PREDICTING REGIONAL AND LANDSCAPE DYNAMICS IN AUSTRALIAN SAVANNAS[1]

– ECONOMIC DIMENSIONS

Project Report

2004

Prepared by:

Natalie Stoeckl and Owen Stanley
School of Business
James Cook University
Townsville
QLD 4811

For the: Tropical Savannas CRC

[1] *Map available at the TS-CRC website:* *http://savanna.cdu.edu.au/information/savannaexplorer.html*

Acknowledgements:

This report is the outcome of a project that was co-funded by the Tropical Savannas CRC and JCU. It builds upon work previously carried out by Stafford-Smith et al (2003) – this project, thus owes a great deal to researchers who were involved in that earlier project.

We are also very grateful to those who willingly agreed to participate in the stakeholder survey, and to our research assistants (Wolf Stoeckl and Barbara Neil) who worked so diligently, to find, and to interview those participants.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abbreviations and Acronyms used in this report

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
ATSIC	Aboriginal and Torres Strait Islander Commission
CGE	Computable General Equilibrium
CoPs	Centre of Policy Studies (Monash University)
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSIRO LW	CSIRO, Division of Land and Water
CSIRO SE	CSIRO, Division of Sustainable Ecosystems
DPI	Department of Primary Industry (QLD)
GDP	Gross domestic product
GIS	Geographic Information System
GRP	Gross regional product
IO	Input-Output
IT	Information technology
LGA	Local Government Area
MLE	Maximum Likelihood Estimation
NATSEM	National Centre for Social and Economic Modelling (University of Canberra)
NGO	Non-Government Organisations (primarily conservation and community respondents to the survey)
NT	Northern Territory
OESR	Office of Economic and Statistical Research (QLD)
OLS	Ordinary Least Squares
QLD	Queensland
SAM	Social Accounting Matrix
SD	Statistical Division
SLA	Statistical Local Area
Stakeholders (TS)	Those who live in the Savannas, those who care about the Savannas and those who make regular decisions affecting the Savannas.
TS	Tropical Savannas
VAR	Vector Auto Regression
VIC	Victoria
WA	Western Australia

1 Introduction and outline of report

1.1 Background

This document summarises key findings from research that was undertaken by the authors as part of a much larger study. The aim of the larger study was to develop a regional dynamic modelling capacity for the Australian Savannas that can simulate the effect (on the environment, on regional communities and on the Savannas economy) of specific changes or shocks to the system.

The task would be non-trivial even if the aim of the larger project was less ambitious (eg developing regional dynamic modelling capacity for the economy only). At least part of the reason for this is because the social and economic structure of the Australian Savannas differs so substantially from the more densely populated, southern and/or coastal areas of Australia, that one cannot simply 'transfer' methods or results from urban areas to these.

For example, a large proportion of the Savannas population is composed of Indigenous people (Table 1-1).

Table 1-1: Population across the Australian Savannas[2]

	Proportion of land area in Savannas (estimated %)	Estimated Population	Indigenous persons (number)	Indigenous persons (% of Pop)
North East Qld		339,363	17,435	5
Cape York		20,430	10,892	53
Mitchell Grass Lands	≈ 72%	10,446	856	8
Gulf Country Qld	≈ 80%	31,047	7,917	26
QLD total		401,286	37,100	9%
Mitchell Grass Lands	≈ 28%	4,062	307	8
Gulf Country NT	≈ 20%	7,762	1,979	25
Arnhem land		17,249	11,464	66
VRD Stuart	≈ 90%	7,034	3,115	44
Darwin Kakadu		126,019	15,538	12
NT total		162,126	32,403	20%
VRD Stuart	≈10%	782	346	44
Kimberley		39,252	13,157	34
WA total		40,034	13,503	34%
Savanna Total		**603,446**	**83,006**	**14%**

[2]Population figures were taken from TS CRC web site. These were compared to ABS 2001 Census data by area on map (% of overlap between states estimated, taking into consideration towns and land mass.) http://www.Savannas.ntu.edu.au, http://www.abs.gov.au

There are a number of medium to small towns in the area, whose population is predominantly non-Indigenous, though the non-Indigenous people stay in the savannas for only relatively short periods of time. A number of Indigenous communities are growing so rapidly that they will soon become large in the context of the savannas, although the economies of these communities are vastly different from those of the mainstream towns with relatively little economic contact between the communities and neighbouring towns.

Further to that, the Indigenous economy is only weakly linked to the rest of the Savannas' economy. Indigenous communities exist largely as islands of population and activity with little contact with the surrounding towns. The result of this is that even a large development project (such as the construction of the Tindell Air Base in Katherine, NT) will generally lead to no or little increase in employment and incomes of the Indigenous people in the region. The local non-Indigenous community is much more likely to gain a benefit.

There is also considerable variation in the economic structure of regions within, and across the Savannas. This is clearly shown in Figure 1-1, which shows the proportion of persons employed in different industries for three shires in Queensland and for all of Queensland.

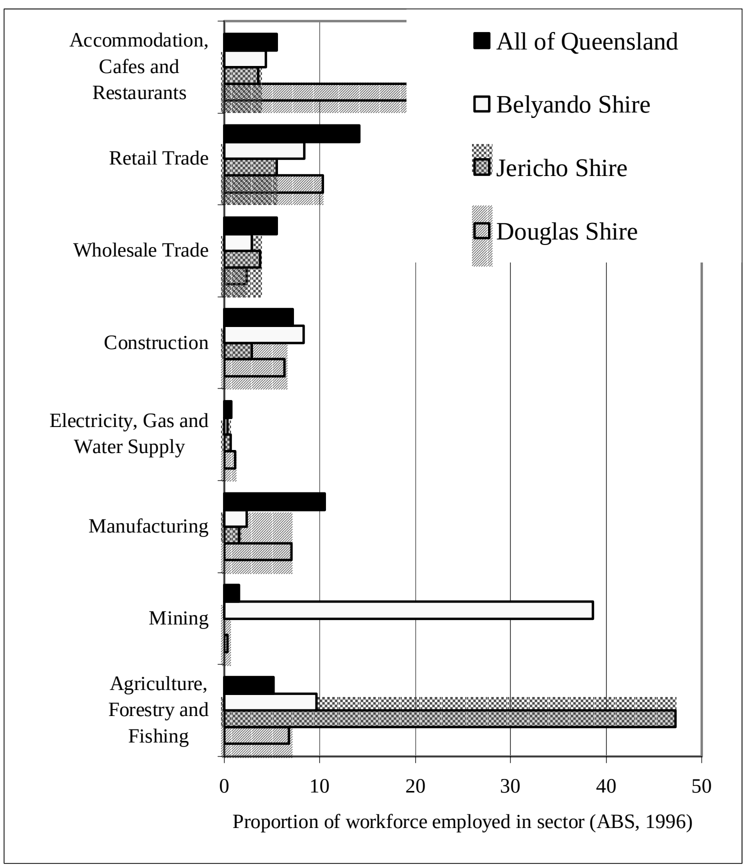


Figure 1-1: The proportion of workforce employed in different sectors of the economy for a selection of regions within Australia (ABS, 1996)

In the shire of Jericho, the most important industry is agriculture – with more than 40% of all workers engaged in that industry. In neighbouring Belyando, mining is the 'key' industry; whilst in Douglas, the sectors associated with tourism employ most people. Not surprisingly, the figures for Queensland show a more even distribution of employment across different industries:

If a man stands with one foot on a hot stove, and one foot in a freezer, the statistician will report that he is – on average – comfortable.

These regional differences mean that individuals living in the Australian savannas need information about what is happening locally: aggregate economic information (eg. about employment in Australia, or in Queensland) is not generally transferable to these smaller, remote areas, and may often be irrelevant.

In short, the complex social and economic structure of the Australian savannas means that job of modelling the economy (even without interdisciplinary links) is non-trivial. Clearly, one cannot simply take a model from another region and apply it to the savannas, and the task of building a 'tailor made' model is substantial. Hence the importance to dividing the large investigation into a series of smaller, sub-projects.

In 2003/04, the project was divided into three separate disciplinary investigations: economic, biophysical and demographic – the justification for this being that the overarching aims of such an ambitious project might be best worked towards in a series of small, incremental yet related steps. This document relates specifically, to the economic component of the 2003/04 project.

The primary task of the economic investigation was to conduct a stocktake of currently available methods, approaches and models, analysing them in the Savannas context, with a view towards determining which (if any) may be able to:

a) Simulate changes in the Savannas, generating predictions about the effect of different types of change on regional economies; and

b) Integrate with other disciplinary approaches also generating predictions about the effect of changes on a broad range of social, demographic, environmental and economic issues; and

c) Answer questions that stakeholders are interested in;

or

d) Be adapted so as to achieve all of the above.

The ultimate aim of the economic investigation was to generate a short-list of promising approaches to developing an integrative, dynamic, predictive model of Australian Savannas.

Importantly, this research did not intend to – nor was it designed to – determine whether the overall goal of developing a fully integrated model of the Savannas is a good one. Rather, it accepts such as goal a 'given' and sets out to generate a short-list of promising approaches to meeting that goal. More specifically, the research question was approached with the following philosophy:

- Let us pretend that there are enough resources to develop a fully integrated dynamic predictive model of the Savannas (implicitly assuming that the idea is a good one).

- Let us acknowledge that we know little about demographic or biophysical modelling approaches, and focus on economic modelling approaches.
- Let us note that there are many different economic models.

NOW, let us see if we can find out which (if any) of these economic models would provide useful information to stakeholders. How that was done, is outlined below.

1.2 Methods and structure of report

There is an extensive body of research focusing on issues of dynamic modelling – indeed entire journals are devoted to the topic (the *Review of Economic Dynamics, Structural Change and Economic Dynamics;* the *Journal of Economic Dynamics and Control* to name just three). Development of new methods to predict regional dynamics in the savannas is thus inappropriate if one can use and/or adapt one or more of the many methods that are currently available. Before doing so, however, it is important to assess whether such methods or models are suitable in this context.

The first stage of work therefore involved a stock-take of currently available methods, approaches and models. This review built on the regional dynamics scoping study conducted by Stafford-Smith and others in 2002-03. It collected information on existing regional economic models / approaches, noting: data requirements; underlying assumptions (regarding data, structure and processes); level of integration with other disciplinary perspectives; and final 'outputs' (variables, timescales, geographic scales, etc). A summary of key issues arising from the stock-take is presented in Section 2 (and details of some of the applied models are provided in Appendix A).

For those interested in developing a regional dynamic modelling capacity in the Australian savannas, the key point to be made from the stocktake is that there are many different economic models and modelling approaches – approaches that can make quite different predictions about the impact of change. This is not to say that such differences mean that some approaches are 'right' and some are 'wrong' – one expects differences to arise for several legitimate reasons:

1. Different models seek to answer different questions about different variables/issues;
2. Different models often consider different temporal scales;
3. Different models use different spatial scales;
4. Different models consider different sectoral scales;
5. Different models consider different feedbacks (environmental, social, and/or economic);
6. Different models use different types of data;
7. Different models make different assumptions about the structure of the relevant economy (eg. about the proportion of extra income re-spent within the local economy, about production technologies, about the price and availability of imports, about the existence of a global equilibrium, etc); and
8. Different models use different estimation techniques.

Researchers can comment on the theoretical soundness of the different modelling approaches, and on whether or not there is enough data to run them (providing information to others that will allow them to assess the desirability of different modelling approaches according to points 6–8). But they are not always well placed to determine which issues are most important to those who must make regular decisions that affect the environment, the economy, and/or the community of the Australian Tropical Savannas (hereafter called stakeholders). That is, researchers, alone, may not always be able to determine which questions stakeholders would like to be able to ask about which variables, over which time frames in which geographic scale, for which sectors (points 1–5). Hence the importance of identifying stakeholder priorities, and of taking such issues into consideration when assessing the 'desirability' (or otherwise) of different modelling approaches.

The authors of this document therefore undertook a two-pronged assessment of existing modelling approaches, conducting

- A survey of stakeholders to collect information that allows one to assess the relevance of different modelling approaches vis-à-vis their ability to provide information that is relevant to different groups (Section 3); and
- A desk-top analysis of practical, and theoretical issues associated with different modelling approaches (Section 4).

Insights from the stakeholder survey and the researcher assessment were subsequently synthesised in the final section, allowing for the identification of broad classes of models and modelling approaches that are well suited to the task of developing an integrated predictive dynamic model of the Australian Savannas (ie they are theoretically robust, operationally feasible and likely to be able to answer questions/address issues that stakeholders are interested in).

The overall structure of the report is given in Figure 1-2.

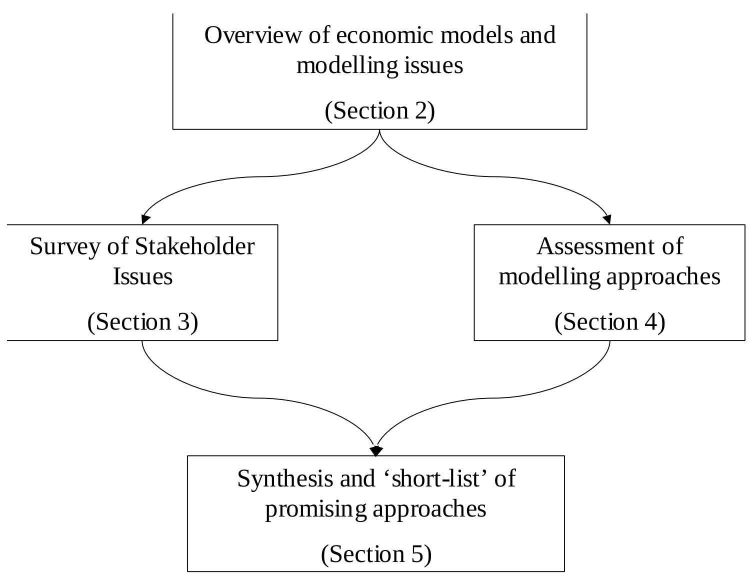


Figure 1-2: Structure of the report

2 Overview of economic modelling issues

For many years, economists have recognised that the total effect of a change *can* be greater than the initial impact. This is based on the idea of multipliers – a concept introduced by Kahn and made famous by Keynes (1936). The process by which this occurs can best be explained with an example.

Imagine that a visitor to *Location x* spends $100 (earned elsewhere) at the local grocery store and that we are interested in the total economic impact of that extra expenditure.

The owner of the grocery store may decide to save a little money (say $10), and put some money aside for taxation – say $20. Imagine that the grocer also spends $30 on imported noodles, and then pays the local gardener $40 for tidying up the lawns around the store. The local gardener comes out a winner – earning and extra $40. Figure 2-1 shows the process diagrammatically.

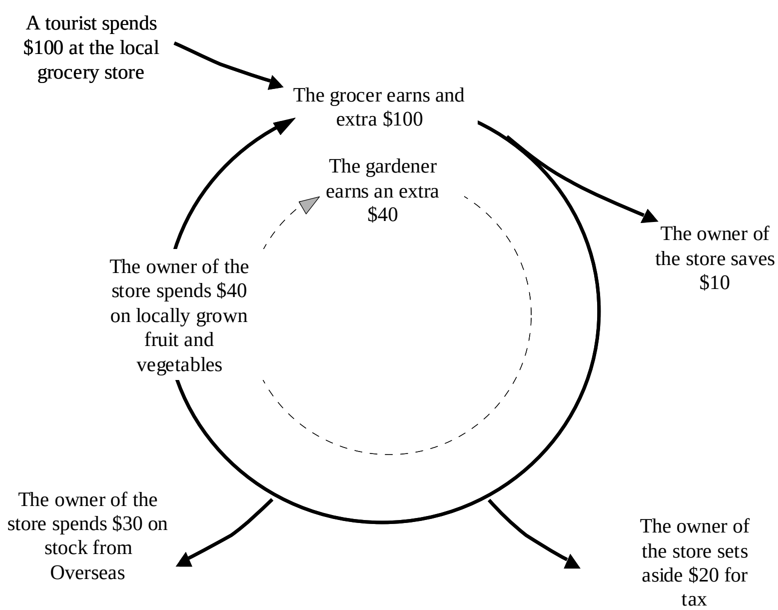


Figure 2-1: The circular flow of extra expenditure in a regional economy

The key point to note here is that the total economic impact of the money spent by the visitor is greater than just the $100. In this example the economic impact is $140: the initial $100 plus the extra $40 earned by the gardener. Importantly, if the gardener spends at least some of his/her $40 locally, then the benefits are spread even wider throughout the local community.

In other words, over time (say, a period of 12 months[3]), extra money that is 'injected' into an economy will work its way around the community in ever-diminishing circles. In some circumstances, the extra expenditure will follow a geometric progression. If so, then one can calculate the total change to regional income over the course of say, one year, (ΔY) that follows from an initial injection of monies (Δ E) using Equation 1:

$$\Delta Y = \frac{1}{1 - \text{proportion of extra income re-spent within the local economy}} \times \Delta E$$

$$\Delta Y = \kappa \Delta E$$

Where: κ is the Keynesian multiplier

Equation 1

What this equation tells us, is that – all else constant – the higher the proportion of extra earnings that households and businesses re-spend within the local community, the greater the total regional benefit of an initial injection of funds. In other words, the total impact of a change in expenditure will depend upon the size of that initial change, the expenditure patterns of those in the regional community, and any 'feedback effects' that enhance or dampen the expenditure effects (discussed in greater detail below).

2.1 Temporal issues

Over time, feedback effects will moderate at least some of the effects described above. These effects occur when, for example, changes in expenditure patterns generate changes in prices (or wages) that induce further changes in expenditure. In other words, the simplistic multiplier process above is valid if – and only if – other changes do not occur within the economy that reinforce or, more commonly, moderate the effect.

Figure 2-2 presents stylised representation of the impact of an imagined change over time. This representation shows an initial change that generates an extra \$5 of expenditure. Over time, that extra \$5 is assumed to circulate within the economy, inducing extra expenditure in other areas (as per Equation 1). The net impact rises to almost \$23, twelve months after the initial change in expenditure (a *typical prediction generated via input-output analysis – see section 4.2.1 for more detail*).

[3] The 'normal' period of time to which economic variables like GDP refer to (ie Gross Domestic Product = the value of all goods and services produced within one year).

Eventually, however, feedback effects may occur. For example, the increased demand for groceries, may cause the price of groceries to rise, which may force some customers to cut back on their expenditure. Hence, subsequent price effects feed-back into the economy, moderating the initial change (a *typical prediction generated in computable general equilibrium models – see section 4.2.2 for more detail).* In the stylised picture of Figure 2-2, feedbacks are shown with a net impact that is negative after two years, and close to zero two and a half-years after the initial change.

