	"	Government
D.INV	"	Gross Investment (GI)
D.STK	"	Stock Change
D.EXP	"	Exports

M.CON	Imported into	Private Consumption
M.INV	"	Gross Investment (GI)
M.STK	"	Stock Change

DINTER1 to DINTER2

Domestic Intermediate Components of the I-O Table

MINTER1 to MINTER2

Imported Intermediate Components of the I-O Table, valuation in constant purchasers' prices

(TOTAL columns include totals from FINAL table)

Export Abbreviations

DAIR	Dairy
MEAT	Meat
WOOL	Wool
FISH	Fishing
HORT	Horticulture
OFBT	Other Food and Live Animals
TEXT	Textiles etc.
WOOD	Wood Products
PAPR	Paper and Pulp etc.
CHEM	Chemicals
ENGY	Energy
MINE	Mining and Mineral Products
CERA	Ceramics
BASE	Base Metal Products
MAEQ	Machinery and Equipment
OMFG	Other Manufactured Products
SERV	Services including foreign tourism

S1 to S3
The matrix giving the degree of potential competitiveness of each cell in the import matrix MINTER

OMEGA1 to OMEGA3
The capital input - output matrix

XI1 to XI3
The export commodity by sector conversion matrix

PHI
The private consumption commodity by sector conversion matrix

PHIM
The proportion of each cell in PHI which is imported

PHIS
The degree of potential competitiveness of each cell in PHIM

CDF1 to CDF4
The matrix of cost differences or tariff equivalents for both intermediate imports and final demand imports

PART 2: DESCRIPTION OF 1981/82 DATABASE

Production Functions

The JULIANNE model Cobb-Douglas production functions are based on: the official Input-Output gross output figures, labour force figures provided by E. Harris of BERL and capital stock data provided by G. Nana [64]. Factor shares come from the I-O table rows; compensation of employees, operating surplus and consumption of fixed capital; adjusted in the Agriculture and Fishing sectors where part of operating surplus is reclassified as compensation of employees to account for returns to owners' labour as. That is:

1. In Agriculture $995.6m is reallocated to compensation of employees; being 91,321 working owners, leaseholders and sharemilkers working on farms at 30 June 1981 - Farm Employment Survey - multiplied by RPEP estimate of the average 1981/82 wage in the Skilled Blue Collar (Metal and Electrical) group of $10,902 pa.
2. In Fishing $16.1m is reallocated, being 1477 working proprietors and partners engaged in fishing as at 28 February 1981 - Census of Fishing 1980/81 - multiplied by $10,902.

All the data plus the calculated constant terms are given in Table 1. Note that the figures for the Trade sectors undergo some subsequent adjustment as described below.

Consumption Function

The old 1976/77 based versions of the model used LES functions derived from L.F. Jackson's [52] work with the 1976/77 Household Expenditure Survey as described by A. Stroombergen.[1] There are no 1981/82 LES estimates available so it was assumed in the first instance that the 1977 parameters are still relevant. However, the 1982 data does not exactly fit the 1977 estimated functions due to both statistical error and, more significantly, to variables other than prices and incomes which affect consumer expenditure patterns such as family composition, age, education etc. Two obvious answers for the JULIANNE model are to:

1. Assume that the total proportion of committed expenditure is constant and that the marginal propensities are constant, and let the commodity specific committed shares adjust accordingly.

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[1] "The Specification of Consumer Demand in the JULIANNE Model - Theory and Practice", by A. Stroombergen, RPEP Internal Paper No. 149, July 1983.

TABLE 1

Cobb-Douglas Production Functions

	output	labour	capital	labour share	recip. of constant
Agriculture	5229.5	129.6	19920.7	0.6097	0.17685
Fishing & Hunting	217.1	5.0	207.6	0.5135	0.14112
Forestry	554.3	9.9	636.8	0.4328	0.18949
Mining	569.6	5.0	1868.7	0.2381	0.80065
Food etc	6280.7	75.5	3950.7	0.7425	0.03331
Textiles etc	2617.8	45.0	886.9	0.6263	0.05237
Wood	1344.4	23.5	731.7	0.6250	0.06346
Paper	2054.3	34.0	1727.2	0.5902	0.08277
Chemicals	3134.1	27.0	1454.5	0.6374	0.03671
Non-Metallic	653.8	11.5	560.2	0.4450	0.15202
Base Metals	862.8	7.1	677.5	0.6292	0.04453
Fabricated Metals	4798.1	80.9	2253.0	0.6454	0.05485
Other Mfg.	196.2	6.1	170.8	0.5521	0.13830
Ele, Gas, Water	1645.0	15.0	11024.4	0.3164	0.83043
Construction	5074.2	85.5	1578.6	0.6439	0.04759
Trade & Accom.	10098.2	216.0	7501.1	0.5169	0.11872
Transport	3201.4	71.5	7123.1	0.7044	0.08703
Communications	846.3	35.5	1964.7	0.7162	0.13103
Finance etc	4335.1	98.3	8208.8	0.4434	0.26619
Ownership of Dwell.	1543.6	--	35759.4	0.0	23.1662
Private Services	2596.7	74.7	1838.4	0.6427	0.09035
Govt. Services	5516.4	227.0	(18886.2)	1.0	0.04115

2. Assume that the committed expenditure on each good is the same proportion of total expenditure on each good as in 1977 and let the discretionary shares adjust accordingly.

Option (1) was chosen on the premise that future (that is 1982 relative to 1977) consumption patterns would be be determined more by the discretionary components than by the committed components, so it was felt that the former should have the greater empirical content.

Second Hand Assets

The row 'second hand assets' in the standard input-output table is reallocated to the indirect taxes row in the JULIANNE model.

TABLE 2

LES Alternatives

	(1)		(2)	
	comm	disc	comm	disc
Food	3264.0	0.10115	3301.5	0.09238
Housing	945.1	0.14024	931.2	0.14350
Household Operation	2391.6	0.16306	2390.0	0.16344
Apparel	1129.9	0.05786	1109.4	0.06266
Transport	2301.3	0.28348	2374.4	0.26637
Tobacco & Alcohol	674.8	0.06140	696.9	0.05621
Other Goods	1138.7	0.07023	1193.9	0.05739
Other Services	834.9	0.12249	683.0	0.15806

4th Quadrant Emptying

In JULIANNE all taxes and subsidies except those relating to exports are removed from the 4th quadrant - (that is where the factor input rows intersect the final demand columns). They are reallocated to the Trade row, and the indirect taxes cell in the Trade column is adjusted to maintain balance.

Cost Excesses

Domestic cost excesses with respect to imports, which arise because of import protection (notably licensing) are converted into tariff equivalents - see Chapter 6. The tariff row in the standard I-O table is then redefined to be a tariff equivalents row. Where the tariff equivalent payment exceeds the original pure tariff payment the difference, in the JULIANNE model, is subtracted from the indirect tax row.

Overall then the sectoral indirect tax row is rather a residual 'catch-all' with the Trade sector also being assigned this role but to a lesser degree. Such reallocations of the data are required to match the data with the limitations of the model, or indeed to match the model with the limitations of the data.

It is imperative that any such reallocations do not bias model results. For example it would be absurd to force balance of trade equality on the model when constructing the base year database, if in reality the equality did not exist. With regard to the data adjustments in JULIANNE, sectoral indirect taxes are not modelled in any detail (being simply a constant share of the value of output) and the adjustments in Trade amount to less than 1% of its gross output value - well within the margin of measurement error for this type of sector. If one wished to study a goods and services tax then probably the stated adjustments would need to be amended. But it is considered most unlikely that the adjustments would significantly bias the applications for which JULIANNE is intended.

PART 3: 1981/82 DATABASE

```
SPIEGEL        #        #        #        #        #        #        #        #        #        #        #

 COMPTE      1.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  COUNT      2.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
   TELL      1.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0



   MACRO         CONSUM         INVEST         GOVCON         STOCKS         EXPORT         IMPORT            GDP

NOMINAL      16952.2666      6197.6370      5331.6105      1592.1088      7991.6118      8910.3118     29155.4233
   REAL      16952.5669      6196.9506      5332.0000      1592.1018      7991.7150      8910.3118     29155.0226
  PRICE          1.0000         1.0001         0.9999         1.0000         1.0000         1.0000         1.0000



              PEXG           PIMG          TT        PREL          RW          MW          MR

           1.02572        1.14854     0.99999     1.00001     1.00003    13.07178     0.09141


                TL             TK        TTAX         BOT          VO          VL          VK

           1283.84      110062.44     2312.52     -918.70    63293.94    16782.09    10060.81



 CONSUM          FD         HG         HO         AP         TN         TA         OG         OS

    DOM     3500.54    1544.13    2665.67    1304.39    2427.00     871.23    1158.00    1337.12
    IMP      195.87       0.00     422.43      72.77    1085.36      65.94     281.18      20.96



MONEY             Q           P           R           W         TAX      GROSSM        NETM          PE         PEX

  AGR        1.0000      1.0001      0.0463     11.1235     47.0824     99.6277     99.6277    713.0605      1.0000
  FIS        1.0120      1.0000      0.2105      9.2198      0.0106      1.7259      1.7054     22.9929      1.0000
  FOR        1.0000      1.0000      0.2802     13.7577      1.2589      6.1889      6.1889     32.0103      1.0001
  MIN        1.0000      1.0000      0.1065     12.4401    -13.3884    149.6804    149.6804     39.0052      1.0000
  FBT        1.0905      1.0000      0.0949     14.3219     15.8567    457.5607    419.5749   2870.3113      1.0001
  TAL        1.3604      1.0000      0.3320     10.9646    -79.0206    573.2325    421.3652    797.9698      1.0000
  WOD        1.3098      0.9999      0.2500     12.9745      6.3307     48.8056     37.2627    126.0312      1.0000
  PAP        1.1761      1.0000      0.1854     13.5677    -27.1015    295.3412    251.1242    469.9379      0.9999
  CHE        1.1122      1.0000      0.1560     14.7075   -151.2140   2543.2302   2286.7421    106.9981      1.0000
  NOM        1.3395      1.0000      0.3022     11.7999      1.9484    139.6667    104.2663     41.0045      1.0000
  BAS        1.0495      0.9998      0.1149     18.4739    -18.1898    638.6848    608.5890    217.0707      0.9999
  FAB        1.2799      1.0001      0.2708     13.7109   -100.6923   3323.6208   2596.8226    381.0250      1.0000
  OTH        1.3900      0.9999      0.2200      7.5901      0.1128    103.8622     74.7216     20.0086      1.0000
  EGW        1.0000      1.0000      0.0521     17.7264     16.8408      4.6740      4.6740     12.0001      0.9999
  CON        1.0000      1.0002      0.3092     10.3263     42.0207    119.1991    119.1991      8.9925      1.0000
  TRA        1.0000      0.9999      0.3189     11.8490   1132.4524    162.8476    162.8476   1122.7335      0.9999
  TRN        1.0000      1.0000      0.0618     14.6672    -77.0988   1243.6912   1243.6912    996.0990      1.0000
  COM        1.0000      1.0002      0.1048     14.6337     -5.1342     32.4460     32.4460     44.9470      0.0000
  FIN        1.0000      1.0000      0.1798     11.9623    186.4603    222.4750    222.4750    125.0794      0.0000
  OWN        0.0000      1.0000      0.0113      0.0000    227.9390      0.0000      0.0000      0.0000      0.0000
  PRI        1.0000      1.0001      0.2392     10.5903    -13.3725     67.3079     67.3079     30.9571      0.0000
  GOV        0.0000      1.0000      1.0000     16.2502      1.5032      0.0000      0.0000     19.0134      0.0000
TOTAL        0.0000      0.0000      0.0000      0.0000   1194.6047  10233.8683   8910.3118   8197.2480      0.0000
```