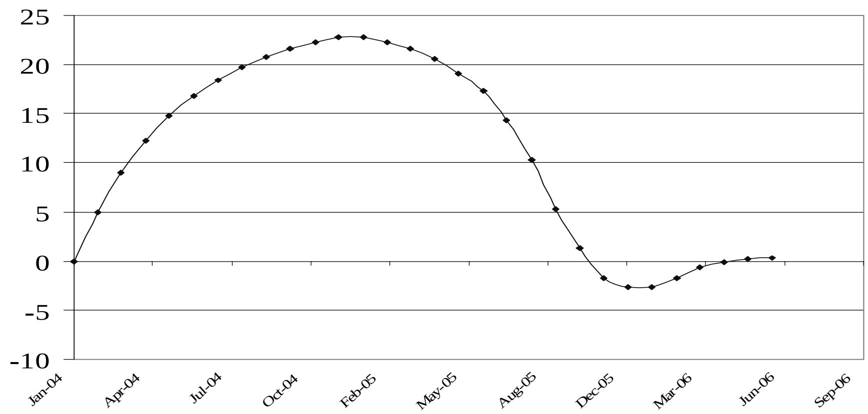


Figure 2-2: The effect (deviation from trend) of a 'change' over time

Clearly, the effect of 'real' changes in a 'real' economy need not follow this stylised dynamic path – many different trajectories are possible, over many different time frames. Indeed a considerable amount of economic research (theoretical and empirical) investigates these trajectories[4]. Irrespective of the type of change being investigated, however, the message here is clear – those interested in modelling the effect of change need to carefully specify an appropriate time scale, since the effect will vary with time.

2.2 Issues of integration with other disciplines

Following on from the discussion of section 2.1, it is clear that different models that consider different feedbacks will make different predictions about the impact of change (in terms of magnitude and timing). For example, an integrated model that considers the impact of a fall in beef prices, might predict lower stocking rates, which subsequently improve land condition, generating improvements in productivity in years to come. An economic-only model might miss the productivity change, making more pessimistic assessments about the financial impact of falling beef prices than the integrated model.

[4] Seeking to identify, for example, whether changes in government spending and/or changes in technology and/or changes in the quantity of money in circulation have short-run, medium-run or long-run effects on the economy.

One therefore expects integrated models to make different predictions about the impact of change than non-integrated models. The wider the variety of feedbacks considered, the wider the trajectory of possible outcomes – and there are few *a priori* assumptions that can be made about either the magnitude or the timing of those differences.

2.3 Spatial issues

As formally presented in Equation 1, in the absence of feedback effects, the total impact of a notional change will depend upon the expenditure patterns of the local businesses and residents: the more that is re-spent within the local economy, the greater will be the total impact. But how much is re-spent locally, depends, *by definition*, on the size of the local economy. Normally, the larger is the region (in terms of the population and variety of industry), the greater is the opportunity for businesses to re-spend within the region, and the larger is the multiplier.

Suppose, for example, that one is interested in the effect of a change in a small town (region 1), that is nested within a larger shire (region 2), within a state (region 3), within a country (as illustrated in Figure 2-3).

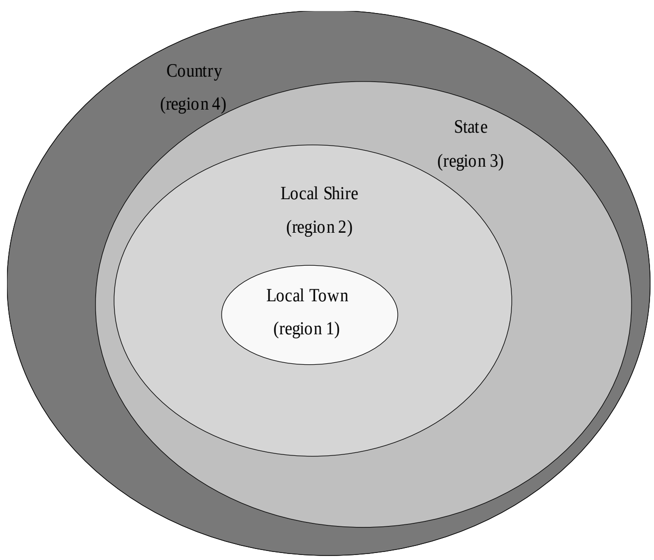


Figure 2-3: Identifying and Delineating Regions of interest

The initial economic impact will occur solely within the small town – subsequent changes will be dispersed across time and space depending upon where the recipients of the initial and subsequent injections choose to re-spend their money. Dispersion across space and time will also vary according to the feedback effects within each region. Figure 2-2 depicted the distribution of the economic impact of a change across time. Figure 2-4 shows one possible stylised distribution of that same change across four different regions (using the same time-frame).

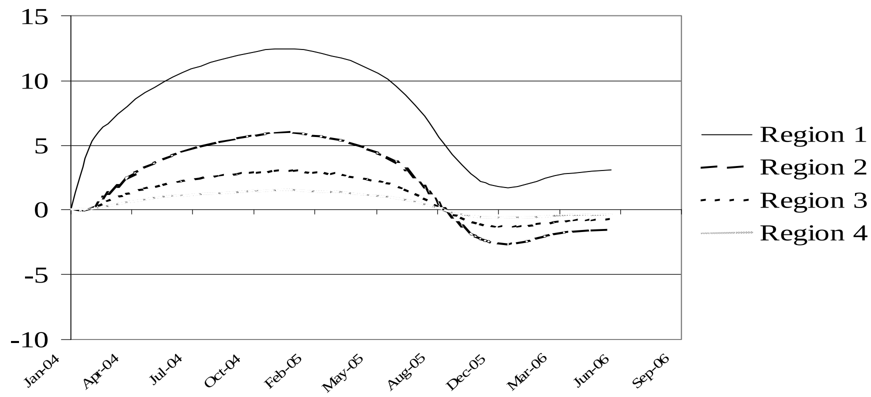


Figure 2-4: The effect (deviation from trend) of a 'change' over time and across space

Here too, it is important to stress that many different space-time trajectories are possible in the real world. These are but stylised representations of imagined changes, used to illustrate an important point, namely that the economic impact of change has both spatial and temporal dimensions that must be carefully defined if seeking to develop a predictive, dynamic model of the tropical Savannas.

2.4 Sectoral Issues

As is apparent from the foregoing examples, the total economic impact of change in a regional economy depends, at least in part, upon the expenditure patterns of those within the local economy, which depends, *by definition*, on the size of the local economy. It also depends upon the sector in which the initial change has its impact. This is because different sectors often have different financial links with other sectors of the economy: if the income of a person who regularly spends their money in local stores falls, then local stores will also suffer; if the income of a person who only spends their money outside the region falls, then local stores will not bear any side-effects of that person's income reduction.

Similarly, it is important to note that the average impact of change will not always be felt equally throughout regional communities: some changes may have a net positive impact on the local economy, but the net impact may be comprised of large benefits in some sectors, and costs in other sectors. In some cases, policy makers may only be interested in the aggregate impact of change in a local community, but in other cases, it may be important to look at changes in specific sectors. In the extreme, stakeholders may be interested in considering the effect on individuals or groups of individuals. In either case, model developers need to consider what level of sectoral detail is most appropriate, before selecting a model – not all models are able to show similar sectoral details.

2.5 Empirical Issues

Although the theory behind multiplier processes are well understood, methods of measuring the total effect of change and/or of identifying its causes, empirically, are far from perfect. Prior to the – relatively recent – explosion in information technology (IT), analysis was laborious and researchers were frequently required (for logistical reasons) to choose between analysing either short-run or long run problems using either historical or cross-sectional data that was organised using ideas from one disciplinary branch (ie to test or investigate one particular theory/issue). However technological advances have been closely followed by theoretical advances: nowadays there are many sophisticated models that are capable of examining multiple impacts of multiple changes over multiple time-frames in multiple regions using ideas from more than one discipline.

These different 'models' (discussed in more detail in section 4) use different econometric/mathematical methods to analyse different types of data that have been organised in a manner that is consistent with the ideas/theories of many different disciplines. Given the differences in data, theory and analytical techniques, it is not therefore surprising, to find that different models make different predictions about the impact of change – even when considering changes made within the same temporal, spatial and sectoral scale.

2.6 Summary of key economic modelling issues

Those interested in simulating the dynamic impact of change in the Australian Savannas have many different methods available to them – methods/models that will frequently make quite different predictions about the impact of change. As is apparent from the foregoing discussion, one expects such differences to arise for several reasons:

1. Different models seek to answer different questions about different variables;
2. Different models often consider temporal scales;
3. Different models use different spatial scales;
4. Different models consider different sectoral scales;
5. Different models consider different feedbacks (environmental, social, and/or economic);
6. Different models use different types of data;
7. Different models make different assumptions about the structure of the relevant economy (eg. about the proportion of extra income re-spent within the local economy, about production technologies, about the price and availability of imports, about the existence of a global equilibrium, etc); and
8. Different models use different estimation techniques.

There are no 'rights' or 'wrongs' here: a model which is appropriate in one situation may be entirely inappropriate in another. It is, therefore important to assess the suitability of different models, according to the context in which they will be used – i.e. on needs to consider

a) The relevance of the model

   i. Is the model able to consider questions that are relevant to stakeholders? When attempting to answer this question, it is important to consider the 'outputs', 'timeframe' and 'scale' (temporal, geographic and sectoral) of a model and compare that to the type of information required by stakeholders.

   ii. Can the model be integrated with other disciplinary perspectives? (i.e. is the output of interest to the key stakeholder – the TS CRC ?).

   Models that can only consider economic issues and that cannot be 'linked' to other non-economic models may provide valuable insights into methods of handling regional economic dynamics, but by themselves, are not suitable to the goal of developing an *integrative* model.

b) Practical issues:

   What data do the models require? Is that data available, at an appropriate temporal, geographic and sectoral scale? If not, is it feasible to collect such data?

c) Theoretical/Structural issues: Does the model's outputs/predictions provide accurate information of the type required by stakeholders?

   The output/results of dynamic models can be very sensitive to underlying assumptions – assumptions about the value of parameters, the relationship between variables, the relationship between 'agents', etc. If those assumptions do not validly describe the region one wishes to model, then the model may not be able to provide 'practical', 'useable' information to stakeholders. But this may not always be so – on occasion, models with seemingly inappropriate assumptions are capable of generating useful, and reasonably accurate results. Hence, one needs to consider whether the underlying assumptions 'fit' the situation, and/or if model results are sensitive to underlying assumptions and/or if assumptions can be changed if they do not suit the situation AND distort model predictions.

As noted earlier, researchers can comment on the theoretical soundness of the different modelling approaches, and on whether or not there is enough data to run them, but they are not always well placed to determine which issues are most important to those who must make regular decisions that affect the environment, the economy, and/or the community of the Australian Tropical Savannas. Hence the importance of identifying stakeholder priorities – as discussed in the following section.

3 Survey of Stakeholder Issues

To repeat an important point: there are many different ways to develop a dynamic, regional economic model and each will – by design – generate different predictions about the impact of 'change'. This is to be expected, because different models ask different questions about different types of change and simulate the effects of change in different ways (and on different variables).

The main point of the research described in this section is to determine which questions stakeholders are most likely to ask, about which economic issues, in which regions, over what period(s) of time. Since different models are capable of answering different questions, this allows us to identify, by association, models that are likely to be able to generate information that is relevant to local stakeholders.

The investigation was carried out in steps that required researchers to (a) develop an appropriate questionnaire; (b) identify 'key stakeholders'; (c) determine an appropriate sampling technique; (d) conduct the survey; and (e) analyse the results. Each of these steps are discussed in section 3.1, before presenting a summary of the responses in section 3.2.

3.1 Method

The questionnaire

The questionnaire comprised nine questions; the first four seeking background information about the respondent's organisation, the fifth and sixth seeking information about the stakeholders interest in different geographic and temporal scales; the seventh asking stakeholders about the types of 'change' they would be interested in having simulated; the eighth asking stakeholders about the types of 'impacts' they would be like a model to be able to simulate; and the last, attempting to determine key issues that regularly consume the time (and energies) of the respondents' organisation. A copy of the information sheet that was sent to potential participants is provided in Appendix C, and a copy of the questionnaire is provided in Appendix D.

Defining stakeholders

As noted earlier, we adopted a relatively 'loose' definition of Savannas Stakeholders: namely those who live in the Savannas and /or who make regular decisions affecting the economy, environment and/or society within the Savannas.

Defined in this manner, it is apparent that stakeholders in the Savannas come from an extremely diverse range of groups (for example: government agencies, Indigenous traditional owners, householders, businesses, graziers, tourists, non-government associations, etc). Yet some stakeholders may be in a better position to provide meaningful answers to questions relating to predictive modelling than others – this will depend on many factors such as age, experience, time spent in the Savannas, time spent thinking &/or working on issues raised in the survey, level of understanding of key modelling issues, etc. The main problem here, however, is that many of these factors, are inherently unobservable – we cannot judge, objectively, whether respondents are able to provide 'meaningful' answers. Similarly, although all stakeholders have important interests and contributions to make in the Savannas, some will be more inclined than others to 'use' a large-scale, predictive, dynamic model – most likely those working in government departments that focus on related policy.

Rather than attempting to collect a random sample of views across all types of stakeholders, we thus set out to collect a cross-section of views from those most likely to use such a large-scale predictive dynamic model – believing that they would most likely be associated with the following organisations:

- Local governments, some state government departments, some federal government bodies,
- Indigenous bodies (regional councils, land councils, etc),
- Regional development bodies, regional natural resource management bodies, and other non-government organisations,
- Industry and business associations, and
- Some large mining and pastoral businesses

Results from the survey are presented for all respondents together, and for each type of stakeholder group – leaving readers to decide how best to weight the importance of responses from different groups.

Sampling

For the reasons outlined above, our identification of stakeholder groups was non-random: instead we deliberately target organisations likely to have knowledge of, a keen interest in, or a desire to use a large-scale model. We attempted to contact the chief executive officers of all regional councils, land councils, and local governments. Responses for these groups, are therefore, reasonably representative. We also attempted to contact state and federal government departments involved in economic policy and planning, natural resource management, tourism, mining, agriculture, regional development, and/or indigenous affairs, interviewing heads of sections (and/or persons nominated by the heads).

As for other stakeholder groups, we started by contacting the 'stakeholders' listed on the TS web-site; again, seeking to gain interviews with heads/managers of sections (and/or persons nominated by the heads). That list of contacts was supplemented by word of mouth during interviews. We also attempted to contact the managers (or nominees) of all mines in the area, as well as pastoral and tourism associations.

Conduct of the survey

Surveying was conducted between 8th of March 2004, and the 21st of May 2004. Initial contact with selected respondents was made by sending prospective respondents a personalised email, with an explanatory cover-page and questionnaire (attached). Respondents were later telephoned and asked if they would like to take part in the survey. The survey was completed over the telephone (with researchers entering data), although respondents had a copy of the questionnaire in front of them. Five respondents chose to complete the survey themselves, and post or fax it back.

Overall the survey obtained a response rate of 73%. As shown in Table 3-1: the highest number of responses was from Government being 62 at a response rate of 75%. Indigenous organisations had a high response rate at 87% with 33 responses. We had a similar number of responses from industry associations and private business although the response rate was relatively low for private business. Reasons for not participating in the survey varied, examples being: too busy; not applicable to their business; survey 'lost' within the ranks of larger organisations.

Table 3-1: Types of organisations contacted: responses and response rates

Type of organisation	Number contacted	Number of responses	Response rate
Government	83	62	75%
Indigenous Association	38	33	87%
NGO	7	5	71%
Industry Association	30	24	80%
Business	44	23	52%
Other	1	1	100%
Grand Total	203	148	73%

3.2 Responses

Table 3-2 provides a summary of responses by type of organization and by state of origin (location of head-office). The number of responses by location was 47% Queensland, 30% Northern Territory and 19% Western Australia – giving a slight over-representation of respondents from NT and WA when compared to the distribution of people across the Australian Savannas (66% in Queensland, 27% in the Northern Territory and 7% in Western Australia[5]). This was the result of a deliberate attempt to seek the views of those in the sparsely populated areas (following the recommendation of Stafford-Smith et al, 2003, who suggested that the TS CRC should concentrate on issues that are unlikely to be considered by other researchers).

Of the 148 respondents, 62 were employed in either local, state or federal government departments, and 33 were employed by ATSIC or in a Land council. In short 95 of the 148 respondents (65%) were Government employees – this following from our deliberate strategy of contacting those most likely to use a model like that proposed.

[5] These figures were calculated by taking the population figures from TS CRC web site, and comparing them to the ABS 2001 Census data by area on map. The percentage of overlap between states was estimated, taking into consideration towns and land mass.

Table 3-2: Location and Types of organisations responding to survey

Type of organisation	Sub-type	Responses from					
		WA	NT	QLD	ACT	VIC	ALL
Government	Local Government	3	4	26			33
	State / Territory Government	8	10	10			28
	Federal Government				1		1
Government Total		**11**	**14**	**36**	**1**		**62**
Indigenous Associations	Land Council	2	9	5			16
	Regional Council	4	3	6			13
	Other		2	2			4
Indigenous Association Total		**6**	**14**	**13**			**33**
NGO	Environmental NGO			2	1		3
	Community NGO	1		1			2
NGO Total		**1**		**3**	**1**		**5**
Industry Association	Tourism Association	2	2	1			5
	Agricultural Association		3	2	1		6
	Regional Development Group / Body	2		4			6
	Other Association	5	2				7
Industry Association Total		**9**	**7**	**7**	**1**		**24**
Business	Agricultural Business		2	1			3
	Communication Services Business		1			2	3
	Other Business		1	1			2
	Transport and Storage Business			1			1
	Manufacturing Business		1				1
	Mining Business	1	4	4		2	11
	Cultural and Recreational Business			1			1
	Retail Business			1			1
Business Total		**1**	**9**	**9**		**4**	**23**
Other Total				**1**			**1**
Grand Total		**28**	**44**	**69**	**3**	**4**	**148**

3.3 Results

As highlighted above, a diverse group of organisations agreed to participate in the survey, and to analyse all responses as one homogenous mass, may not be particularly enlightening. We therefore present results for all respondents and for each type of stakeholder group – leaving readers to decide how best to weight the importance of responses from different groups. Although views varied across stakeholder groups, one of the more interesting findings of the survey is that some views are remarkably similar.

Before proceeding however, we wish to emphasis an important point. The selection of broad stakeholder types and of organisations within the groups was not random. Although every effort was made to contact as broad a cross-section of stakeholders as possible, readers are cautioned that the non-randomness of the sample means that one cannot use these results to draw inferences about the entire population – the results simply summarise the views of chosen respondents.

3.3.1 Interest in geographic scale

Respondents were asked to indicate which geographic scale(s) they, or others within their organisation, would find it useful to have data/information about. Scales offered included local town, local shire, state, Australian Savannas, Australia, the international community and other. Responses noting NT regions or WA regions (corresponding to LGA's) were coded as if local shire/LGA. The results are shown in Figure 3-1.