REAL	X	L	K	GJ	GI	DEP	ECOM
AGR	5228.74	129.61	19919.95	769.29	17.18	589.63	1068.03
FIS	217.47	5.01	207.99	28.50	0.08	20.63	1547.84
FOR	554.27	9.90	636.67	43.30	19.46	27.31	907.94
MIN	568.52	4.99	1864.91	45.50	3.38	60.24	204.92
FBT	6281.26	75.50	3949.66	407.30	0.72	201.43	211.85
TAL	2618.13	45.02	887.19	36.20	16.47	50.92	336.38
WOD	1345.45	23.52	732.32	27.50	153.62	38.96	385.93
PAP	2053.18	33.98	1726.36	113.10	2.42	114.11	177.25
CHE	3133.44	27.00	1454.68	349.90	41.50	70.12	365.23
NOM	655.28	11.53	561.52	50.80	5.80	31.67	274.41
BAS	862.34	7.15	677.17	117.50	4.06	33.86	94.11
FAB	4797.41	80.89	2252.77	146.90	2538.33	110.84	41.41
OTH	197.15	6.13	171.66	2.90	5.06	8.65	40.01
EGW	1645.98	15.01	11030.75	499.59	9.35	371.74	380.96
CON	5074.12	85.50	1578.64	123.10	3103.18	124.87	259.35
TRA	10016.96	215.99	7501.07	406.40	15.54	395.31	124.76
TRN	3201.74	71.50	7122.55	577.09	89.06	414.53	1571.32
COM	846.76	35.53	1966.23	119.30	35.99	121.32	0.00
FIN	4336.04	98.33	8210.76	518.39	107.11	270.96	0.00
OWN	1544.13	0.00	35771.42	1088.80	0.00	0.00	0.00
PRI	2596.07	74.69	1838.18	100.50	4.67	72.06	0.00
GOV	5518.19	227.08	0.00	625.10	23.97	0.00	0.00
TOTAL	63292.64	1283.84	110062.44	6196.95	6196.95	3129.15	7991.72

OCC	L	W
PROF	168.0067	18.2843
SWC	91.6755	19.5444
USWC	318.3251	11.3767
SBC-ME	110.7361	13.3889
SBC-B	57.3072	10.9064
SBC-O	71.1437	12.7700
USBC	274.4353	11.6312
RURAL	143.6195	11.5858
AS	12.2329	19.5211
OTHER	36.3589	5.1175

FINAL	D.CON	D.GOV	D.INV	D.STK	D.EXP	SUBTOT	M.CON	M.INV	M.STK	SUBTOT
AGR	222.01	0.00	17.18	68.61	712.95	1020.75	64.96	0.00	-6.21	58.75
FIS	34.11	0.00	0.08	2.71	22.99	59.88	1.02	0.00	0.00	1.02
FOR	0.93	0.00	19.46	236.43	32.01	288.82	0.00	0.00	0.00	0.00
MIN	3.91	0.00	3.38	8.76	39.01	55.06	1.96	0.00	1.11	3.07
FBT	2134.38	0.00	0.72	95.21	2870.38	5100.69	222.19	0.00	49.43	271.62
TAL	999.09	0.00	14.11	115.11	797.98	1926.29	197.59	2.36	1.07	201.03
WOD	139.83	0.00	152.70	49.04	126.04	467.61	0.00	0.92	0.46	1.38
PAP	141.94	0.00	2.42	42.67	469.92	656.94	111.77	0.00	3.32	115.09
CHE	432.96	0.00	41.50	274.31	106.99	855.76	238.59	0.00	52.15	290.74
NOM	35.96	0.00	5.80	17.83	41.01	100.60	25.04	0.00	4.45	29.49
BAS	4.94	0.00	4.06	44.75	217.11	270.85	0.00	0.00	3.18	3.18
FAB	652.74	0.00	963.36	294.97	381.00	2282.07	325.58	1574.96	103.30	2003.84
OTH	92.07	0.00	5.06	14.33	20.01	131.47	77.88	0.00	2.88	80.76
EGW	383.91	0.00	9.35	0.32	12.00	405.58	3.02	0.00	0.00	3.02
CON	25.93	0.00	3103.18	2.07	8.99	3140.18	0.00	0.00	0.00	0.00
TRA	5103.77	0.00	15.54	109.98	1122.84	6352.13	8.00	0.00	0.00	8.00
TRN	348.34	0.00	89.06	23.40	996.13	1456.93	851.94	0.00	0.00	851.94
COM	283.91	0.00	35.99	0.00	44.94	364.84	2.00	0.00	0.00	2.00
FIN	768.06	0.00	107.11	0.48	125.08	1000.73	3.99	0.00	0.00	3.99
OWN	1544.13	0.00	0.00	0.00	0.00	1544.13	0.00	0.00	0.00	0.00
PRI	1349.09	289.51	3.82	2.39	30.96	1675.77	8.97	0.85	-18.47	-8.65
GOV	106.07	5042.49	23.97	2.07	19.01	5193.60	0.00	0.00	0.00	0.00
SUBTOT	14808.07	5332.00	4617.85	1395.43	8197.35	34350.70	2144.50	1579.10	196.67	3920.27

DINTER1	AGR	FIS	FOR	MIN	FBT	TAL	WOD	PAP	CHE	NOM	BAS	FAB
AGR	978.29	2.39	0.83	0.06	2713.50	431.73	12.65	0.62	2.51	0.13	0.43	1.92
FIS	4.71	3.52	0.00	0.00	74.12	9.95	0.27	0.21	0.31	0.07	0.17	0.96
FOR	19.87	0.00	70.72	0.00	0.63	0.00	98.89	63.24	0.00	0.00	0.00	0.00
MIN	8.37	0.02	0.83	117.80	8.79	1.31	0.27	11.70	239.40	33.62	4.23	1.44
FBT	58.04	10.85	0.28	0.68	398.86	115.46	2.96	3.90	24.13	0.52	1.38	9.59
TAL	25.62	3.54	0.50	0.63	6.91	459.49	20.18	11.29	29.14	1.05	0.78	21.11
WOD	19.35	0.26	1.22	1.08	3.77	4.97	246.09	25.87	5.33	4.65	1.64	44.62
PAP	10.46	0.17	0.44	1.93	144.47	27.49	17.22	439.99	50.76	15.86	3.45	44.62
CHE	483.65	22.81	42.96	29.11	61.56	37.96	73.33	107.38	179.85	29.49	20.78	151.60
NOM	14.64	0.07	0.11	2.39	34.55	1.83	8.07	1.44	8.77	55.96	4.74	18.71
BAS	7.84	0.11	0.17	0.28	9.42	1.05	11.57	3.29	7.83	10.81	41.75	395.82
FAB	168.89	25.55	5.88	13.36	89.19	26.97	57.72	24.84	68.94	14.15	30.96	678.33
OTH	1.05	1.17	0.06	0.17	1.26	11.26	1.21	1.85	2.19	0.26	0.26	3.84
EGW	33.46	0.30	1.55	5.97	72.86	17.02	14.80	54.61	26.95	13.56	44.24	34.54
CON	77.91	1.46	40.79	24.16	62.18	5.50	12.78	27.92	22.56	10.48	3.54	35.02
TRA	242.30	17.96	15.03	19.54	352.16	208.84	102.48	125.49	215.27	51.05	76.89	427.48
TRN	118.17	10.48	28.05	28.88	225.50	50.27	54.76	90.96	74.89	22.93	27.68	99.31
COM	23.53	2.72	1.44	2.67	14.45	7.59	4.17	9.86	15.04	4.78	3.28	15.83
FIN	145.36	17.07	21.62	28.37	126.88	75.93	32.83	54.61	97.45	32.63	20.01	147.28
OWN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRI	141.70	5.83	2.22	4.49	50.88	16.23	12.11	10.27	16.29	7.60	4.83	24.47
GOV	16.21	1.11	1.44	3.58	15.70	5.76	3.63	4.52	5.95	2.03	1.29	9.59
SUBTOT	2599.40	127.41	236.12	285.15	4467.64	1516.60	787.99	1073.84	1093.57	311.66	292.32	2166.07

INTER2	OTH	EGW	CON	TRA	TRN	COM	FIN	OWN	PRI	GOV	SUBTOT	TOTAL
AGR	0.65	0.16	5.58	18.18	2.56	0.08	6.50	0.15	7.53	21.52	4207.99	5228.74
FIS	0.04	0.00	0.00	58.57	0.96	0.08	0.43	0.00	1.56	1.66	157.59	217.47
FOR	0.00	0.00	2.03	4.04	0.00	0.00	0.00	6.02	0.00	0.00	265.44	554.27
MIN	1.26	56.13	19.28	2.02	0.32	0.17	0.43	0.62	1.04	4.41	513.46	568.52
FBT	0.45	0.16	2.54	494.85	12.17	0.34	4.34	1.70	29.08	8.28	1180.56	6281.26
TAL	6.23	0.16	12.69	27.27	6.72	0.42	4.34	4.48	18.95	30.35	691.84	2618.13
WOD	2.25	0.33	407.96	22.22	4.48	0.17	4.34	60.38	8.05	8.83	877.84	1345.45
PAP	9.78	2.30	51.76	257.52	31.38	0.42	104.06	36.90	59.71	85.53	1396.24	2053.18
CHE	15.22	26.34	202.96	180.77	266.06	5.33	37.29	50.96	139.15	113.12	2277.68	3133.44
NOM	0.39	2.14	264.87	45.45	5.12	1.35	8.24	51.27	12.98	11.59	554.69	655.28
BAS	9.68	2.14	52.78	10.10	1.92	2.29	3.47	0.93	3.89	14.35	591.49	862.34
FAB	10.17	17.94	596.71	115.13	193.38	5.84	36.42	40.30	145.12	149.54	2515.33	4797.41
OTH	6.92	0.16	3.55	12.12	2.56	0.08	2.60	2.01	7.79	3.31	65.68	197.15
EGW	1.34	609.18	18.77	122.20	15.37	3.73	28.18	27.79	32.71	61.25	1240.40	1645.98
CON	0.85	15.31	798.65	89.88	127.43	6.44	89.32	83.23	28.82	369.72	1933.94	5074.12
TRA	17.58	13.91	426.14	570.41	164.95	17.28	139.52	91.58	185.63	183.36	3664.83	10016.96
TRN	8.10	4.94	82.71	247.43	286.88	26.50	83.69	7.72	61.79	103.19	1744.82	3201.74
COM	1.46	3.95	17.25	133.31	33.94	1.95	80.65	2.63	41.28	60.15	481.91	846.76
FIN	10.21	9.05	267.41	784.69	122.63	4.32	642.60	333.07	147.20	214.11	3335.32	4336.04
OWN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1544.13
PRI	2.72	3.13	18.27	201.98	60.19	6.01	70.24	2.78	174.19	83.88	920.30	2596.07
GOV	0.67	14.48	20.30	45.45	48.99	0.51	34.69	15.13	15.06	58.49	324.59	5518.19
SUBTOT	105.99	781.92	3272.20	3443.56	1388.02	83.33	1381.36	819.63	1121.51	1586.63	28941.94	63292.64