It can be seen that a relatively low proportion of respondents indicated an interest in data for Australia as a whole and/or for the international community. Irrespective of type of organisation responding, most interest was shown in data at the LGA level, rather than at the smaller, local town level. All organisations except NGO's had the following ranking: most interest in data at the shire or Local government area (LGA) level, next at the local town level, followed by state-wide data. NGO's also expressed most interest in LGA data, although second and third preferences were equal for data across the state and across the Australian Savannas.

The open-ended question/comments revealed the following: Most Indigenous organisations noted that it would be particularly useful to have access to data relevant to the Aboriginal and Torres Strait Islander Commission (ATSIC) regions. Others indicated that it would be useful to have data at the catchment scale, &/or supplied in a way that allowed managers to aggregate upwards (for example, combining data on more than one shire).

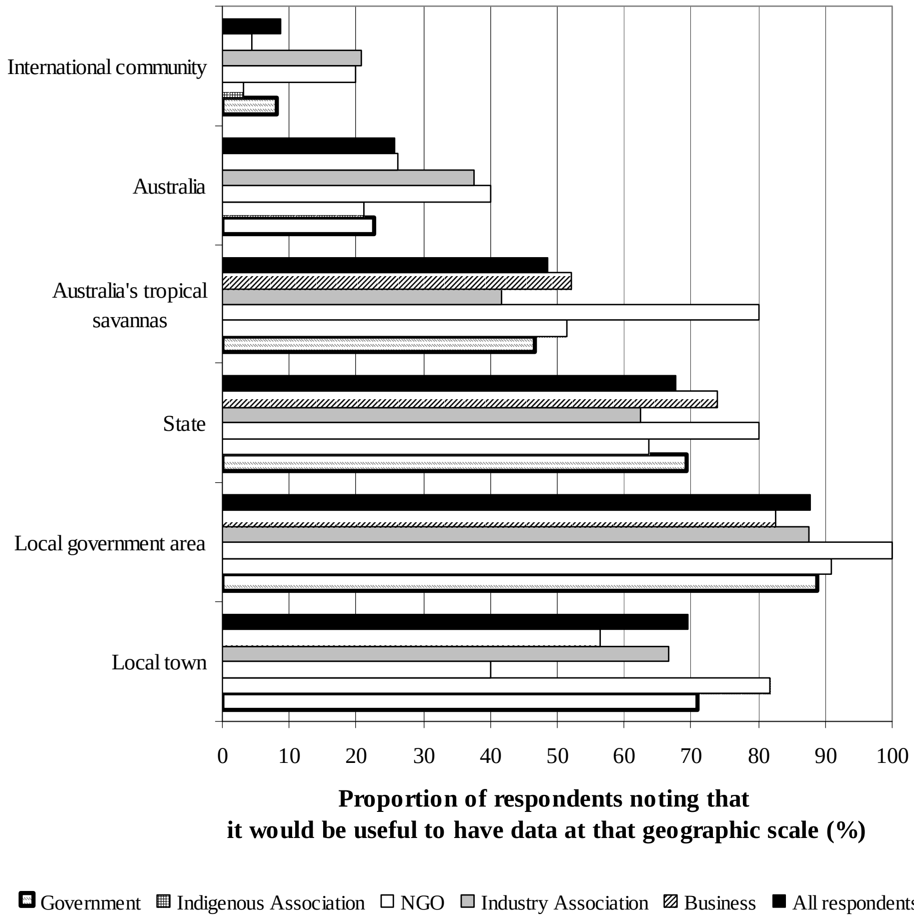


Figure 3-1: Stakeholder interest in data at different geographic scales

3.3.2 Interest in different temporal scales

Different economic models make predictions about the impact of a shock or change to the economic system over different time horizons. To gauge stakeholder preferences on this issue, respondents were asked to indicate whether they – or others within their organisation – would be interested in models that could simulate the effect of change over a range of different temporal scales. Responses are shown in Figure 3-2, which graphs the proportion of respondents indicating interest for each temporal option for each stakeholder group.

As for the question about geographic scale, the pattern of responses across different types of organisations is surprisingly similar. In all cases, greatest interest was shown for relatively short time horizons; little interest was shown for long time horizons – except for the environmental NGO's. The 2-5 year time horizon was the most popular for all types of organisations. The next most popular time-scales for private businesses and Industry associations were 1 – 2 years, and 1 – 12 months. The second preference of Government bodies, Indigenous associations, and NGO's was for a 5 – 10 year horizon.

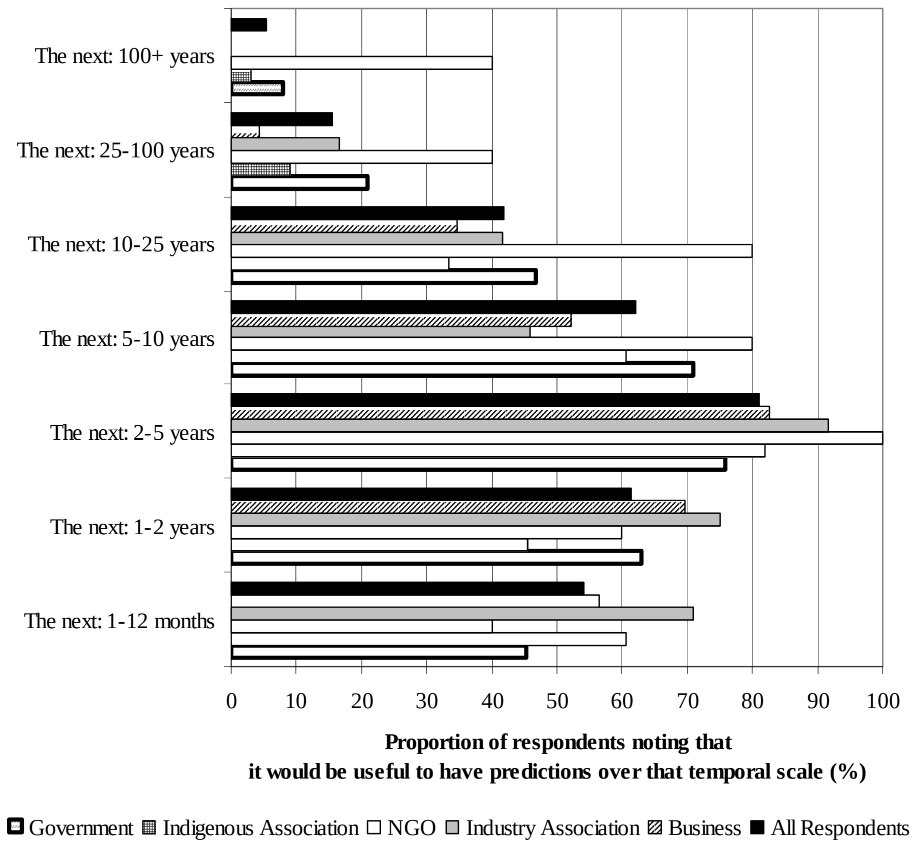


Figure 3-2: Stakeholder interest in predictions over different temporal scales

3.3.3 Interest in particular sectors/segments of the economy

Questions 7 and 8 both included some parts/prompts that aimed to determine the level of interest in particular sectors – eg asking about interest in monitoring employment in the region, then asking about interest in monitoring employment within specific industries or sectors within the region. If the respondent indicated that they were interested in data for a specific sector, they were asked to indicate which sector.

There was substantial interest in monitoring the impact of change on specific industry sectors – particularly Tourism, Mining and Agriculture (not surprising given heavy reliance of Savannas economies on those industries, and the way in which the sample was constructed). There was also much interest in being able to consider the Indigenous sector separately, and in being able to separate information on small-business from information on large business.

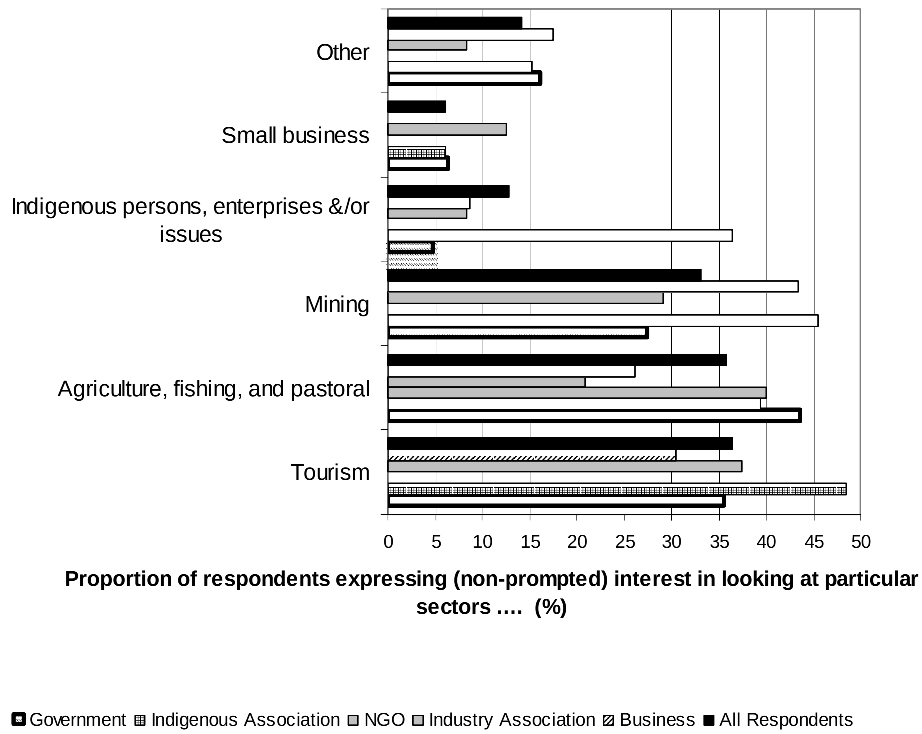


Figure 3-3: Respondent interest in particular sectors (non-prompted answers)

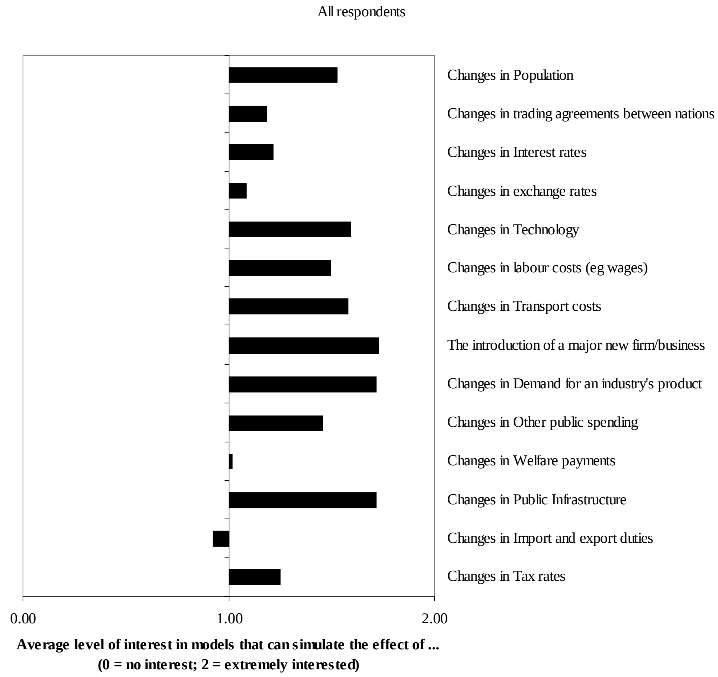
3.3.4 Interest in modelling <u>different types of change</u>

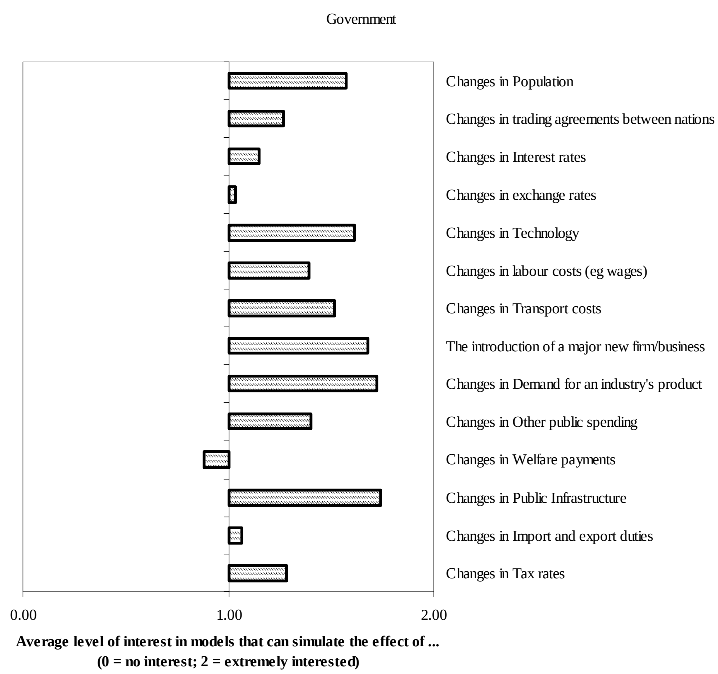
Recognising that different models make predictions about the impact of different types of change, respondents were provided with a list of changes frequently considered. They were then asked to indicate (on a three point scale) how interested they – or others within their organisation – would be in a model that could simulate such changes: *not at all interested* (given a value of 0); *moderately interested* (given a value of 1); and *extremely interested* (given a value of 2).

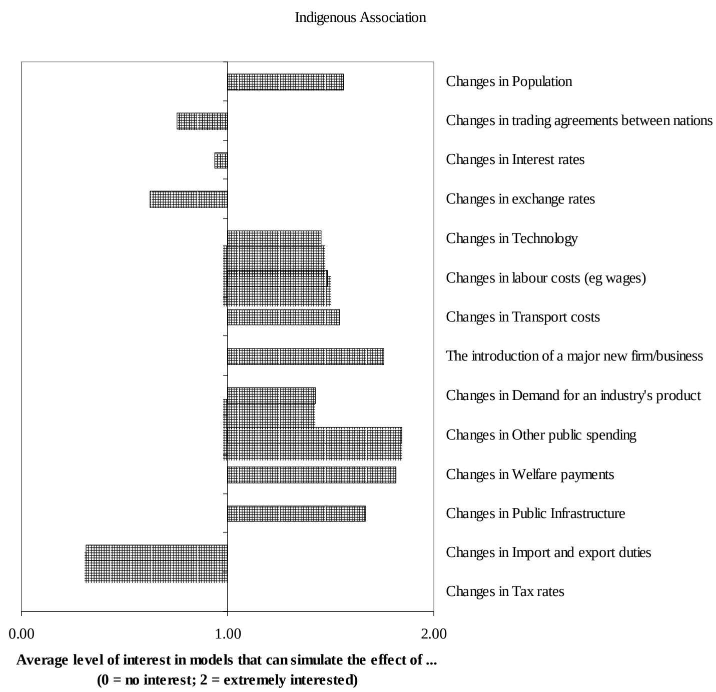
These results are summarised in Figure 3-4 – which is comprised of six separate graphs. The first graph shows the average level of interest in simulating the effect of different types of change across all respondents. Most interest is shown in models that can simulate the effect of changes in public infrastructure, in changes in demand for an industry's product and/or in the introduction of new businesses.

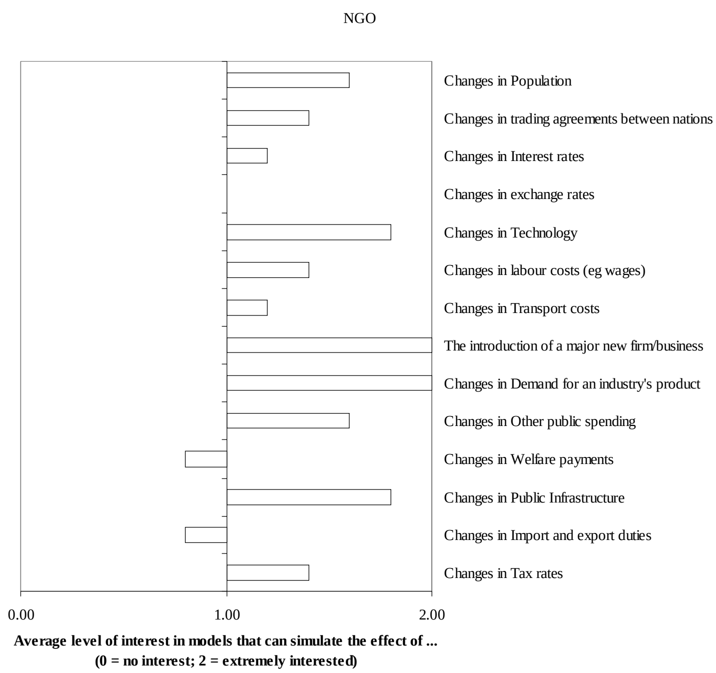
The other five graphs show responses for each of the five different stakeholder groups (no 'bar' in the chart indicates that average level of interest was exactly equal to 1 - *moderately interested*). The combined order of preferences across all groups also applies to government organisations and NGO's (although NGO's were also interested in modelling changes in technology). The top three areas of interest for Indigenous associations included modelling changes in public spending (non-infrastructure), in welfare, and in the introduction of new firms. Businesses were interested in modelling changes in demand, new firms, and changes in production costs (labour and transport).

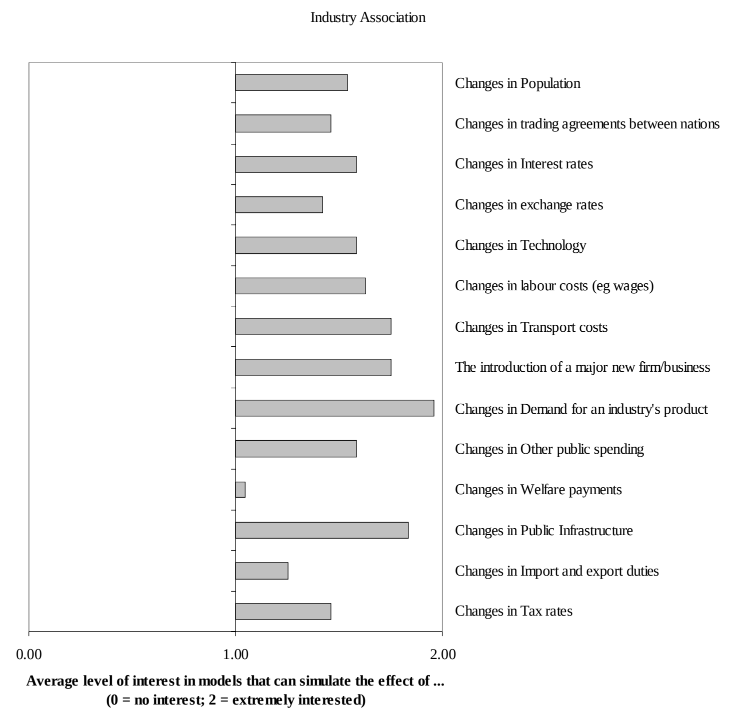
Industry associations were primarily interested in demand, infrastructure, new firms and transport costs. Little interest was shown in models that could simulate changes in exchange rages, interest rates or welfare payments.






Indigenous Association
Changes in Population
Changes in trading agreements between nations
Changes in Interest rates
Changes in exchange rates
Changes in Technology
Changes in labour costs (eg wages)
Changes in Transport costs
The introduction of a major new firm/business
Changes in Demand for an industry's product
Changes in Other public spending
Changes in Welfare payments
Changes in Public Infrastructure
Changes in Import and export duties
Changes in Tax rates
0.00
1.00
2.00
Average level of interest in models that can simulate the effect of ...
(0 = no interest; 2 = extremely interested)


NGO
Changes in Population
Changes in trading agreements between nations
Changes in Interest rates
Changes in exchange rates
Changes in Technology
Changes in labour costs (eg wages)
Changes in Transport costs
The introduction of a major new firm/business
Changes in Demand for an industry's product
Changes in Other public spending
Changes in Welfare payments
Changes in Public Infrastructure
Changes in Import and export duties
Changes in Tax rates
0.00
1.00
2.00
Average level of interest in models that can simulate the effect of ...
(0 = no interest; 2 = extremely interested)



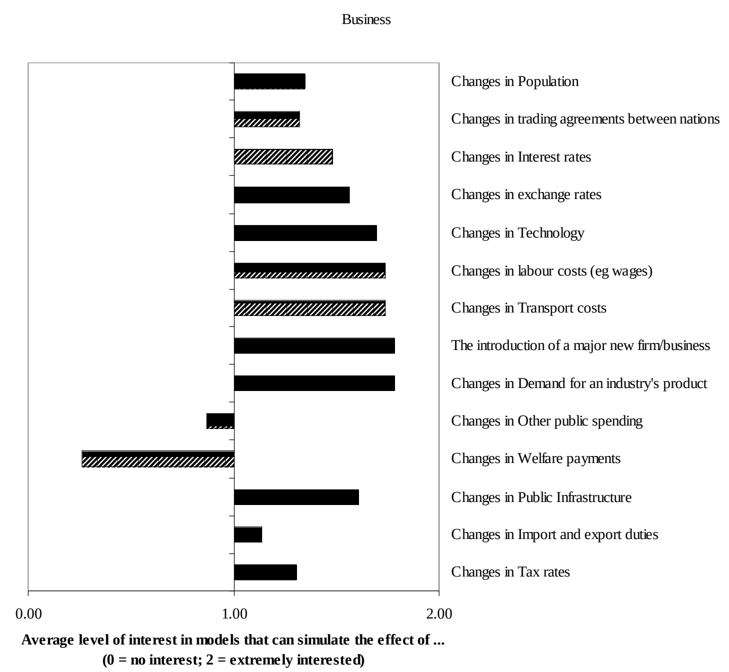


Figure 3-4: Stakeholder interest in modelling different types of 'change'

Open-ended comments indicated that there was a substantial interest in health and education. Other areas of interest were associated with defence, roads, law and order. Defence was mentioned as a source of revenue in the area and not the need for defence as such. Figure 3-5 shows proportion of respondents mentioning (non-prompted responses).

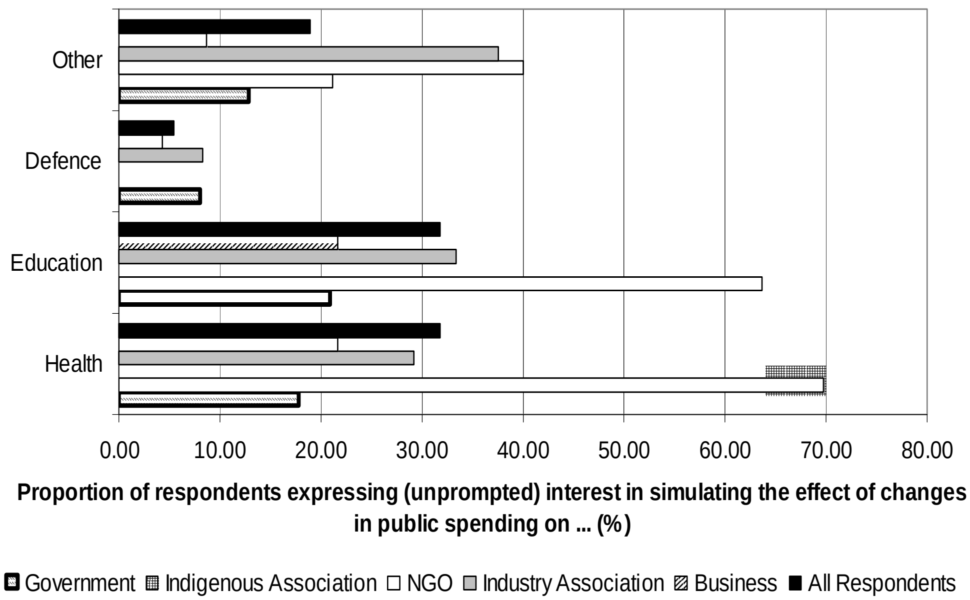
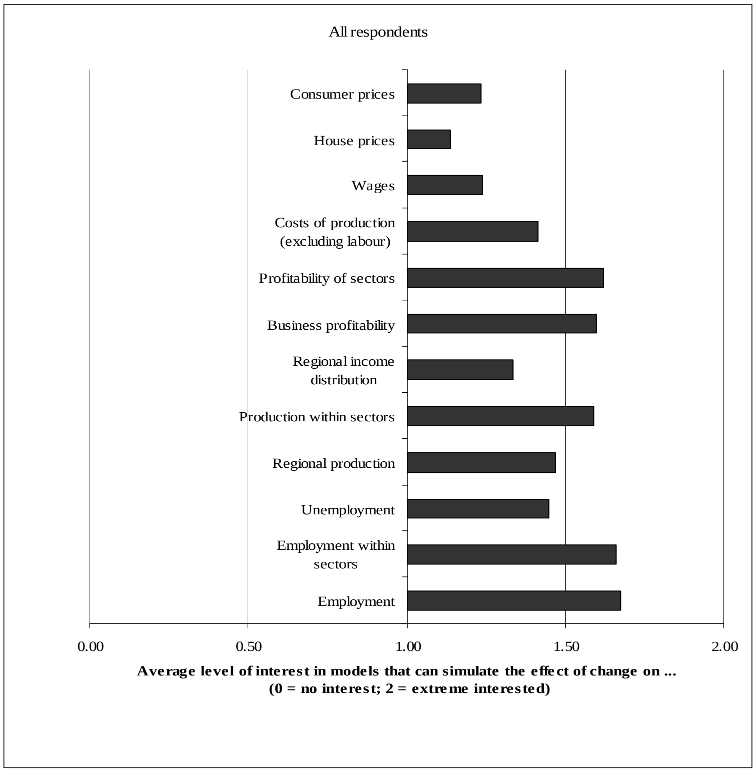


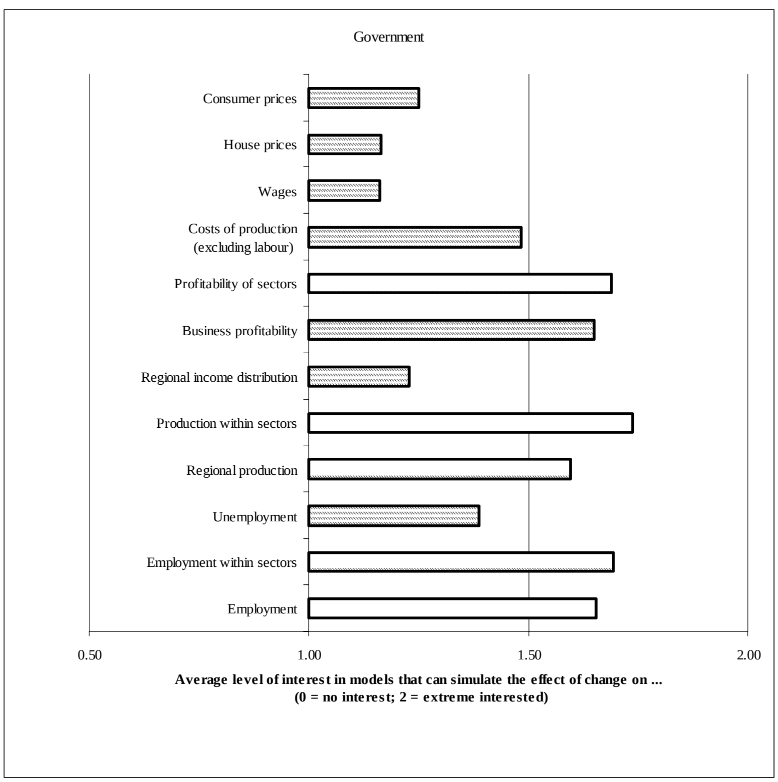
Figure 3-5: Stakeholder interest in simulating the effect of changes in different types of public spending (non-prompted responses)

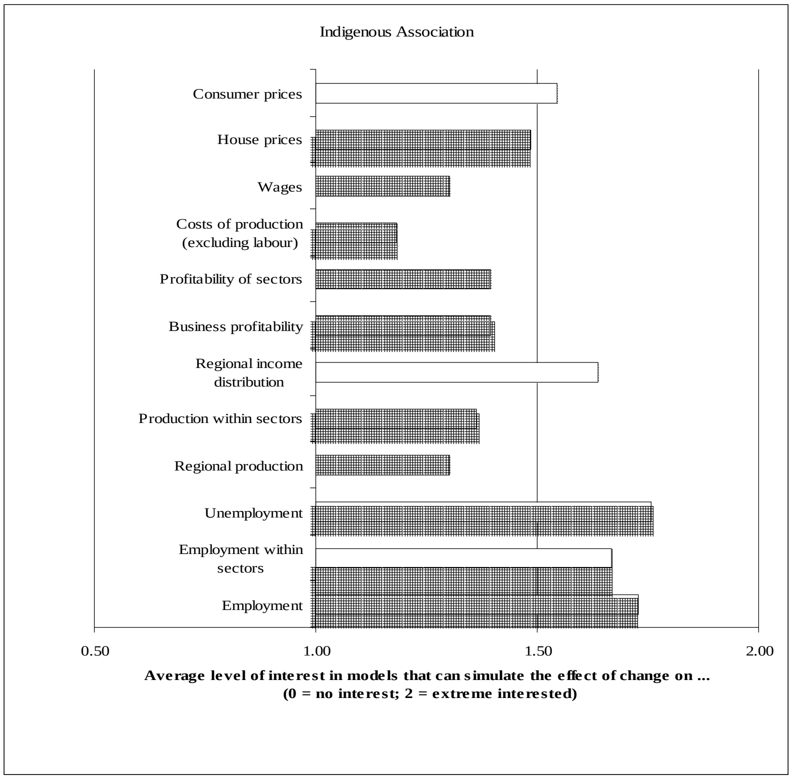
3.3.5 Interest in modelling different impacts of change

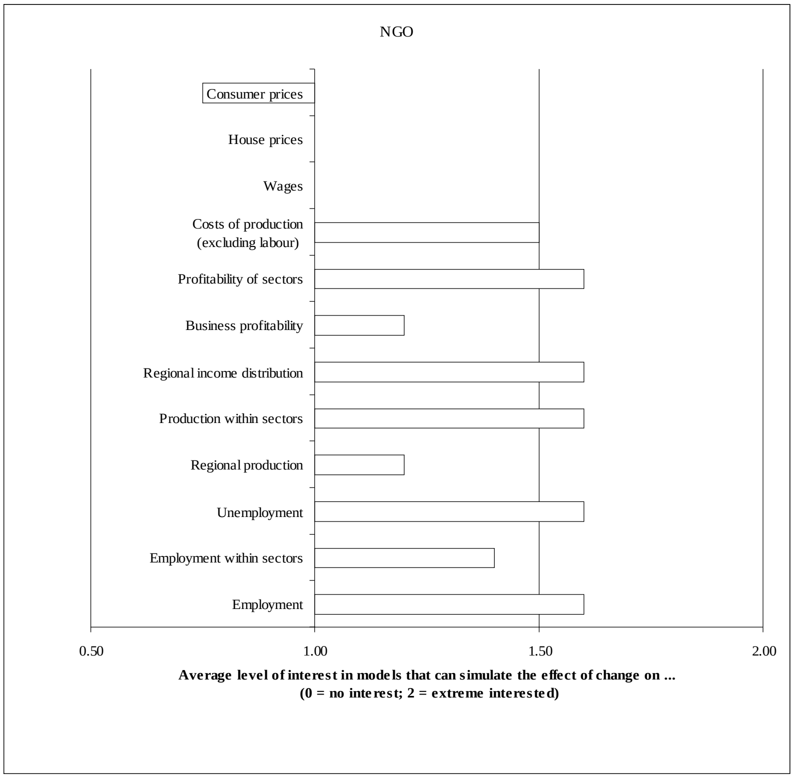
Different simulation models also make predictions about the impact of different types of change on different variables (eg. the impact of a change in 'x' on regional unemployment, or on the profitability of regional businesses). To gauge interest in different impacted variables, respondents were provided with a list of impacts frequently considered by economic models. They were then asked to indicate (on a three point scale) how interested they would be in a model that could simulate such changes: *not at all interested* (given a value of 0); *moderately interested* (given a value of 1); and *extremely interested* (given a value of 2). Average responses by organisation type are shown in Figure 3-6 (no 'bar' in the chart indicates that average level of interest was exactly equal to 1 - *moderately interested*).

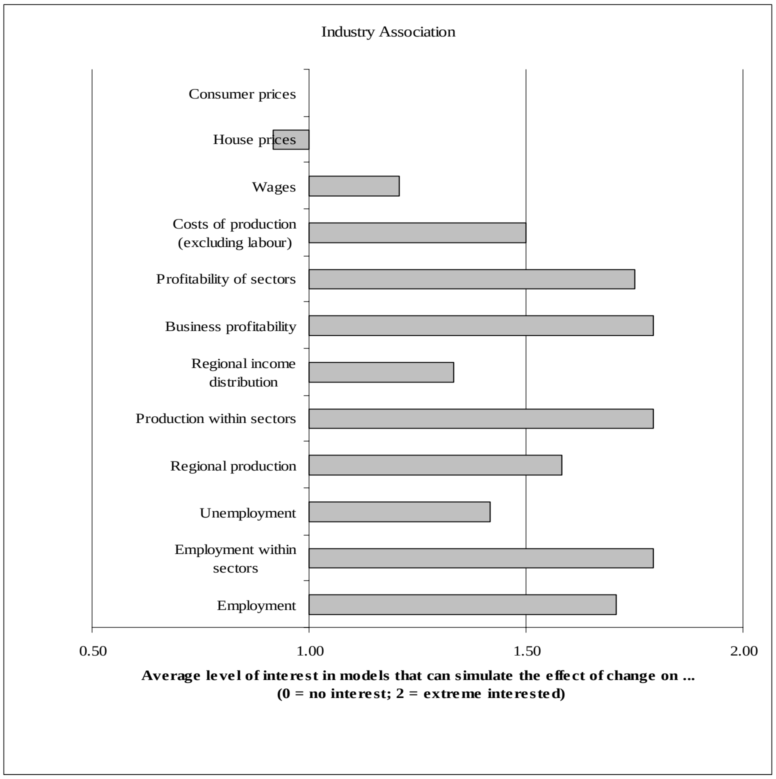
Across all respondents, most interest was shown in modelling the impact of change on employment, production and profitability – in aggregate and at the sectoral level. This was also true of Government organisations and NGO's (although NGO's were also interested in monitoring the gap between rich and poor). Indigenous associations were more interested in monitoring the impact of change on unemployment, employment, and income distribution. Businesses and industry organisations were more interested in profits and employment.