MINTER1	AGR	FIS	FOR	MIN	FBT	TAL	WOD	PAP	CHE	NOM	BAS	FAB
AGR	15.17	0.00	0.00	0.00	25.13	0.00	0.27	0.00	0.00	0.00	0.00	0.00
FIS	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00
FOR	0.00	0.00	0.00	0.00	0.00	0.00	6.19	0.00	0.00	0.00	0.00	0.00
MIN	0.00	0.00	0.00	0.28	3.14	0.00	0.00	0.00	123.45	15.14	0.09	0.00
FBT	1.07	0.00	0.00	0.00	153.58	5.89	0.00	0.00	0.00	0.00	0.00	0.00
TAL	14.12	0.00	0.00	0.77	14.42	282.71	18.89	0.00	6.35	0.00	0.00	1.30
WOD	0.00	0.00	0.00	0.00	0.00	5.89	18.21	0.00	0.63	0.00	0.00	0.00
PAP	2.15	0.00	0.00	0.06	26.55	1.05	0.00	81.13	2.23	0.00	0.00	0.50
CHE	140.32	0.00	0.06	8.88	63.67	69.11	2.16	60.98	1403.92	0.13	29.41	25.31
NOM	1.08	0.00	0.00	0.11	18.33	0.00	1.80	0.00	0.00	16.03	0.70	9.02
BAS	0.00	0.00	0.00	0.00	0.00	0.00	2.85	0.00	2.52	0.00	341.53	193.39
FAB	30.75	0.00	2.22	3.72	16.71	6.23	7.35	39.66	17.49	0.18	2.99	758.99
OTH	0.00	0.00	0.00	0.00	0.00	13.10	0.00	0.57	0.00	0.00	0.00	0.00
EGW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CON	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRA	1.15	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.24
TRN	6.27	0.09	0.00	3.81	15.70	3.67	1.21	42.71	6.27	0.52	3.62	10.55
COM	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIN	3.66	0.00	0.00	18.25	3.77	3.93	3.90	0.00	3.76	3.93	0.00	11.51
OWN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRI	2.61	0.00	0.00	0.00	0.00	0.26	0.00	0.21	0.63	0.00	0.00	2.40
GOV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUBTOT	218.35	0.09	2.27	36.04	340.99	392.35	62.83	225.26	1567.29	35.94	378.24	1013.21

INTER2	OTH	EGW	CON	TRA	TRN	COM	FIN	OWN	PRI	GOV	SUBTOT	TOTAL
AGR	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	40.88	99.63
FIS	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	1.73
FOR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.19	6.19
MIN	0.00	1.98	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	146.61	149.68
FBT	1.62	0.00	0.00	21.68	1.00	0.00	0.00	0.00	0.00	1.11	185.94	457.56
TAL	0.00	0.00	2.74	17.72	0.00	0.00	2.93	7.30	0.00	2.98	372.20	573.23
WOD	0.00	0.00	18.26	0.00	0.00	0.00	0.00	4.43	0.00	0.00	47.43	48.81
PAP	0.00	0.00	0.51	22.75	3.64	0.00	18.68	1.45	1.31	18.25	180.25	295.34
CHE	0.91	0.00	67.77	42.63	137.73	0.00	12.60	0.00	86.37	100.52	2252.49	2543.23
NOM	0.00	0.00	49.37	5.40	0.66	0.00	0.00	0.00	7.68	0.00	110.18	139.67
BAS	0.00	0.00	68.72	0.00	2.27	0.00	0.00	23.67	0.00	0.55	635.51	638.68
FAB	0.03	0.69	76.01	30.81	35.25	39.97	3.64	50.59	116.61	79.99	1319.78	3323.62
OTH	2.93	0.00	0.00	4.21	0.00	0.00	1.21	0.00	1.08	0.00	23.10	103.86
EGW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	1.66	4.67
CON	0.00	0.00	96.93	17.17	2.88	0.00	0.00	0.00	0.00	2.21	119.20	119.20
TRA	0.00	0.15	1.78	144.62	4.96	0.00	0.35	0.00	0.21	1.27	154.85	162.85
TRN	0.83	3.62	1.01	87.86	175.77	2.12	6.94	0.00	10.90	8.28	391.75	1243.69
COM	0.00	0.00	0.00	16.16	2.56	0.00	7.80	0.00	0.00	3.86	30.44	32.45
FIN	0.00	0.00	4.06	60.59	26.57	0.00	58.54	3.86	0.00	12.14	218.48	222.47
OWN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRI	0.24	0.00	0.00	17.17	8.33	0.68	3.04	0.00	33.23	7.17	75.96	67.31
GOV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUBTOT	6.73	6.44	389.71	488.77	401.95	42.76	115.71	91.29	257.40	239.99	6313.59	10233.87

PART 4: SUPPLEMENTARY DATA MATRICES

S1	AGR	FIS	FOR	MIN	FBT	TAL	WOD
AGR	0.6380	0.0000	0.0000	0.0000	0.1883	0.0000	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000
MIN	0.2161	0.0000	0.0000	0.5009	0.0000	0.0000	0.0000
FBT	0.4158	0.0000	0.0000	0.0000	0.6025	0.3303	0.0000
TAL	0.7486	0.0000	0.0000	0.7273	0.7420	0.6786	0.7018
WOD	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
PAP	1.0000	0.0000	0.0000	0.0000	1.0000	0.1629	0.0000
CHE	0.3487	0.0000	0.0000	0.0457	0.1135	0.0666	0.4713
NOM	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
BAS	1.0000	1.0000	0.0000	1.0000	0.6318	0.0000	0.7020
FAB	0.2505	0.0000	0.2500	0.2442	0.2492	0.2500	0.2516
OTH	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.1429
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.4949	0.5000	0.4961	0.4444	0.5099	0.5389	0.5000
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.5093	0.0000	0.5000	0.4039	0.5010	0.5085	0.5000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

S2	PAP	CHE	NOM	BAS	FAB	OTH	EGW
AGR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000
FBT	0.6939	0.5906	1.0000	0.0000	0.0000	1.0000	0.0000
TAL	0.7419	0.6503	0.0000	0.0000	0.7484	0.1807	0.0000
WOD	0.0000	1.0000	0.0000	0.0000	1.0000	1.0000	0.0000
PAP	0.9934	0.5244	0.0000	0.0000	1.0000	0.0000	0.0000
CHE	0.0296	0.3220	0.6405	0.0000	0.4372	0.1882	0.0000
NOM	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000
BAS	0.0000	0.0745	1.0000	0.7950	0.7714	0.4487	1.0000
FAB	0.2494	0.2539	0.3303	0.1705	0.2504	0.2553	0.2490
OTH	0.1839	0.0150	0.3333	0.0000	0.2480	0.0323	0.0000
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.4994	0.5038	0.5000	0.5000	0.5225	0.5000	0.0000
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.4986	0.4870	0.5088	0.5000	0.4981	0.5556	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PART 4: SUPPLEMENTARY DATA MATRICES

S3	CON	TRA	TRN	COM	FIN	OWN	PRI	GOV
AGR	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0000	0.4826	0.7343	0.0000	0.0000	0.5000	0.0000	0.9524
TAL	0.7470	0.7508	0.0000	0.0000	0.7540	0.7500	0.7548	0.7442
WOD	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
PAP	0.1044	0.8742	0.8925	0.0000	0.9458	1.0000	0.1271	0.1019
CHE	0.3696	0.1212	0.0050	0.0000	0.0551	0.7529	0.0000	0.0062
NOM	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000
BAS	0.7977	0.8835	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000
FAB	0.2925	0.2596	0.2604	0.2505	0.2510	0.2502	0.2574	0.1039
OTH	0.0000	0.1984	0.0856	0.0000	0.2202	0.0000	0.1708	0.1873
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000
CON	0.5000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.5000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.4800	0.5000	0.5001	0.5007	0.5004	0.0000	0.4640	0.4968
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.5000	0.4997	0.5001	0.3333	0.5004	0.0000	0.4874	0.5000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000
PRI	0.0000	0.5000	0.5000	0.5000	0.5000	0.0000	0.5000	0.5000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

OMEGA1	AGR	FIS	FOR	MIN	FBT	TAL	WOD
AGR	0.0207	0.0003	0.0002	0.0001	0.0001	0.0001	0.0002
FIS	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0241	0.0000	0.0083	0.0002	0.0001	0.0001	0.0001
MIN	0.0044	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0002	0.0003	0.0001	0.0001	0.0002	0.0003	0.0002
TAL	0.0005	0.0900	0.0004	0.0009	0.0014	0.0127	0.0019
WOD	0.0164	0.0045	0.0031	0.0497	0.0148	0.0481	0.0166
PAP	0.0003	0.0003	0.0002	0.0005	0.0007	0.0005	0.0003
CHE	0.0308	0.0049	0.0025	0.0022	0.0046	0.0075	0.0077
NOM	0.0004	0.0009	0.0005	0.0005	0.0024	0.0005	0.0005
BAS	0.0007	0.0024	0.0012	0.0009	0.0017	0.0008	0.0013
FAB	0.4132	0.9813	0.4945	0.4105	0.5749	0.9602	0.5531
OTH	0.0006	0.0022	0.0011	0.0009	0.0010	0.0005	0.0012
EGW	0.0013	0.0005	0.0017	0.0033	0.0010	0.0003	0.0010
CON	0.4126	0.0494	0.5461	1.1312	0.2776	0.0103	0.2756
TRA	0.0241	-0.1747	-0.0941	-0.6382	0.0889	-0.0879	0.1048
TRN	0.0192	0.0320	0.0209	0.0214	0.0189	0.0405	0.0259
COM	0.0002	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
FIN	0.0254	0.0009	0.0078	0.0076	0.0081	0.0021	0.0044
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0009	0.0020	0.0009	0.0008	0.0010	0.0013	0.0011
GOV	0.0040	0.0023	0.0041	0.0072	0.0027	0.0012	0.0028

OMEGA2	PAP	CHE	NOM	BAS	FAB	OTH	EGW
AGR	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0002	0.0001	0.0001	0.0001	0.0002	0.0002	0.0000
TAL	0.0026	0.0007	0.0020	0.0017	0.0048	0.0052	0.0002
WOD	0.0179	0.0068	0.0185	0.0094	0.0496	0.0650	0.0010
PAP	0.0002	0.0001	0.0002	0.0002	0.0006	0.0007	0.0000
CHE	0.0086	0.0020	0.0053	0.0036	0.0139	0.0162	0.0005
NOM	0.0002	0.0010	0.0235	0.0026	0.0016	0.0007	0.0012
BAS	0.0003	0.0003	0.0016	0.0010	0.0008	0.0017	0.0002
FAB	0.6881	0.2127	0.8301	0.4544	0.6789	0.6102	0.2244
OTH	0.0003	0.0006	0.0014	0.0008	0.0007	0.0047	0.0001
EGW	0.0004	0.0021	0.0003	0.0012	0.0007	0.0007	0.0020
CON	0.1126	0.7268	0.0809	0.3811	0.1599	0.1489	0.7018
TRA	0.1473	0.0219	0.0191	0.1245	0.0500	0.1042	0.0533
TRN	0.0159	0.0134	0.0095	0.0110	0.0304	0.0310	0.0065
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0026	0.0070	0.0050	0.0043	0.0046	0.0057	0.0043
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0009	0.0003	0.0003	0.0008	0.0010	0.0014	0.0002
GOV	0.0013	0.0043	0.0010	0.0030	0.0019	0.0026	0.0040