All respondents
Consumer prices
House prices
Wages
Costs of production (excluding labour)
Profitability of sectors
Business profitability
Regional income distribution
Production within sectors
Regional production
Unemployment
Employment within sectors
Employment
0.00
0.50
1.00
1.50
2.00
Average level of interest in models that can simulate the effect of change on ...
(0 = no interest; 2 = extreme interested)


Government
Consumer prices
House prices
Wages
Costs of production (excluding labour)
Profitability of sectors
Business profitability
Regional income distribution
Production within sectors
Regional production
Unemployment
Employment within sectors
Employment
0.50
1.00
1.50
2.00
Average level of interest in models that can simulate the effect of change on ...
(0 = no interest; 2 = extreme interested)


Indigenous Association
Consumer prices
House prices
Wages
Costs of production (excluding labour)
Profitability of sectors
Business profitability
Regional income distribution
Production within sectors
Regional production
Unemployment
Employment within sectors
Employment
0.50
1.00
1.50
2.00
Average level of interest in models that can simulate the effect of change on ...
(0 = no interest; 2 = extreme interested)


NGO
Consumer prices
House prices
Wages
Costs of production (excluding labour)
Profitability of sectors
Business profitability
Regional income distribution
Production within sectors
Regional production
Unemployment
Employment within sectors
Employment
0.50
1.00
1.50
2.00
Average level of interest in models that can simulate the effect of change on ...
(0 = no interest; 2 = extreme interested)



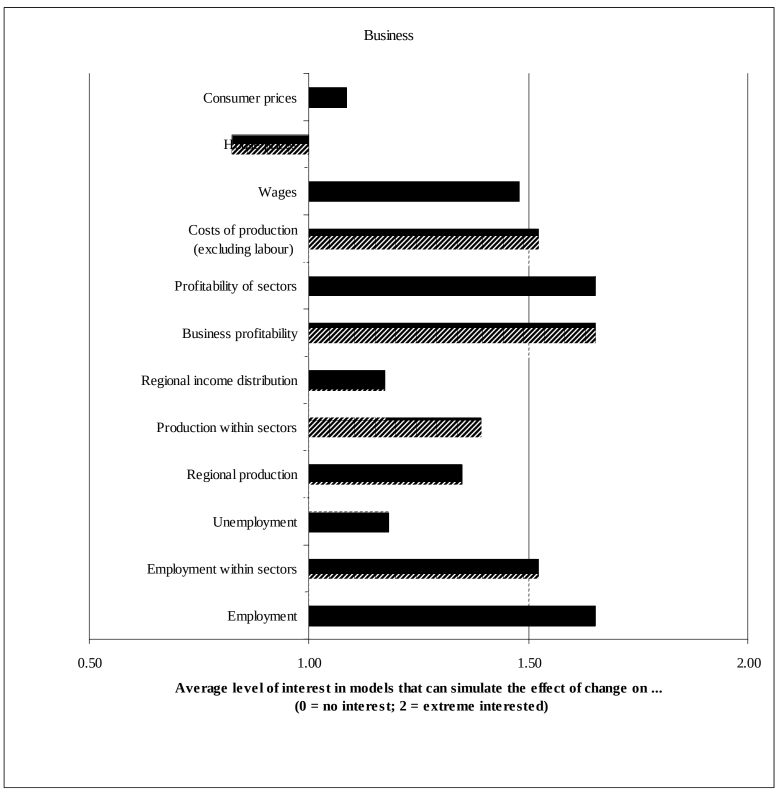


Figure 3-6: Stakeholder interest in modelling different impacts of 'change'

Table 3-3: Non-prompted interest in 'other' issues by stakeholder group

	Type of respondent	Number
Health	Total	59
	Indigenous Associations	33
	Government	14
	Business	4
	Industry Associations	7
	Other	1
Education	Total	54
	Indigenous Associations	24
	Government	18
	Business	4
	Industry Associations	8
Indigenous persons (culture, health, way of life, financial well-being, etc)	Total	53
	Indigenous Associations	46
	Government	3
	Business	4
Biodiversity / Environment issues	Total	37
	Indigenous Associations	6
	Government	22
	Business	3
	Industry Associations	2
	NGO	4
Land Condition	Total	31
	Indigenous Associations	3
	Government	23
	Business	1
	Industry Associations	1
	NGO	3
Prices (transport, commodity prices, house prices, etc)	Total	31
	Government	22
	Business	3
	Industry Associations	5
	NGO	1
Demand for infrastructure	Total	27
	Indigenous Associations	3
	Government	16
	Business	4
	Industry Associations	4
Climate Change	Total	23
	Indigenous Associations	3
	Government	14
	Industry Associations	4
	NGO	2
Indigenous Employment	Total	19
	Indigenous Associations	17
	Government	2
Water Use	Total	19
	Government	14
	Business	1
	Industry Associations	2
	NGO	2
Migration and seasonal employment	Total	10
	Government	5
	Business	3
	Industry Associations	2
Defence	Total	8
	Government	5
	Business	1
	Industry Associations	2
Law and Order	Total	5
	Indigenous Associations	3
	Government	1
	Industry Associations	1

3.3.6 Non-prompted interests: Change and Impacts

Questions 7 and 8 both included open ended questions asking respondents to mention other issues that they would be interested in having included in a model (either so they could see the change, or so that they could monitor the impact). Sometimes the respondents used these questions to reinforce an emphasis on an issue made earlier in the questionnaire. The results are shown in Table 3-3. There was strong interest in health, education, Indigenous, and environmental issues (including biodiversity, land condition and climate change).

3.4 Characteristics of models capable of generating 'relevant' information

A tabular summary of the results of the survey is provided in Table 3-4 and Table 3-5. Overall, they indicate that:

1) All groups of respondents were primarily interested in their own LGA.
2) All groups were primarily interested in a time horizon of 2 – 5 years.
3) There was widespread interest in the agriculture, mining and tourism sectors amongst the respondents. Some respondents, particularly in the NT, were interested in the defence industry.
4) Government organisations, NGOs and industry organisations were all interested in public infrastructure developments. All organisations were interested in changes in demand for their products. Indigenous and government organisations, NGOs industry associations and businesses were all interested in the impacts of new firms for different reasons. In some cases, there was concern because of potential competition, in some cases there was hope that the new firms would introduce new technology and ideas, and in the case of Indigenous organisations there was the hope that the new firms would create employment opportunities. The Indigenous organisations were also very interested in changes in government expenditure and welfare benefits.
5) Health and education was of major interest to all categories of respondents, other then the NGOs, and health was not of major concern for industry associations, though education was presumably because of businesses' need for educated employees.
6) Employment and unemployment, output by sector and profits were of great and widespread interest amongst the respondents. The impacts of changes in interest rates, exchange rates, inflation, wages and non-labour costs of production were of secondary interest to the respondents.
7) Some respondents were interested in the interaction between economy and the environmental and social characteristics of the region.

Importantly, points (1) and (2) do not mean that there is no accepted role for longer-term or larger-scale predictions. Many stakeholders were interested in longer-term predictions and/or predictions over a larger scale (as shown in the bar charts which depict the proportion of respondents expressing an interest in predictions over different time and geographic scales). What this narrow focus of interest does mean is that

LGA's and 2-5 year time frames were the most popular. Similar comments apply to other items in the questionnaire –'least popular' does not mean 'unimportant'.

Table 3-4: Summary of stakeholder interests – prompted responses

Stakeholder group	Geographic Focus Top 3, in order*	Temporal Focus Top 3, in order*	Sectoral Focus Top 3, in order*	Interest in change Top 3, in order*
All	LGA Local town State	2 - 5 years 5 - 10 years 1 - 2 years	Tourism Agriculture Mining	New firm Infrastructure = Demand
Indigenous Associations	LGA Local town State	2 - 5 years 5 - 10 years = 1 – 12 months	Tourism Mining Agriculture	Public spending Welfare New firm
Government	LGA Local town State	2 - 5 years 5 - 10 years 1 - 2 years	Agriculture Tourism Mining	Infrastructure Demand New firm
NGOs	LGA State = Savannas	2 - 5 years 5 - 10 years = 10 - 25 years	Agriculture	Demand New firm =technology Infrastructure
Industry Associations	LGA Local town State	2 - 5 years 1 - 2 years 1 – 12 months	Tourism Mining Agriculture	Demand Infrastructure Transport costs = New firm
Business	LGA State Local town	2 - 5 years 1 - 2 years 1 – 12 months	Mining Tourism Agriculture	Demand New firm Labour & transport costs

* '=' indicates same rank/level of importance

Table 3-5: Summary of stakeholder interests – unprompted responses

Stakeholder group	Public sector spending focus Top 2, in order*	Interest in Model impact Top 3, in order*	Issues considered frequently Top 3, in order*	Un-prompted extra issues mentioned Top 3, in order*
All	Health = Education	Employment Employ x Sector Profit x Sector	Employment Profit x Sector Employ x Sector	Health Education Indigenous persons (culture, health, way of life, financial well-being, etc)
Indigenous Associations	Health Education	Unemployment Employment Employ x Sector Income Dist	Welfare Unemployment Employment	Indigenous persons (culture, health, way of life, financial well-being, etc) Health Education
Government	Education Health	Output x Sector Profit x Sector Employ x Sector	Employment Interest rates Employ x Sector	Land condition Biodiversity / Environment issues = Prices (transport, commodity prices, house prices, etc)
NGOs	Other	Income Dist = Output and profit x Sector = Employ and Unemployment	Unemployment Business Profitability	Biodiversity / Environment issues Land condition Climate change = Water use
Industry Associations	Other Education	Profit = Output x Sector = Emp x Sector	Profits x Sector Interest rates Wages	Education Health Prices (transport, commodity prices, house prices, etc)
Business	Health = Education	Profit = Profit x Sector = Employment	Exchange rates Interest rates = Inflation = Costs of Production (non-labour)	Education = Health = Indigenous persons (culture, health, way of life, financial well-being, etc) = Demand for infrastructure

* '=' indicates same rank/level of importance

Finally, it is worth noting that this research did not intend to – nor was it designed to – determine whether the overall goal of developing a fully integrated model of the Savannas was a good one. Nonetheless, it is worth mentioning that many of those interviewed in the stakeholder survey were extremely enthusiastic about the project: not simply because they were interested in the model per se, but because they were interested in having access to the data/information that such a model would require.

4 Assessment of modelling approaches

Whilst the previous chapter set out to assess model relevance, this chapter sets out to assess practical and theoretical issues associated with several 'classes' of predictive economic models – those most common in the empirical literature[6].

The chapter begins with a brief discussion of some key practical and theoretical issues associated with economic modelling. The 'classes' of models are then analysed, the discussion paying particular attention to:

- Type of information generated. Is the technique (theoretically at least) suited to the task of developing a dynamic, predictive model?
- Data/input and modelling requirements. Is it operationally feasible to collect enough data and information to apply/develop such models in the Australian Savannas? If not, could one 'scale up' or 'scale down' existing data or use existing data sources to create useable 'synthetic' data sets to run the model?
- The underlying assumptions. Are the underlying assumptions appropriate? If not, are model results sensitive to underlying assumptions? Is it possible to change underlying assumptions (where necessary) to improve model performance?
- The ability to interface with other disciplinary approaches. Can the model be integrated with other disciplinary perspectives to work towards the development of the large-scale model.

Ideas from the assessment are briefly summarised at the end of this chapter before proceeding to the concluding section (chapter 5) where insights from this section are synthesised with insights from the stakeholder survey, thus identifying broad classes of modelling approaches that are theoretically robust, operationally feasible and likely to be able to answer questions/address issues that stakeholders are interested in.

4.1 Practical and theoretical issues of modelling the Australian Savannas

4.1.1 Data

In the Australian Savannas, data – like people – are scattered sparsely, and unevenly, across the landscape. Where data are available, there are significant spatial and temporal inconsistencies that are largely attributable to differences in data collection methods, aggregation processes and collection/aggregation boundaries. This poses a significant challenge for those interested in developing an integrated regional dynamic

---

[6] The discussion excludes Cost-Benefit analysis, since that well known technique is primarily useful for assessment rather than for prediction/analysis. So too, have forecasting models been excluded from the analysis – they usually use highly aggregated time-series data on just a few variables to generate forecasts about the likely time paths of those variables over the next few quarters. They do not generally contain either sectoral or regional detail, and are hence, unsuited to the task at hand.

model that uses data from multiple sources (with multiple spatial and temporal scales). The options available to modellers include:

i. Collecting data at an aggregate level and 'scaling down'

   Whilst techniques are available for 'scaling down' models from large regions into smaller ones (Flegg et al, 1995) care must be taken since structural differences between regional economies makes it difficult to simply scale the data, the model or the final estimates from larger to smaller areas. As illustrated in McCann and DeWhurst, (1998), for example, there is no simple, linear relationship, between the size of a region and the size of its multiplier: the spatial relationships depend, *inter alia,* on the spatial distribution of industry and economic linkages between such industries.

ii. Collecting data at a micro level and 'scaling up'

   Such an approach would seek to collect relevant data by survey, and/or observation. In general, it would not be practical to collect data for all individuals across the Savannas, but a well designed, stratified random sample could generate useful information that would allow one to draw valid inferences about the population as a whole. Nevertheless, it could prove costly to collect the breadth of data required by some models, meaning that this option may need to be combined with other options.

iii. Drawing inferences about one region using data/information from another region

   Baaijens et al (1998), use meta-analysis to consider factors influencing the magnitude of regional tourist income multipliers that have been estimated in a cross section of different research studies. A significant outcome of their investigation is that they are able to identify situations when researchers can 'transfer' estimates of multipliers from one, similar, region to another thereby circumventing the need to generate region-specific estimates. A similar solution (that results from quite a different approach) is given in Chang (2001) – who estimates Input-Output tables for 114 regions, using information from them to generate 'look-up tables' for regional tourism multipliers. Also, Harris and Liu (1998) demonstrate a process by which one can generate a 'hybrid' local IO table, using local survey data to tailor/alter larger-scale tables to regional conditions.

iv. Creating 'synthetic' data sets (closely related to *iii*)

   Another alternative – of working with synthetic data – has been clearly demonstrated by the National Centre for Social and Economic Modelling (NATSEM). They recently developed a method of creating synthetic data (Melhuish, et al, 2002) for small areas. The method essentially looks for data matches on similar variables from different surveys. When a match is found, data from one survey is combined with data from the other survey, creating a 'synthetic observation'. Figure 4-1 illustrates this process with an extremely simple example. Here, it is assumed that two surveys have been conducted – one collecting information about the income and geographic location of individuals, and one collecting information about the income and expenditure of individuals. When a match is found on the common variable (income), data from both surveys is combined to create a new 'observation' / synthetic individual with data from each survey. The actual process is considerably more complex than that described here

(NATSEM does this with a re-weighting technique, although it could be done by bootstrapping, or by markov-chain-monte-carlo simulations) – but the key point remains: namely that there are techniques for creating synthetic, spatially disaggregated data sets.

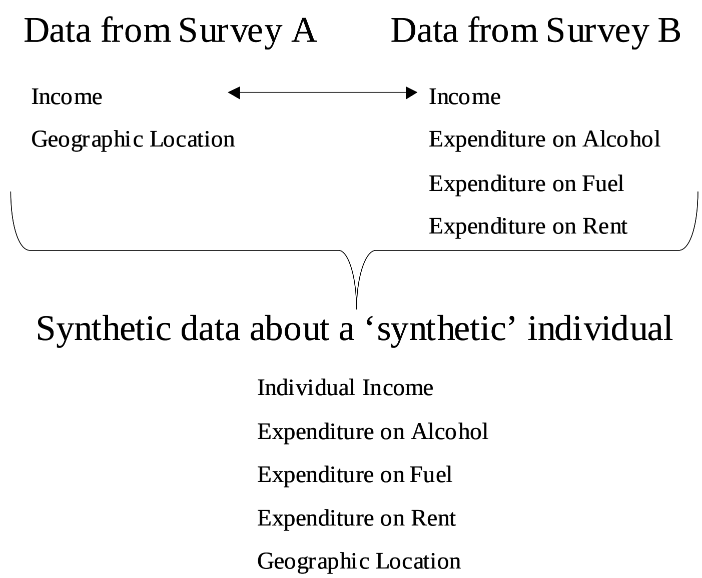


Figure 4-1: A stylised representation of the way in which synthetic data is created

Clearly, all of these data-creation/collection processes are fraught with difficulties, all consume resources, and all will have some deficiencies. But if faced with a choice between no data, or deficient data, one will often find that deficient data is the lesser of two evils. That said, one needs to be careful with the way in which model outputs are presented and interpreted – taking the opportunity to conduct some type of sensitivity analysis of final results.

4.1.2 Assumptions underlying particular methods/estimation techniques

If one wishes to develop a predictive, dynamic model, then one will need to build a model that is mathematically computable. Problems/issues that cannot be treated technically, and converted into mathematical formulas may need to be omitted from the model (perhaps running the model whilst assuming such problems do not exist, and then providing a qualitative discussion of ways in which their existence might alter the model's predictions). An alternative (often adopted in economics) is to adopt simplifying assumptions that allow one to create a skeletal representation of the key problems, including that representation within a larger model. Ideally, these simplified representations ensure that the models are analytically and mathematically tractable, but do not distort empirically observable behaviour (although most analysts will try to include a qualitative discussion of key issues after the computable model has been run – the main aim being to highlight ways in which the key simplifying assumptions may or may not have distorted model predictions).

In most cases, the law of large numbers works to the economists' favour – extreme observations in some parts of the population are counteracted by extreme observations in another part, with the average observation following familiar and predictable patterns. However, when working with small samples – as is the case in the Savannas – extreme observations in some parts of the population may not be counterbalanced by other observations. Hence the need to carefully scrutinise assumptions underlying models before simply 'applying' them to a new situation.

Specific examples of assumptions that need to be scrutinised (highlighted in Stafford-Smith et al, 2003) include:

a) Assumptions about market equilibrium. Does the model assume that an economy that is subjected to a shock returns to some sort equilibrium? If so, over what time period? Does this apply to all markets within the economy?

b) Behavioural assumptions. Does the model require 'rationality'? Are agents assumed to optimise? What goals are agents assumed to have? What assumptions are made about the way in which expectations are formed, and how are these integrated into the model?

c) Assumptions about inputs into the production process (factors). Does the model assume that all factors of production are fully utilized or does some form of un(der) employment exist? Does the model assume that changes in the availability of factors of production (eg. population growth rates, the accumulation of physical, institutional, social and/or human capital, etc), is exogenously given, or determined endogenously.

d) Assumptions about production technology. What assumptions are made about the way in which various inputs (including physical, human, social, institutional, environmental, etc) combine to make various outputs? How are these assumed to change over time?

e) Assumptions about market structure and price flexibility (eg whether they are perfectly competitive, monopoly, or somewhere in between).

f) Assumptions about the market distortions (eg externalities etc). How are the 'activities' (and the impact of activities) of economic 'agents' linked to other parts of the system? Are non-economic systems ignored, or is it possible to make provision for interaction between the economic system and other, related, systems?

It must, however, be remembered that there is not always a direct link between the quality/reality of underlying assumptions and the quality/reality of model predictions. A striking example of this is Ptolemy's "model" of the solar system (i.e. circular orbits). For astronomers interested in describing actual elliptical orbits, such a model is not useful, yet for navigators it works well – not only is it simple to use, but it generates accurate information about one's global position. The key message here, therefore is that a model should not be tested solely on the validity of its underlying assumptions – the true test of a model is whether it is able to generate accurate information of the type required by users.

4.2 Generic types of models / modelling approaches

4.2.1 Input-Output models

Input-output (IO) analysis is, perhaps, the most well known tool of regional economists. First used in the USSR, it allowed analysts to examine industry links within an economy. The philosophy behind its approach is as follows:

To manufacture 7 million pairs of brown leather shoes, for example, one needs leather, glue and rubber. To manufacture leather, one needs hides and chemicals. To manufacture hides, one needs cattle and fodder. So changes in the demand for shoes can impact upon pastoralists – the key issue, being by how much. If one collects data for all final goods and services (or outputs) within a regional economy, one can construct a 'transactions table' – a table that describes how much of each type of input (or input category) is used in the production of each type of output (or output category). This allows one to consider inter sectoral linkages, and to make predictions about the change in inputs that would be required to meet a change in the production of an associated product.

In Australia, IO tables are produced regularly at the national and state levels. IO tables for smaller regions are produced much less frequently – Queensland Treasury generally produces transactions tables at the statistical division (SD) level once every 5–10 years. Few agencies/organisations produce transactions tables at smaller geographic scale – although some groups will make them, on request and for payment, at the statistical local area (SLA) level.

When producing such tables, it is possible for the client to specify the level of sectoral detail subject to data availability. Most existing tables use the ABS's Industry classification codes – at either the 2 or 3 digit level. This can pose something of a problem for those interested in tourism since there is not a one-to-one correspondence between the sectors/industries normally used by ABS and those directly relevant to the tourism industry. Those interested in the tourism industry, therefore need to think across several sectors, or develop tourism-specific tables.

Given the costs involved in collecting data for transactions tables (the building block of IO analysis), it is not surprising to find that regional models are often constructed from national IO tables. This works well if the underlying structure of the regional economy closely approximates the national economy, but adjustments need to be made if that is not the case (Berck and Hoffman, 2002: 140). The problem of obtaining data at small regional scale is relevant to all economic models – as discussed earlier.