OMEGA3	CON	TRA	TRN	COM	FIN	OWN	PRI	GOV
AGR	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0005	0.0016
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0002	0.0000	0.0001	0.0002	0.0001	0.0002	0.0001
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0002	0.0003	0.0002	0.0001	0.0001	0.0000	0.0002	0.0000
TAL	0.0003	0.0128	0.0010	0.0003	0.0056	0.0002	0.0118	0.0009
WOD	0.0035	0.1043	0.0183	0.0291	0.0704	0.0001	0.0908	0.0212
PAP	0.0002	0.0019	0.0003	0.0003	0.0007	0.0000	0.0010	0.0003
CHE	0.0017	0.0132	0.0018	0.0003	0.0043	0.0002	0.0049	0.0013
NOM	0.0004	0.0006	0.0004	0.0001	0.0006	0.0001	0.0006	0.0011
BAS	0.0079	0.0006	0.0008	0.0001	0.0003	0.0000	0.0013	0.0001
FAB	0.8248	0.6572	0.8985	0.4708	0.2860	0.0286	0.5058	0.1839
OTH	0.0007	0.0038	0.0007	0.0001	0.0003	0.0000	0.0102	0.0003
EGW	0.0004	0.0008	0.0005	0.0004	0.0017	0.0024	0.0011	0.0021
CON	0.1023	0.2488	0.1021	0.1314	0.5712	0.8488	0.3208	0.7310
TRA	0.0438	-0.0700	-0.0614	0.0615	0.0206	0.0526	0.0168	0.0395
TRN	0.0101	0.0182	0.0328	0.0072	0.0091	0.0047	0.0253	0.0076
COM	0.0000	0.0000	0.0000	0.2955	0.0002	0.0004	0.0000	0.0000
FIN	0.0016	0.0039	0.0013	0.0010	0.0227	0.0547	0.0023	0.0045
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0010	0.0011	0.0010	0.0004	0.0015	0.0003	0.0031	0.0003
GOV	0.0014	0.0025	0.0015	0.0011	0.0045	0.0067	0.0032	0.0042

PART 4: SUPPLEMENTARY DATA MATRICES

XI1	DAIR	MEAT	WOOL	FISH	HORT	OFBT
AGR	0.0000	0.0000	0.5225	0.0000	0.7980	0.2066
FIS	0.0000	0.0000	0.0000	0.1122	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.9053	0.9493	0.0509	0.8429	0.0000	0.6397
TAL	0.0000	0.0000	0.3926	0.0000	0.0000	0.0996
WOD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PAP	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CHE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NOM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FAB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OTH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0757	0.0371	0.0230	0.0259	0.0613	0.0262
TRN	0.0190	0.0250	0.0110	0.0493	0.1496	0.0490
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

XI2	TEXT	WOOD	PAPR	CHEM	ENGY	MINE
AGR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.1806	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.9420
FBT	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TAL	1.0044	0.0000	0.0000	0.0743	0.0000	0.0000
WOD	0.0000	0.7111	0.0000	0.0000	0.0000	0.0000
PAP	0.0000	0.0784	1.0769	0.2285	0.0000	0.0000
CHE	0.0000	0.0000	0.0000	0.3899	0.0000	0.0000
NOM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FAB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OTH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
EGW	0.0000	0.0000	0.0000	0.0000	0.1275	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0347	0.0356	0.0000	0.3495	0.8725	0.0290
TRN	0.0632	0.0728	0.0279	0.0313	0.0000	0.0290
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PART 4: SUPPLEMENTARY DATA MATRICES

XI3	CERA	BASE	MAEQ	OMFG	SERV
AGR	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0000	0.0000	0.0000	0.0000	0.0000
TAL	0.0000	0.0000	0.0000	0.0000	0.0000
WOD	0.0000	0.0000	0.0000	0.0000	0.0000
PAP	0.0000	0.0000	0.0000	0.0000	0.0000
CHE	0.0000	0.0000	0.0000	0.0000	0.0000
NOM	1.0050	0.0000	0.0000	0.0064	0.0000
BAS	0.0000	0.5699	0.0000	0.0000	0.0000
FAB	0.0000	0.3159	0.9877	0.0361	0.0000
OTH	0.0000	0.0000	0.0000	0.1604	0.0000
EGW	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0236	0.0000	0.0000	0.0000
TRA	0.0750	0.0756	0.0756	0.8669	0.3679
TRN	0.0325	0.0328	0.0328	0.0329	0.3997
COM	0.0000	0.0000	0.0000	0.0000	0.0286
FIN	0.0000	0.0000	0.0000	0.0000	0.0796
OWN	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0197
GOV	0.0000	0.0000	0.0000	0.0000	0.0121

PHI	FD	HG	HO	AP	TN	TA	OG	OS
AGR	0.0601	0.0000	0.0210	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0095	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.4713	0.0000	0.0000	0.0000	0.0000	0.5605	0.0504	0.0000
TAL	0.0000	0.0000	0.0702	0.6340	0.0000	0.0000	0.0376	0.0000
WOD	0.0000	0.0000	0.0381	0.0000	0.0000	0.0000	0.0154	0.0000
PAP	0.0000	0.0000	0.0034	0.0000	0.0000	0.0000	0.1646	0.0000
CHE	0.0000	0.0000	0.0325	0.0066	0.1291	0.0000	0.0683	0.0000
NOM	0.0000	0.0000	0.0175	0.0000	0.0000	0.0000	0.0003	0.0000
BAS	0.0000	0.0000	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000
FAB	0.0000	0.0000	0.1705	0.0000	0.0644	0.0000	0.1078	0.0000
OTH	0.0000	0.0000	0.0172	0.0000	0.0000	0.0000	0.0678	0.0000
EGW	0.0000	0.0000	0.1253	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0084	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.4520	0.0000	0.2606	0.3415	0.3215	0.4326	0.4324	0.1402
TRN	0.0071	0.0000	0.0045	0.0083	0.3220	0.0068	0.0079	0.0000
COM	0.0000	0.0000	0.0926	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0878	0.0000	0.0708	0.0000	0.0091	0.1761
OWN	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0464	0.0097	0.0921	0.0000	0.0385	0.6057
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0781

PART 4: SUPPLEMENTARY DATA MATRICES

PHIM	FD	HG	HO	AP	TN	TA	OG	OS
AGR	0.2924	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0286	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0648	0.0000	0.0000	0.0000	0.0000	0.1327	0.3159	0.0000
TAL	0.0000	0.0000	0.4248	0.0605	0.0000	0.0000	0.0000	0.0000
WOD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PAP	0.0000	0.0000	0.4245	0.0000	0.0000	0.0000	0.4263	0.0000
CHE	0.0000	0.0000	0.3396	0.3407	0.3463	0.0000	0.3459	0.0000
NOM	0.0000	0.0000	0.3426	0.0000	0.0000	0.0000	0.0000	0.0000
BAS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FAB	0.0000	0.0000	0.2809	0.0000	0.2810	0.0000	0.2811	0.0000
OTH	0.0000	0.0000	0.3887	0.0000	0.0000	0.0000	0.3893	0.0000
EGW	0.0000	0.0000	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0420
TRN	0.0000	0.0000	0.0000	0.0000	0.7533	0.0000	0.0000	0.0000
COM	0.0000	0.0000	0.0070	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0167
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0109
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PHIS	FD	HG	HO	AP	TN	TA	OG	OS
AGR	0.0097	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.2945	0.0000	0.0000	0.0000	0.0000	0.5000	0.6543	0.0000
TAL	0.0000	0.0000	0.7500	1.0000	0.0000	0.0000	0.0000	0.0000
WOD	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PAP	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CHE	0.0000	0.0000	0.0000	0.2500	0.2912	0.0000	0.1014	0.0000
NOM	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAS	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FAB	0.0000	0.0000	0.2761	0.0000	0.2500	0.0000	0.2500	0.0000
OTH	0.0000	0.0000	0.2500	0.0000	0.0000	0.0000	0.0914	0.0000
EGW	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PART 4: SUPPLEMENTARY DATA MATRICES

CDF1	AGR	FIS	FOR	MIN	FBT	TAL	WOD
AGR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0217	0.0164	0.0000	0.0000	0.0449	0.0218	0.0000
TAL	0.3500	0.0000	0.0000	0.3500	0.3500	0.3464	0.3500
WOD	0.0000	0.0000	0.0000	0.0000	0.0263	0.0228	0.4400
PAP	0.0286	0.0000	0.0000	0.0000	0.3206	0.0040	0.0000
CHE	0.0165	0.0037	0.0025	0.0009	0.0036	0.0036	0.0049
NOM	0.0294	0.0000	0.0000	0.0000	0.3900	0.0309	0.0274
BAS	0.0168	0.0183	0.0000	0.0050	0.0111	0.0000	0.0096
FAB	0.4000	0.0000	0.3791	0.3093	0.4000	0.4000	0.4000
OTH	0.0000	0.0000	0.0000	0.3900	0.0000	0.3900	0.3900
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

CDF2	PAP	CHE	NOM	BAS	FAB	OTH	EGW
AGR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0343	0.0187	0.0203	0.0000	0.0000	0.0370	0.0000
TAL	0.3500	0.3500	0.0000	0.0000	0.3500	0.3500	0.0000
WOD	0.0000	0.0096	0.0000	0.0000	0.4400	0.0207	0.0000
PAP	0.3864	0.0189	0.0000	0.0000	0.0365	0.0000	0.0000
CHE	0.2914	0.1263	0.0018	0.3644	0.0991	0.0042	0.0016
NOM	0.0000	0.0000	0.3900	0.0142	0.3424	0.0280	0.0000
BAS	0.0000	0.0068	0.0054	0.0500	0.0500	0.0099	0.0060
FAB	0.3897	0.3956	0.4000	0.3966	0.4581	0.4000	0.4000
OTH	0.3900	0.3900	0.3900	0.0000	0.3900	0.3900	0.0000
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PART 4: SUPPLEMENTARY DATA MATRICES

CDF3	CON	TRA	TRN	COM	FIN	OWN	PRI	GOV
AGR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIS	0.0000	0.0420	0.0193	0.0000	0.0000	0.0000	0.0000	0.0105
FOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FBT	0.0000	0.0735	0.0450	0.0000	0.0000	0.0449	0.0000	0.0055
TAL	0.3500	0.3500	0.0000	0.0000	0.3500	0.3500	0.3500	0.3500
WOD	0.4400	0.0000	0.0234	0.0000	0.0000	0.0251	0.0000	0.0000
PAP	0.0050	0.3250	0.0336	0.0000	0.0254	0.0405	0.0088	0.0021
CHE	0.0517	0.0295	0.0027	0.0023	0.0020	0.0081	0.2747	0.3012
NOM	0.3900	0.0690	0.0357	0.0000	0.0000	0.0340	0.3450	0.0173
BAS	0.0500	0.0119	0.0112	0.0000	0.0000	0.0500	0.0217	0.0061
FAB	0.4000	0.3865	0.4116	0.3964	0.4000	0.4000	0.4169	0.3177
OTH	0.3900	0.3900	0.3900	0.0000	0.3900	0.0000	0.3900	0.3900
EGW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

CDF4	PRICON	STOCKS	INVEST
AGR	0.0000	0.0000	0.0000
FIS	0.0204	0.0000	0.0000
FOR	0.0000	0.0000	0.0000
MIN	0.0000	0.0000	0.0000
FBT	0.1507	0.0112	0.0000
TAL	0.3914	0.3500	0.0302
WOD	0.3500	0.4400	0.0134
PAP	0.0754	0.3900	0.0000
CHE	0.0699	0.2361	0.0033
NOM	0.3900	0.0354	0.0182
BAS	0.0118	0.0500	0.0064
FAB	0.4212	0.3423	0.1525
OTH	0.3900	0.3900	0.0507
EGW	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000
TRA	0.0000	0.0000	0.0000
TRN	0.0000	0.0000	0.0000
COM	0.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000
OWN	0.0000	0.0000	0.0000
PRI	0.0000	0.0000	0.0000
GOV	0.0000	0.0000	0.0000

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Abbreviations used above:

N.Z.I.E.R.	New Zealand Institute of Economic Research
N.Z.P.C.	New Zealand Planning Council
R.B.N.Z.	Reserve Bank of New Zealand
R.P.E.P.	Research Project on Economic Planning
V.U.W.	Victoria University of Wellington