Data problems aside, as a descriptive tool IO analysis has much to offer – particularly if one is interested in the examining the economic linkages between different sectors, and/or the links between a region and the 'outside world'. However, there are several problems with its use as a predictive model.

First, although it is relatively easy to model the impact of a change on the 'demand side' of the economy (eg changes in demand for the output of one sector), it is more difficult to use IO to simulate changes that originate from the supply side of the economy (eg change in quantity and/or access to a resource). As noted by Berck and Hoffman (2002: 144), natural resource projects or policies such as opening a mine or restricting harvesting a forest, do not really follow the logic of these demand-driven multiplier models – such changes are perhaps better modelled using techniques that handle the supply side more easily.

Secondly, when calculating multipliers from IO tables, one is required to assume that marginal changes are approximately equal to average changes. This is because the transaction tables used in IO analysis summarise the average proportion of business expenditure within each sector/industry that is spent in all other sectors/industries. So when one uses the tables to estimate the impact of an increase in demand in one sector, one is implicitly assuming that the extra revenues received by that sector will be distributed according to the current, observed (average) expenditure patterns[7]. From a business perspective, this is equivalent to assuming that inputs are used in fixed proportions (i.e. Leontief technologies) and that production technologies are constant across time. IO analysis will, therefore, likely provide better estimates of the impact of relatively small changes in expenditure (that do not alter production techniques) than of the impact of larger changes.

Importantly, IO analysis also assumes (even if only implicitly) that prices are constant. As discussed in section 3, this is not valid in the medium-to long term, since changes in one market may generate changes in price, which may cause changes in demand for other products, which then generate changes in that market (etc etc). In other words, IO analysis fails to consider longer-run 'feedbacks'. Multipliers generated from IO analysis will therefore tend to overestimate the long-run effects of change.

In other words, because IO models do not allow for changes in technology (production techniques) or prices, they are best thought of as either providing high quality descriptive information about an economy's current sectoral linkages, or (slightly) lower quality information about the short-run impact of marginal changes.

The assumptions underlying the most 'basic' version of an IO model are probably too restrictive to be useful to those interested in developing a fully integrated, long-term dynamic, predictive model of the Tropical Savannas. In particular, the assumptions that production technologies do not change, that prices are constant, and that changes are relatively small, are not well suited to the Savannas environment where changes are often substantial (the introduction of a new mine in a region with very few people is not a 'marginal' change, and will likely impact upon both prices and technology), and impacts play out over long time horizons.

This is not to say that IO is of no use to those interested in regional dynamic modelling. The 'traditional' approach to input-output analysis has been adapted to allow for dynamic relationships (Leontief & Duchin 1986; Robinson & Duffy-Deno 1996; Nabors et al 2002). IO models can also be adapted to allow for multiple regions – eg the core-periphery models of Hughes and Holland (1994) – and to allow for economy-environment interactions (Cumberland 1966; Huang *et al.* 1994; Hawdon & Pearson 1995; Gustavson *et al.* 1999; Eder & Narodoslawsky, 1999). They can also be

[7] From the perspective of a householder, using observed expenditure patterns to predict changes in expenditure that may result from changes in income, is tantamount to assuming that the marginal propensity to consume (MPC) is equal to the average propensity to consume (APC). Ceteris paribus, if consumption (C) is a linear function of income (Y), comprised of both an autonomous (C_A) and an induced component that increases with income[7] (C_I), then the higher is the MPC and/or the smaller is C_A relative to Y, the closer will the APC be to the MPC, and the more 'palatable' will be the assumptions underlying IO analysis.

extended to consider distributional impacts – using what is termed a SAM (social accounting matrix – see Berck and Hoffman, 2002). SAMs are similar to IOs, but households are usually disaggregated by income or other demographic characteristics and government is disaggregated by level of government. In other words, more sophisticated IO models – that allow for dynamic relationships, multiple regions and economy-environment-society interactions are likely to be more appropriate to the task at hand – then the 'basic' models discussed above.

Importantly, IO models have also been adapted to allow for non-linear relationships between inputs and outputs (Wang 2001). Liew (2000), describes a dynamic version of the 'original' leontief input-output model. Rather than using leontief production technology, it uses cobb-douglas production functions, thereby allowing for input substitutability. It also allows for dependence between price and output (including prices in the technical coefficients); and for the dynamic effects of factor market adjustments that incorporate inter-regional migration. The model allows one to consider both short-run and long-run multipliers (although Liew notes that the model could be improved by relaxing some of the assumptions about the production technology and/or resource abundance and by including a spatial dimension). In some sense, therefore, the dynamic variable input-out model is but one version of a computable general equilibrium model – a class of model discussed below.

4.2.2 Computable general equilibrium (CGE) models

Most CGEs require an IO/transactions table as their core database, to which researchers add systems of equations that specify relationships between the different sectors identified in the core. Some CGE's are thus best thought of as sophisticated IO models, with the following common set of characteristics (Wilcoxen, 2004):

- Multiple interacting agents
- Behaviour derived from optimization
- Multiple markets
- Often highly disaggregated
- Finds a decentralized equilibrium rather than optimizing a planner's objective function
- Includes prices (and costs) – shown in relative terms (eg compared to a numeraire)
- Designed for policy analysis

The greatest advantage of a CGE is the flexibility that it grants to model developers. They do not have to simply accept the assumptions inherent in IO analysis – instead they can specify their own production (and/or consumption) technologies (See Woollett et al, 2003:9).

CGE models are, in other words, collections of equations describing different sectors of an economy, which are solved simultaneously. In many cases, the simultaneous solutions assume that all prices in all markets have adjusted to ensure that all markets clear (hence the term "general equilibrium" models). Yet this does not have to be the case – CGE's can, in practice, have non-equilibrium features (such as involuntary unemployment) and recent technological, statistical/econometric and theoretical advances have enabled researchers to develop sophisticated models that are capable of simulating the short-run and long effects of multiple changes across multiple sectors using a variety of different 'internal' assumptions about prices, production technologies, etc (Rose, 1995).

For example, Pakko (2002) uses a general equilibrium framework that incorporates stochastic technology trends to look at transition paths (from one, long-run 'equilibrium' to another) following changes in technology. Maffezzoli (2001) uses a stochastic version of a dynamic general equilibrium model, to consider impulse response functions in Italy and in the US (referring to the approach as one which incorporates 'non-Walrasian' features). Beaudry and Green (2002) present a (mathematical, rather than computable) general equilibrium model, the aim of which is to explore links between population growth, the price of technology, and employment; and Giesecke (2000), uses a CGE model to investigate why the Tasmanian economy was growing slower than the Australian economy.

In short, there are many different types of CGE models. At the broadest level, it is possible to differentiate two classes: comparative static and dynamic. The comparative static models typically compare the state of any economy *with* a policy change and the state of an economy without the change. They do not provide any details of the adjustment path and the broad timeframe of the model is specified by the closure conditions (short-run models typically consider time frames of 1 – 2 years, longer run models typically looking at time-frames of 8 – 10 years). Dynamic models are typically recursive – performing year-to-year simulations with several types of inter-temporal links that are generally specified as accumulation relationships for capital stocks. Those interested in developing a dynamic, predictive model of the Savannas, may tend to find dynamic CGE's more useful – primarily because they provide information about the total change over time, and the period of transition.

Although most of the early CGEs considered a single region, multi-region CGEs are now relatively common, and these are built using three general approaches: 'top down', 'bottom up' or some combination thereof ('hybrid').

Top-down Models

As noted by the Centre of Policy Studies (CoPS, 2004) at Monash University, top-down models generally start with a large, aggregated database and build a single model that simulates the effect of change. Regional impacts are modelled by distributing the aggregate effects across regions.

Top-down CGE models therefore recognise regional variations in quantities, but not in prices. They therefore tend to lack regional/geographic detail – and cannot generally allow for region-specific supply changes. The upside to this is that 'top-down' models use much less data and computing time, allowing researchers to consider greater sectoral detail then they might otherwise be able to.

Bottom-up models

In contrast, bottom-up multi-region CGEs consist of multiple, independent models that are linked via trade and primary factor flows. Such models allow for considerable regional detail (across quantities and prices) and therefore require much more data, and modelling effort. This tends to come at the cost of less sectoral detail.

Hybrid models

'Hybrid' models – like the MMRF-GREEN – have some bottom-up characteristics (eg MMRF's model of the 8 Australian states) and some top-down characteristics (eg MMRF's method of breaking down each set of state-wide results into 10 or more sub-state regions).

Like IO models, CGEs can be readily customised to include physical interactions with the environment. Thus, there is a large body of research and expertise to draw on here. Some have been tailored to focus are specific sectors of interest (as when Queensland Treasury adapted the Monash MRF model to develop QGEM-T, a model that explicitly deals with the tourism sector – see Woolett et al, 2003), and research between Monash University's CoPs and the University of Canberra's NATSEM is underway on methods of linking CGEs with Microsimulation models (discussed in more detail below) that specialise in monitoring the distributional impact of policy change. Once developed, these techniques might later be adapted so as to allow researchers to consider the distributional impacts of change across different types of households that are differentiated, for example, by Indigenous status – a differentiation that would clearly satisfy the needs of many stakeholders in the Australian Savannas. Some overseas CGEs (eg the IMAGE and INGENUE models) also allow for overlapping generations (agents that live at different times), endogenous growth, and stochastic variations (Maffessoli, 2001).

This ability to specify relationships, add sophisticated twists, aggregate or disaggregate data and define appropriate assumptions gives model developers significant flexibility. CGEs therefore have the potential to create a more realistic representation of an economy than IO models. However, this comes at the cost of significantly greater data and modelling requirements. For example, the ORANI-NT model (based upon ORANI – a widely used Australian model developed by Peter Dixon in the 1970s[8], comprised more than 7983 variables, in 3249 equations (Knapman et al, 1991) and the Monash model (which used ORANI as its base and which is discussed in more detail below) took nine years to develop.

In short, greater flexibility does not necessarily equate to superiority: "most CGE analyses have a thin empirical base, and modellers are forced to make heroic assumptions regarding transboundary flows, production structure, and household behavior" (Rose 1995:301). As with most modelling exercises, the key here, is data: it matters not how good the equations are, if the numbers that are fed into the equations do not accurately describe the region one wishes to model.

There are currently many applied CGE models of the Australian economy – a large proportion of which have built upon ORANI. Several of the models are specifically designed to model the national economy and its relationship with the rest of the world (eg Gtem, G-Cubed, Austem). More relevant here, are those that focus on Australia, its states, and regions within those states. These include: the Monash suite of models

[8] See, for example, Breece et al 1994

and the Murphy Regional Model (MMR); Federal F (a CGE model of Tasmania and the rest of Australia); and the QGEM suite of models (for Queensland and the rest of Australia). Of those, the Monash suite of models and Murphy's regional model are most relevant, primarily because they include all of the Australian Savannas and have some level of regional detail.

The information set out in Figure 4-2, taken from the CoPS web-site, summarises some of the key characteristics of the Monash suite of models. The last column – added by the authors – provides similar information on the Murphy Model Regional (MMR).

Model	MONASH	MMRF	MMRF-GREEN	TERM	MMR
Type of regional modelling	Top-down	Bottom-up	Bottom-up	Bottom-up	Bottom-up
Region-specific prices	No	Yes	Yes	Yes	Probably (since bottom-up)
Region-specific quantities	Yes	Yes	Yes	Yes	Yes
Typical no. of sectors	113	around 40	around 40	around 40	18
Typical no. of regions	8 states or 57 statistical divisions	8 states	8 states (but see below)	57 statistical divisions	32
Forecasting (year-to-year dynamics)	Yes	No	Yes	Under development	No
Region-specific demand-side shocks	Yes	Yes	Yes	Yes	Yes
Region-specific supply-side shocks	No	Yes	Yes	Yes	Probably (since bottom-up)
State Government Accounts module	No	Yes	Yes	Under development	Probably not (?)
Other features			Detailed modelling of CO_2 emissions; within-state top-down breakdown to statistical divisions	Exports and imports distinguished by port of exit/entry. Sectoral and regional aggregation tailored to particular simulations	Configured so that individual industries can be treated as either producing tradeables or non-tradeables, depending on what makes more economic sense in the context of the particular regional policy.

Figure 4-2: The Monash Suite of CGE's and the Murphy Model Regional

In short, CGEs appear to offer themselves as an attractive option for those interested in developing a dynamic predictive model of the Australian Savannas that could be readily integrated with other perspectives. It must, however, be noted that the applied CGE models that are currently available in Australia are probably not at a fine enough geographic scale to be of immediate use. As noted in the previous chapter stakeholders within the tropical Savannas are primarily interested in data at a smaller regional scale, eg. at the LGA level. The Monash Model is a hybrid CGE – with each of the 8 states and territories modelled separately (using a bottom up approach). Predictions derived from each state-wide model are then transferred to 57 smaller regions within the states (generally statistical divisions) using a top-down approach – although the Monash team are currently working on a model that will provide genuine bottom-up predictions of 57 regions within Australia (the TERM model). The MMR model (regional Murphy Model) also provides information at the state and sub-state level, although there are only 32 sub-regions in total (one of which, for example, comprises all of the Northern Territory).

Consequently, there would need to be a further scaling down of results. One way of doing so would be to develop a hybrid model that is based on Monash's TERM (currently under development), allocating predictions from it across LGAs using top-down approaches (subject, of course, to the availability and quality of data). As noted earlier, the primary problem with top-down approaches is that they do not allow different regions to face different price vectors. A hybrid model such as this would partially circumvent this (modelling each statistical division separately), but would not adequately deal with SDs that contain significant inter-regional price variation. If such an approach were taken, it might, therefore prove useful to use the hybrid model as a stepping stone towards the development of a genuine bottom-up model of LGAs within the Australian Savannas (again, subject to the availability of good quality data). CoPS (2004) notes that in practice, the number of regions *plus* the number of sectors must not exceed 100. In the short term, this may prove to be a problem if aiming to develop a model with many more regions, yet technological advances are likely to occur in the interim, serving to relax that constraint in the near future.

4.2.3 Growth theory and associated models

Historically, economists who were concerned with determinants of economic growth and development tended to work with 'growth models'. These models told researchers how to organise data (normally highly aggregated time-series data) and analyse it using econometric techniques (eg. regressing 100 years of data on gross domestic product against measures of land, labour and capital). The hypothesis underlying such an approach was that one could use historical evidence to determine the way in which different 'quantities' of land, labour, technology and capital affected economic growth.

Neither the intent, nor the outcome of economic growth theory was to make sectoral predictions about the effect of change – rather it was to understand past determinants of growth, in the hope that it would 'flag' issues that might need to be focused on if interested in nurturing future growth. On their own, these models are not, therefore, well suited to the task at hand. Furthermore, growth models generally require long streams of historical data on key economic variables – data that is not generally available in the Australian Savannas.

This is not to say, however, that research in this area has nothing to offer those interested in developing a dynamic, predictive model of the Australian savannas. This is particularly so, when considering the way in which changes in health, education, and population affect the structure of regional economies.

To be more specific, it is worth noting that older, 'neoclassical' growth models – like that developed by Solow in the 1950s/1960s typically assumed that the long run growth rate was determined exogenously (by the rate of technological advancement). More recently, however, researchers have looked at the way in which changes in physical capital, human capital, and economic policy can have a permanent effect on the rate of economic growth, by affecting the rate of growth in productivity. Termed *Endogenous Growth Theory*, research of this nature implies that it may be inappropriate to simply examine 'steady-state' equilibria – one may need to use *transition dynamics* to explore 'transition paths' from one growth path to another.

This is particularly relevant to those attempting to develop dynamic, predictive models (IO, CGE, or otherwise). First, the predictions of static models are generally sensitive to their 'closure' conditions and these closure conditions often contain equations, and/or assumptions about capital, labour, and productivity. As noted by Church et al (2000: 112), "The supply-side of a model determines its long-run properties". Second, dynamic models are often developed as recursive runs of static models, each recursion linked to the next using equations that relate to capital, capital accumulation, and – either directly or indirectly – productivity. If changes in population, health and/or education affect productivity, then model parameters may need to be changed when moving from one period to the next, and growth theory economists may be able to shed some light on the types of changes that may be necessary (or desirable) in different situations.

Examples of investigations into determinants of economic growth are numerous. Hugget (2003), for example, develops a theoretical model of monotone comparative dynamics, identifying conditions that are necessary and sufficient for determining whether an increase in a parameter (say, the discount rate) will generate a permanent increase in future dynamics (eg. increase the capital stock for all future periods). Mateos-Planas (2002) uses a neoclassical growth model with dynastic preferences, but with endogenous fertility to examine the link between mortality changes, technological progress, and the evolution of the cost of children. Hendricks (2001) urges the use of overlapping generations models (as is done in Rasmussen, 2003), and Bellettini and Ceron (1999) use a game-theoretic approach in an overlapping generations model with endogenous growth to investigate the joint determination of social security, public investment and growth. It has also been noted (Ghiglino, 2002) that growth rates are affected by the accumulation of capital, and the accumulation of knowledge – both of which are affected by a variety of factors including: the costs and benefits of innovation; discount rates; uncertainty; attitudes toward uncertainty; development of financial and insurance markets, socio-economic conditions, etc.

Interestingly, Ghiglino (2002: 2) concludes that because these factors are so interwoven, and so complex, that endogenous growth theorists may need to use general equilibrium models to investigate the issues – despite the fact that "The complete integration of endogenous growth theory into general equilibrium theory is a daunting task". Here again, it seems that growth theory, on its own, may not offer itself as a productive avenue of research for those interested in developing a predictive, dynamic, integrated model of the Australian Savannas – but insights from this field may prove invaluable if attempting to calibrate, refine and/or supplement other modelling approaches.

4.2.4 Vector auto regressions

A vector auto regression (VAR) is basically a collection of regression equations that are estimated simultaneously. Generally, each regression equation contains time-series data – the dependent variable being regressed against lagged values of itself, and of other variables. Engle and Granger's 1987 cointegration theory provides econometric structure – allowing one to examine both long-term equilibrium relationships and (short-term) adjustments to changes by way of error correction mechanisms (See Marquez et al, 2003 for empirical example in a single, small regional economy; and Partridge and Rickman, 2002, for and example of a structural VAR that investigates the relative importance of labour demand versus labour migration in regional labour markets).

VARS generally work with relatively aggregated datasets and therefore lack the sectoral detail of IO models, SAMS or CGEs. Furthermore, like growth- models, VARs require time-series data. Consequently, they are not well-suited to the task of developing an integrated, dynamic, and predictive model of the Australian Savannas. Nevertheless, they allow one to use observable data to explore relationships – generating testable hypotheses. Hence, the technique may provide those who have developed (or who are in the process of developing) applied predictive models with a means of testing, and calibrating relationships specified within.

4.2.5 Game theory, agent-based models and evolutionary economics

Game Theory is a special type of model that uses multi-person decision theory. Although there are hundreds – perhaps thousands – of different types of 'games' that have been developed, most consider the problem faced by multiple agents in terms of

a) Their preferences;
b) The information that is available to them;
c) The course of action available to them; and
d) The payoffs which depend, interactively, on the action(s) of other agents.

From a policy perspective, game theoretic models are particularly useful since they can help identify outcomes that are the logical consequences (or inevitable result) of the game's underlying assumptions – termed *Nash Equilibriums*. If, for example, one is able to identify an undesirable outcome ('X') that is the logical consequence of 'Y', and if policy makers are able to influence 'Y' then they may be able to prevent 'X' from occurring. Such models, therefore, have most to offer in the policy development/formation stage – particularly when the range of different outcomes that might result from a policy are large, and are likely to depend interactively on the way in which individuals react to that policy.

Related to these models are agent-based models. Like the game theoretic approaches, these models also consider the problem faced by multiple agents, and the impacts of their combined, sometimes uncoordinated actions. Unlike game theoretic models, agent based models do not always pre-suppose (or look for) the existence of *Nash Equilibrium(s)* - instead one can set up an agent-based model that simply 'runs', adaptively, the primary reason for doing so, being that it may help the researcher determine what could happen in given a range of different starting conditions and/or behavioural rules. As noted by Radzicki (2002: 142) "Although an agent-based modeller knows the decision rules of the individual agents at the start of a simulation, he or she does not know the type of behaviour that will emerge at the aggregate level as the system evolves."

Such approaches to modelling are particularly useful if the modeller has good quality information about the preferences and options available to individual agents. These models also allow researchers to incorporate adaptive behaviour – where strategies change in response to other changes in the system. This approach, in essence, incorporates ideas from Chaos theory into the agent-based models.

Nijkamp and Reggiani (1995), review much of the regional science literature, investigating the relevance of chaos theory for spatial economics. Not surprisingly, leaders in this area of research are frequently found at the Sante Fe Institute (one of the founding institutions of Chaos Theory). Sometimes termed 'evolutionary dynamics', much of this research combines insights from ecology, chaos, psychology, econometrics, growth theory, business cycles, the theory of structural change and game theory into dynamic models that can deal with problems of 'bounded rationality', endogeneity, transition paths, etc (See, for example, Ponti, 2000; Darley and Kauffman, 1996; Arthur et al, 1996; and Forst et al, 1995).

As noted in Stafford-Smith et al (2003), multi-agent adaptive modelling, informed by concepts of complex adaptive system, is increasingly used in exploring the likely impacts of different management strategies on natural resources (Carpenter *et al.*1999), and the dynamics of the rangelands under different policy and institutional regimes (Janssen *et al.* 2000). Janssen and Vries (1998) used both simulations and optimisation for a multi-agent model with adaptive responses to climate change. The models were run in parallel – passing information back and forward interatively with each model 'building' upon output from the other.

Like CGEs these types of models are extremely flexible – giving researchers great freedom to focus attention, define behaviours and enforce assumptions. Also like CGEs, the price paid for this flexibility, is significant: it is extremely time consuming to identify, define, and model the interactive behaviour and outcomes of multiple agents. The more numerous and/or diverse the agents, the more complex the task. In practice, researchers can simplify the problem by categorising and aggregating 'agents'. This can be done on the basis of collective worldviews (Janssen & De Vries 1998), mental models, and roles (Carpenter *et al.* 1999).

What this means operationally, is that those working with game theoretic / agent based modelling approaches face the opposite problem to those working with IO and CGE models. IO / CGE modellers frequently start with highly aggregated data (both sectorally and regionally), and must seek to disaggregate the information down to a meaningful scale. In contrast, those seeking to develop regional game theoretic and/or agent based models must start with micro-level data (eg individual preferences) and seek to aggregate information upwards to a meaningful scale.

To date, there has been little applied work on such models in Australia, and the authors of this report could not find an operational example of an applied game theoretic and/or agent-based model addressing regional economic in Australia. This is a relatively new area, however, and such models may start emerging soon. Researchers in CSIRO's division of Sustainable Ecosystems[9], for example, are in the process of developing an agent-based model to investigate institutional arranges in Australia's Outback, and there may be other groups around Australia, working on similar, or related modelling problems.

Further, it may be possible to use ideas from agent-based models in combination with other modelling approaches. Eg. Rather than using individuals as agents, one may be able to use economic regions as agents, using other economic modelling approaches to generate regional results, but integrating those results with outputs from other disciplinary modules using an agent based approach. On its own, an economic region may not be 'complex' or chaotic, but when links with other sub-systems are considered, the aggregate result may well be. The great strength of agent based modelling is that it allows these complexities to 'evolve'.

4.2.6 Systems models

Other innovative approaches to modelling regional dynamics use 'systems dynamics' (time-step simulations) with multiple modules allowing both within-module and across-module interactions.

The *Ecological Modelling* Journal presented a special section on Modelling ecological and economic systems with STELLA – a time-step simulator with modules for the economy and the environment (Costanza and Gottlieb, 1998; Woodwell, 1998; and Grasso, 1998). "Because of the ease with which [Stella] can be modified and run, the model is especially useful for testing assumptions about the connections. It can also be used to show how models of this type are sensitive to changes in parameters and specification, especially in the case of the technology term" (Costanza and Gottlieb, 1998: 232).

Perez-Trego et al (1993) suggest a modularised spatial dynamic modelling framework (there are rural and urban modules across the agricultural, industrial and service sectors for: demand; incomes; populations movements; and the environment). Guo et al (2001), use eight different sub-systems (modules) including: population, agriculture, industry, tourism, water-resources, pollution control water-quality and forests, in a time-step simulation. Costanza *et al.* (1993) modelled sustainable development at the regional scale using a set of system dynamics modules that were interconnected to a geographical information system and Hall *et al.* (2000) did likewise in their Costa Rican study. "The integration of spatio-temporal processes by interfacing dynamic

[9] Contact Dr Daniel Walker, CSE, Davies Laboratory in Townsville for further details.

modelling with GIS represents the cutting edge of …. modelling" (Moffatt & Hanley 2001:546).

In Australia, Queensland's Department of Natural Resources, Queensland's Department of Primary Industries, and the Commonwealth Scientific and Industrial Research Organisation, have developed an Agricultural Production Systems Simulator (APSIM) along similar lines (multiple, complex modules, which interact – or 'share variables' – at the end of each simulated 'time-step'). There is also considerable Australian expertise on simulators of grasslands in the Savannas ("Savannas.au") – as evidenced by the biophysical component of this Predicting Regional Dynamics project (work being carried out by researchers in CSIRO SE, CSIRO LW and Qld DPI).

Applied Australian examples of systems that integrate regional economic modules[10] with biophysical (or other) modules are rare, but they do exist. For example, the Australian Bureau of Agricultural and Resource Economics (ABARE) is currently working to develop a modelling system that "provides forecasts of farm financial performance for the coming financial year, given the expected impact of forecast climatic conditions on crop and pasture growth (Kokic and Nelson, 2003). ABARE is also looking at the regional economic effects of a potential incursion of Karnal Bunt - using an agent-based simulation model to determine when incursion might occur, and an I/O model to consider wider economic implications of the incursion (Elliston et al, 2004). Outside Australia, Nabors et al (2002) use a systems simulation model to estimate the regional economic impact of wholesale energy rate increases. The economic portion of the analysis was performed using REMI (a dynamic IO model discussed in section 4.2.1), whilst the energy dynamics were integrated using the ENERGY 2020 model. Evidently techniques for integrating biophysical models with regional economic models are not fully developed, but are certainly on the current research agenda.

The most important point to be made here is that research in this area suggests that it may be possible for researchers to build a fully integrated model of the Australian Savannas using a piecemeal approach. That is, they could develop separate modules that are informed by specific disciplinary insights and then integrate those components within a systems framework that allows for cross-module 'sharing' of mutual variables (using insights from other integrative projects such as the REMI/ENERGY 2020 model, and/or the Murhpy (forecasting) suite of models).

4.2.7 Micro-simulation models

Used extensively by the National Centre of Social and Economic Modelling (NATSEM) at the University of Canberra, micro-simulation models are designed specifically to analyse the impact of different types of changes/policy on different groups of individuals or households.

NATSEM has several models: the Harding model, STINMOD, and DYNAMOD. The static model (STINMOD) considers the financial impact of policy changes (like

---

10 Although there are examples of applied systems model that incorporate micro-economic variables/modules – eg SPUR (Simulating Production and Utilization of Range Land), and SPUR2, and DAM EASY.

changes to tax rates, to the medicare levy, etc) on different types of households &/or individuals. The dynamic models (HARDING, DYNAMOD-2 and GEMSIM – currently under development) are time-step models, taking monthly steps for most demographic and labour market processes, and annual steps for education and earnings. They subject the individuals in a large population to the chances of various 'events' occurring (eg birth, death, becoming unemployed, etc), generating predictions about the way in which the characteristics of the population are likely to change over time and/or about the 'life-paths' of individuals.

The above-mentioned suite of models use data from several sources including the five yearly Census of Population and Housing conducted by the Australian Bureau of Statistics (ABS), and the ABS's Household Expenditure Survey. Although the census data provides much regional detail, the other data sources do not. Consequently, these models cannot provide regional detail to predictions. However, researchers at NATSEM are currently working on methods of getting around this problem – combining the information-rich survey data with the geographically disaggregated Census data to create 'synthetic' data sets (See section 4.1.1 for more detail). These data sets can be used within the microsimulation models (SYNAGI) to look at the geographic distribution of the 'impact' of different policies (Melhuish et al, 2002). As noted by Rey (2001), it may also be possible to use Markov transition matrices to analyse spatially disaggregated data sets to consider the regional dimensions of transitional dynamics.

The Australian Research Council is funding Researchers from NATSEM and from CoPs are to look at ways of linking one of the Monash's applied CGEs with NATSEM's microsimulation models. As reported on NATSEM's web-site, they have already used 'top-down' approaches to the links (using the Monash model to generate aggregate predictions about income and relative prices, and then feeding those into STINMOD to consider the distributional impacts of the changes) and are looking towards developing 'bottom-up' linkages (where predictions from the microsimulation models re, for example, the income effect of tax changes, are fed into the CGE, to look at the flow-on effect that such a change might have upon the demand for products in particular sectors).

If it is possible to do that which is described above, then it should also be possible to develop similar 'top-down' and 'bottom-up' approaches that will allow one to consider the distributional impact of different policies across different regions, and/or across Indigenous and Non-Indigenous households. Although still in its embryonic stages, research like this clearly has much to offer and rapid progress is to be expected.

4.3 Models showing promise from a theoretical / practical perspective

The main point of the analysis/research discussed in this section was to draw attention to some of the practical, and theoretical issues associated with different modelling approaches commonly adopted by economists. Hence the focus on issues relating to data availability, assumptions underlying models, and existing links to other disciplinary models (or potential to develop links).

Whilst Input-Output analysis, growth theory, vector-auto regressions and micro-simulation models could be usefully applied in the tropical Savannas, on their own they are not designed to be used as predictive dynamic models. They are, therefore ill-suited to the task at hand. However, this is not to say that they have nothing useful to contribute. Input-output tables, for example, are a required data-input into most CGE models (which are designed to generate long-term predictions of the impact of change). Further, other modelling approaches can be validated with empirically based models (eg vector auto-regressions), and insights from growth-theory can be used to form useful links with other disciplinary perspectives (and to 'calibrate' long-term dynamics). Likewise, micro-simulation models can be linked to other predictive models – their key strength being that they allow researchers to model the distributional impact of change (rather than just the overall effect). Such approaches do not, therefore, offer themselves as useful 'bases' for the larger-scale project, but they do offer themselves as useful addendums.

Of the remaining modelling approaches, CGE's, evolutionary, game-theoretic and agent-based models show most 'theoretical' promise. This is primarily because these modelling approaches do not require researchers to assume that one size fits all and apply a single set of (sometimes pre-determined) assumptions across the entire region. Instead, researchers can tailor the model to suit individual circumstances: eg. the models can be adapted to allow for multiple types of market failures.

A key point to be made here, is that researchers may be able to use insights from all of these modelling approaches to develop a fully integrated model of the Australian Savannas using a piecemeal approach. One could for, example use the output from an regional economic model as an 'agent' in an agent based model. This would allow one to see what will emerge across the entire system when agents act simultaneously, yet interactively. In short, one could use a non-adaptive equilibrium based economic model, within a agent-based systems framework, to explore a complex, and adaptive system (for which, quite possibly, there is not 'equilibrium'). Further details are given in the final section of this report.

5 Summary/Conclusions

5.1 Stakeholder interests

Chapter 3 provided the results of the survey of stakeholders' views on what they would find most useful in terms of a model. Based on the summary of the responses, the basic requirements for the economic component of a suitable model are the following. It would:

1. Allow for shocks and produce results at the LGA region
2. Have a time horizon of 2-5 years.
3. Include at least the following sectors: government administration, health, education, tourism, agriculture, mining, non-residential construction and defence.
4. Enable shocks and produce results for the following: outputs, costs of production and profits for each of the above sectors, employment overall and by sector, the level of unemployment; welfare payments (of secondary importance to stakeholders was the ability to enable shocks and produce results for wages, interest rates, prices and inflation rates, exchange rates and taxes).
5. Model the interaction between the economy and the environmental, demographic and social characteristics of the region.
6. Separately model the Indigenous section of the economy.
7. Be generally accepted in the research and policy communities, which means, among other things, that all of its specifications, equations and data should be in the public domain. That is, the model should be "open and contestable".
8. Be capable of extensions and developments so that it can be adapted to address new research questions.

NB: Items 7 and 8 do not explicitly arise from the questionnaire but follow from the need to ensure confidence in model results and adaptability to new data, information and perspectives.

Importantly, the focus of stakeholder interest in their LGA and short time frames (2-5 years), does not mean that there is no accepted role for longer-term or larger-scale predictions. Many stakeholders were interested in longer-term predictions and/or predictions over a larger scale. What this narrow focus of interest does mean is that LGA's and 2-5 year time frames were the most popular.

That said, the LGA focus is probably a sensible one from an economic perspective. As highlighted earlier, there are vast differences in the economic structure of small areas in the Savannas, even those that are adjacent to each other. A region that is almost entirely dependent upon tourism for its income, will need quite different information than one which is almost entirely dependent upon mining, or agriculture, or defence. Evidently, stakeholders in the top-end do not find economic information that has been 'averaged' across a larger area to be particularly useful. This poses some non-trivial modelling challenges, not the least of which is scarcity of data – data (and models) covering the entire Australian economy are readily available, but to the best of our knowledge there are no currently available regional economic models (or data sets) across the top end at the LGA level.

As regards the relatively short time frame so popular amongst stakeholders – we suspect that it probably reflects the planning horizons of those interviewed (that imposed by electoral cycles and/or strategic plans, etc). This is not to say that models with longer time-frames have little to offer; they may be used by fewer people, but those that do use them could extract some particularly useful information from them.

As recently as 20 years ago, the CRC may have been forced to 'choose' between a short-term or a long-term model, since economic models were not generally capable of handling both short-term and long-term issues. But recent advances in IT have allowed for the development of techniques that allow one to follow 'transition paths', in essence mapping the impact of change over time. No longer, need one choose between one timeframe and another. That said, it is more challenging to develop such models, primarily because:

- Models which ONLY deal with the very short-term (e.g. less than one year) allow one to make some simplifying assumptions (e.g. fixed prices and wages) that make the computing/equations easier to write.
- Models that ONLY look further into the future (e.g. at least 10 years) also allow one to make some simplifying assumptions (e.g. that prices and wages 'adapt' to the situation). Here too, these equations can be relatively simply
- Models that are able to deal with the 2-5 year time frame are more difficult to construct since they need to be able to handle transitions/dynamics as both prices and quantities adjust to changes.

Hence the need for careful scrutiny of modelling options, before beginning work on what could be a long-term, large-scale project.

As noted earlier, there are many different types of economic models and modelling approaches – and much theoretical work has been done on issues relevant to small and/or sparsely populated economies. The desk-top analysis highlighted the fact that from a theoretical perspective, there are several economic modelling approaches that are worthy of consideration. These include a range of economic growth models (Mateos-Planas 2002), computable general equilibrium models, systems dynamics models (Radzicki 2002), game theoretic, and agent-based models (Stafford-Smith 2003). While these all have theoretical appeal, the most promising candidates from a data and stage-of-development viewpoint are computable general equilibrium models (which are also capable of providing information at the temporal, regional and sectoral levels identified as being most relevant to stakeholders). Agent-based modeling approaches show promise when combining interdisciplinary approaches.

To many, this 'list' of promising approaches may seem a little short – but for those looking for examples of applied models, a key issue is that remote areas have typically fewer people and smaller economies. This poses several, problems.

First: modelling is inherently more difficult with small numbers, where standard deviations are typically large and market distortions may be the norm rather than the exception. This poses some 'interesting' – but not insurmountable – modelling challenges. Note: many of the currently available applied economic models that are reasonably complex (in terms of their ability to deal with market failures and other related problems) began as simplistic models of 'large' economies with little market failure. As researchers became adept at manipulating such models – and as substantial improvements were made in information technology – interest began to turn towards more complex problems. Nowadays, a substantial proportion of the modelling literature, focuses on problems, issues and methods of dealing with smallness, market failure, etc. Not all problems are solved – but many methods are under development and rapid advances in IT make the application of complex models a realistic goal.

Second: small regions tend to attract smaller amounts of research funds – the inevitable consequence being that there are fewer, high-quality, applied models of 'small' economies than there are of large economies. This does not mean that there are fewer techniques; just fewer applications, on which to base new research. Hence the relatively short 'short-list' of promising modelling approaches.

5.2 Promising modelling approaches

An assessment of the overall usefulness of modelling approaches needs to be done at two levels: one needs to consider their ability to be used as an operationally practical, theoretically sound, economic model that is capable of satisfying the requirements of stakeholders; and one needs to consider their ability to be incorporated / included within a fully-integrated dynamic predictive model of the Australian Savannas that considers economic, demographic and biophysical issues.

To address the last issue first. There appear to be two broad approaches to the problem of developing an integrative model:

> *OPTION 1: Build a truly integrative model from scratch using techniques from game-theory, agent-based modelling and/ or evolutionary economics to structure the actions/behaviour of the economic components (and using other techniques from other disciplines to frame the actions/behaviour of other parts of the system).*

> *OPTION 2: Build separate, dynamic 'modules' (economic, biophysical, and/or demographic) using discipline-specific information and/or techniques, and then link the modules within a 'systems' framework – sharing mutually important variables at appropriate time-steps – to develop the integrated model.*

The chief drawback with Option 1 is that there is little current applied research – particularly in Northern Australia – on which to build such models, and it could be relatively resource intensive to develop them. Game-theoretic / agent based models basically start from the bottom, and build up. Hence, they need logically consistent micro data and behavioural equations. To the extent that behaviour varies across regions, the data and behavioural assumptions may need to be collected/developed on a region by region basis (although one could probably start with a generic set, designing the overall model in a manner that would allow for the subsequent amendments that formally acknowledge regional differences).

Option 2 would require those working on separate modules to identify common variables (in common geographic units), and to ensure that their modules could pass those variables back and forth with other modules – suspending calculations whilst each module does its work, and recommencing as required (with the updated variable list). This would probably require less inter-disciplinary co-operation than Option 1, where most researchers would need to have some sort of input into the development of most equations. In short, option 1 has considerable potential, but may be riskier and may take longer to develop then option 2.

Before continuing, it is worth noting that the idea of 'linking' separate modules in a systems framework that has each model 'share' common variables, is similar in approach to that taken by agent-based modellers. One starts by modelling the known behaviour of individual agents, the aim being to see what will emerge overall when agents act simultaneously, yet interactively. So in some sense, option 2 can be viewed as an agent-based approach to the integrated system – it is just that the agents are highly aggregated (eg. using an entire regional economy as an agent, instead of an individual or a group of individuals).

This begs the question of how best to do the economic module – or 'agent' (we leave the specifications for the other discipline-specific modules to researchers in those fields). Some sub-options exist:

> *OPTION 2.1: Build the economic module from scratch using game-theoretic and/or agent based methods, including mechanisms to link it to other disciplinary modules*
>
> *OPTION 2.2: Build the economic module from scratch using a CGE approach, including mechanisms to link it to other disciplinary modules*
>
> *OPTION 2.3: Develop the economic module from an existing CGE model, including mechanisms to link it to other disciplinary modules.*
>
> Notice, that the potential *Option 2.4* – to build an economic module using an existing Agent based or game theoretic model – is not listed as an option: the authors of this report could not find any currently available applied models of this type in the Australian Savannas.

Option 2.1 has considerable appeal, although – like option 1 – its chief draw back is that there is little current research on which to build such models. They have considerable potential, but may be riskier and may take longer to develop then other modelling approaches.

From many points of view, Options 2.2 and 2.3 have real advantages. CGE models are capable of conducting the types of simulations which stakeholders want (ie they can provide regional and sectoral data at the levels noted as important by stakeholders – and over the timeframes highlighted), they are generally theoretically sound and have great flexibility, so that developers can tailor the assumptions/specifications to suit the region of interest. As illustrated by Figure 1-1, the ability to tailor assumptions to suit specific regions is particularly important in the Savannas.

Nonetheless, these features come at a price: good quality CGEs, with regional and sectoral detail are very costly to develop. While it is technically feasible to build a high quality CGE model to the specifications of stakeholders, to do so from 'scratch' could take many years. Option 2.3 may therefore be the quickest (if not necessarily the most theoretically 'pure') way to complete a fully operational model.

5.3 Ideas for future research that may progress modelling capacity

The time path to a fully integrated model is likely to be long. For example, it took 9 years to develop an Australian CGE model that was built using ideas, code and background from other models – and that model did not contain separate, interactive, predictive, dynamic modules of the environment and/or the community! Other modelling approaches (eg those using game theory, agent based models, evolutionary economics etc) may well take longer, since the there is less local expertise on which to build. Part of the problem is that it is very time consuming to code such complex simulation programs. Another significant part of the problem is that data of the type required by such models is not readily available in the Savannas.

This is not particularly good news for a CRC charged with showing progress within much shorter time frames – but we note that it may be possible to take steps towards the ultimate goal, generating information that is useful in a piecemeal way, as illustrated in some of the examples below.

First: models require data. The authors of this report are unaware of any, currently available data set that is capable of supporting any of the models identified above. Researchers interested in developing a fully integrated dynamic predictive model of the Australian Savannas, would therefore need to compile an appropriate data set. This could be done by survey, but there are also other techniques for generating fine-scale data – including the creation of 'synthetic' data sets (NATSEM, 2003)[11]. One does, however, need to be careful not to 'stretch' data beyond its limits (Woollett et al, 2003: 7), and we note that researchers may also need to look at various tools for detecting and removing data inconsistencies, like those currently being developed by ABARE (Buetre et al, 2003).

Importantly, a geographically fine-scaled socio-economic database that could support a dynamic predictive model has the potential – on its own – to bring great benefit to stakeholders in the Australian Savannas. In other words, the process of collecting regional data could generate immediate benefit while also allowing one to work towards the larger goal of developing a full-scale model.

Second: it may be possible to start with an existing CGE model (option 2.3), and look at ways of making modifications to enhance its suitability to the task at hand, while also generating some short-term benefits. Figure 5-1 provides a stylised representation of the way in which some modifications could, ultimately, be linked into a larger model. The discussion that follows it, aims to explain the way in which each step ('modification') could be used to generate a short-term benefit whilst working towards

[11] We do, however, caution against the tendency to 'stretch' data beyond its limits (Woollett et al, 2003: 7), and note that those pursuing such an approach may need to consider using tools for detecting and removing data inconsistencies, like those currently being developed by ABARE (Buetre et al, 2003).

the longer-term goal of developing a fully integrated predictive dynamic model across the Savannas.

> NB: the discussion identifies some researchers and/or institutions that have expertise in these areas. This 'list' is neither exhaustive nor definitive. Others would be equally capable of exploring such options - we merely mention the names of these researchers/institutions to illustrate the point that the suggested techniques/approaches are current, realistic options. As for the 'modifications': we note that each of the following have been done (or are currently under way), and are, therefore, technically feasible. They also address key issues identified in the stakeholder survey, and would, therefore, allow a fuller, more integrative model to develop along the lines identified there.

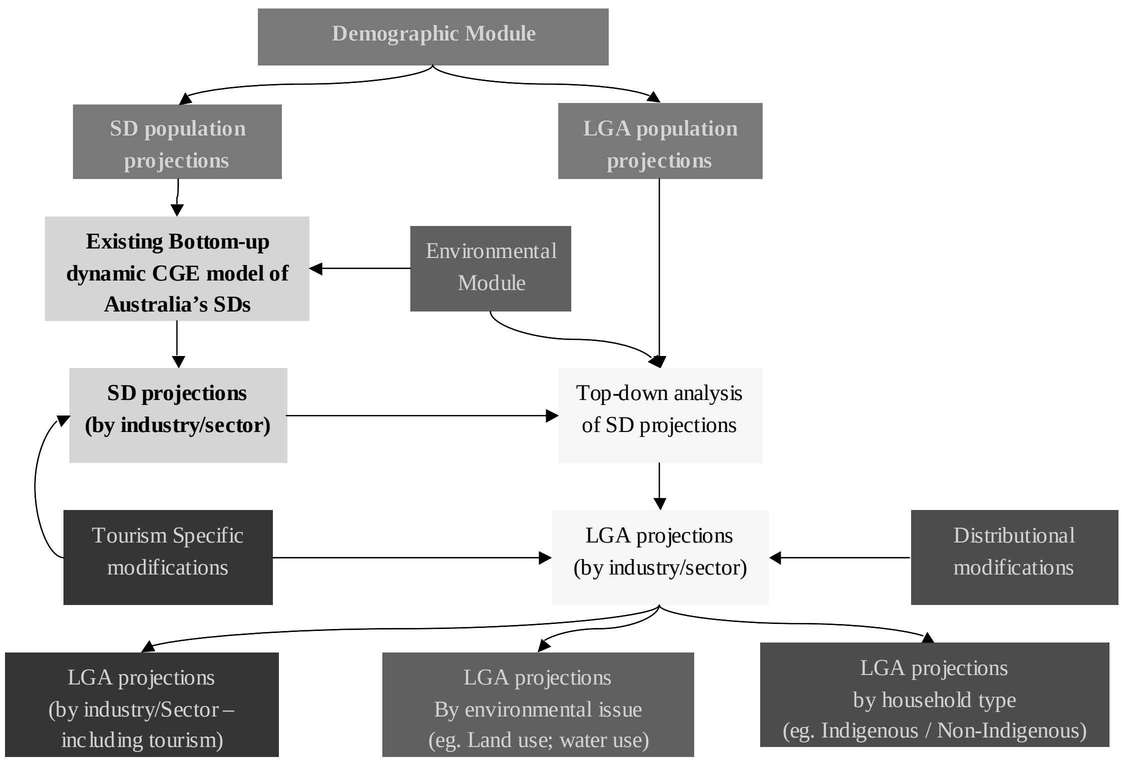


Figure 5-1: Building a model using existing models and approaches

Modification A: Do a top-down analysis of (existing) SD predictions.

> Eg. Compile data (or create 'synthetic' data using insights from NATSEM's research) at a relatively small regional scale (LGA), and use that data in a top-down re-distribution of information from an existing CGE that uses larger regions.

If one wishes to begin with an existing CGE model and make modifications to enhance its suitability to the task at hand, then either Monash's 57 region dynamic TERM model (currently under development – see Centre for Policy Studies, Monash University, 2004) or Murphy's 32 region static MMR model (Murphy, 2002) offer themselves as reasonable starting points. Both models include all of the Australian Savannas, and have some level of regional detail.

In the short-medium term, one could develop a hybrid model, by doing a top-down re-distribution of 'results' from either of these models to the LGA level across the Savannas. This would allow one to do a limited amount of regional modelling (although the 'top-down' models require one to average some predictions – mostly those relating to prices – across relatively large areas). CoPS (2004) notes that in practice, the number of regions *plus* the number of sectors must not exceed 100. In the short term, this may prove to be a problem if aiming to develop a model with many more regions, yet technological advances are likely to occur in the near future, so that this constraint may not be binding by the time the CRC is ready to compile a model that exceeds this limit.

Importantly, this step – of developing a 'hybrid' model of the Australian Savannas – would require researchers to start compiling information that is essential to the development of a genuine 'bottom-up' CGE (which would allow one to incorporate many regional differences within the model). This 'modification', would therefore, allow one to generate some short-term benefits (eg creating a top-down predictive model at the LGA level and a geographically fine-scale dataset) while allowing one to work towards the larger goal of developing a more relevant (bottom-up) model.

Modification B: Consider ways of linking demographic and/or other socio-economic information into a CGE.

> Eg. Use insights from the Murphy (forecasting) suit of models, from some of the currently available European CGEs that allow for over-lapping generations (INGUENE Team, 2002), and from research into endogenous growth theory (much of which focuses on the relationship between health, education, population and economic growth) to develop links between the CGE and another, relevant demographic model.

Stakeholders expressed a great deal of interest in the problems of health and education, and the way in which these impacted upon local communities. Research on these issues thus has the potential to bring immediate benefit to those in the local area, while simultaneously generating information that could be usefully incorporated into a larger predictive model. Here again, the first step – of compiling and analysing data on health and education using insights from endogenous growth theory – has the potential to generate immediate benefits, but could also generate information useful to a larger, longer-term goal.

Modification C: Consider ways of allowing for the tourism sector.

> Eg. Use insights from Woollett et al (2003) to make the CGE explicitly model important aspects of the Tourism Industry (as per QGEM-T, but at a small scale across the Savannas).

Tourism is an extremely important industry in many regions across the Savannas – but few CGE's explicitly model that sector (in most cases, those interested in tourism must 'cobble together' information from other more commonly used sectors such as accommodation, retail trade, etc). However, there is relatively little publicly available data on tourism in the Savannas. Consequently, any research that could collect data on regional tourism could generate immediate benefit to those in the Savannas. If that data were collected or stored in a format that could be used in a CGE, then the research could also contribute towards the development of a more relevant, larger, predictive model.

Modification D: Consider ways of explicitly allowing for Indigenous issues.

> Eg. Use insights from NATSEM's work with the Centre for Policy Studies at Monash University to look at the way in which changes in the larger economy affect Indigenous persons and at the way changes in Indigenous communities affect the larger economy.

The Australian Research Council is funding Researchers from NATSEM and from CoPs to look at ways of linking one of the Monash's applied CGEs with NATSEM's microsimulation models. They have already used 'top-down' approaches to the links (using the Monash model to generate aggregate predictions about income and relative prices, and then feeding those into STINMOD to consider the distributional impacts of the changes) and are looking towards developing 'bottom-up' linkages (where predictions from the microsimulation models re, for example, the income effect of tax changes, are fed into the CGE, to look at the flow-on effect that such a change might have upon the demand for products in particular sectors).

If it is possible to do that which is described above, then it should also be possible to develop similar 'top-down' and 'bottom-up' approaches that will allow one to consider the distributional impact of different policies across different regions, and/or across Indigenous and Non-Indigenous households. Although still in its embryonic stages, research like this clearly has much to offer and rapid progress is to be expected.

As noted earlier Indigenous issues are of central importance in the Savannas – in many areas Indigenous persons comprise the majority of the population, and many Indigenous communities are economically 'disconnected' from other parts of society. Many stakeholders stressed the need for good-quality data on Indigenous persons, particularly in remote areas. As for previous 'modifications', researchers could generate short-term benefits to many by simply compiling relevant data. Ultimately, such data could be incorporated into a larger model – looking at the way in which changes in Indigenous communities affect other parts of the model (eg. the 'non-indigenous economy and/or the environment) and at the way in which external changes affect Indigenous persons and communities.

Modification E: Consider ways of integrating economic and environmental models.

> Eg. Use insights from previous work on 'green' CGEs and on systems-frameworks to either add a 'green' component to the CGE, or to forge links between a separate environmental module, and the CGE.

There are many different ways of trying to explicitly model economy/environment reactions. For example, CGEs can be readily customised to include physical interactions with the environment – although to date much of this is done by looking at 'energy use' per sector – a variable which may be less relevant in the Savannas than in urban areas. Nonetheless, the methodology may be useful; one could, for example, look at water use per sector. Here again the data itself would be useful to those working in water-scare environments – and it might also be useful within a broader model. It is also possible to link economic 'modules' with environmental 'modules' using a systems type framework (where the modules run independently, but stop and 'swap' common variables at specific points in time). Research that is able to identify these common variables, and to develop ways of 'scaling' them in a way that satisfies both types of models could generate information that is useful in the short term, but could also be used as input into a larger fully integrated model, thus progressing work towards the larger, longer-term goal.

A final, important point to be made here, is that the system we are attempting to model (the Australian Savannas) may be inherently chaotic. A network of well-built modules (each of which can be updated and improved upon as new data and/or knowledge becomes available) may therefore be a sensible way of exploring trajectories of change over time. Researchers can concentrate on trying to describe the small parts that they know best, and let the (possibly chaotic) model show them what might emerge at the aggregate level as the parts interact and evolve.

References

ABS 1996 *Integrated regional data base. Catalog No.. 1353.0.* Australian Bureau of statistics, Canberra.

Arthur, W. B., Holland, J. J., LeBaron, B., Palmer, R., and Tayler, P. 1996. "Asset Pricing Under Endogenous Expectations in an Artificial Stock Market, Santa Fe Working Paper 96-12-093." Santa Fe Institute.

Australian Bureau of Statistics

See ABS

Baaijens, S.R., Nijkamp, P., Van Montfort, K. 1998. "Explanatory meta-analysis for the comparison and transfer of regional tourist income multipliers", *Regional Studies*, 32 (9): pp. 839 – 850.

Beaudry, P., Green, D. A. 2002. "Population Growth, Technological Adoption, and Economic OUtcomes in the Information Era." Review of Economic Dynamics, 5, pp. 749-74.

Bellettini, G., and Ceroni, C. B. 1999. "Is Social Security Really Bad for Growth?" Review of Economic Dynamics, 2:4, pp. 796-819.

Berck, Peter and Sandra Hoffmann. 2002. "Assessing the Employment Impacts of Environmental and Natural Resource Policy." Environmental and Resource Economics, 22:1-2, pp. 133.

Breece, James H, Keith R McLaren, Christopher W Murphy, and Alan A Powell. 1994. "Using the Murphy Model to provide shot-run macroeconomic closure for ORANI." Economic Record, 70:210, pp. 292.

Buetre, B., Rodriguez, G., and Pant, H. 2003. "Data issues in general equilibrium modelling." 47th Australian Agricultural and Resource Economics Society Conference. Australian Bureau of Agricultural and Resource Economics, Conference Paper 03.2: Freemantle, Western Australia 11 - 14th February 2003.

Buscher, Herbert S, Hermann Buslei, Klaus Goggelmann, Henrike Koschel, Tobias F N Schmidt, Viktor Steiner, and Peter Winker. 2001. "Empirical macro models under test. A comparative simulation study of the employment effects of a revenue neutral cut in social security contributions." Economic Modelling, 18:3, pp. 455.

Carpenter, S., W. Brock, and P. Hanson. 1999. "Ecological and social dynamics in simple models of ecosystem management." Conservation Ecology 3(2): 4. [online].

Centre of Policy Studies, Monash University (2004), "The MMRF-Green Model", information and documentation available at: http://www.monash.edu.au/policy/mmrf.htm, accessed 14th Feb, 2004

Church, Keith B, Joanne E Sault, Silvia Sgherri, and Kenneth F Wallis. 2000. "Comparative properties of models of the UK economy." National Institute Economic Review:171, pp. 106.

Conway, R. 2000. "The Montana State Aluminum Industry Economic Impact Study (Draft report prepared for the Pacific Northwest Aluminum Industry)." Vol. 2003. Dick Conway & Associates.

Costanza, R. and Gottlieb, S. 1998. "Modelling ecological and economic systems with STELLA: Part ii." Ecological Modelling, 112, pp. 81-84.

Costanza, Robert, Lisa Wainger, Carl Folke, and Karl-Goran Maler. 1993. "Modelling complex ecological economic systems." Bioscience, 43:8, pp. 545.

Cumberland, J.H. 1966. "A regional interindustry model for analysis of development objectives." *Papers of the Regional Science Association*, 7, pp. 33-42.

Darley, V. M., and Kauffman, S. 1996. "Natural Rationality, Santa Fe Institute Working Paper # 96-08-071."

Dwyer, L., Forsyth, P., and Spur, R. forthcoming. "Evaluating tourism's economic effects: new and old approaches." Tourism Management, forthcoming.

Eder, P. and Narodoslawsky, M. 1999. "What environmental pressures are a region's industries responsible for? A method of analysis with descriptive indices and input-output models." *Ecological Economics*, 29, pp. 359-74.

Elliston, L., Yainshet, A., and Hinde, R. 2004. "Karnal Bunt: The regional economic effects of a potential incursion." ABARE eReport 04.4: Canberra.

Elton, E. J., Gruber, M. J., Brown, S. J., and Goetzmann, W. N. 2003. Mordern Portfolio Theory and Investment Analysis (Sixth Edition). NJ: John Wiley & Sons, Inc.

Fiske, J.R., Lamb, J.C., Morss, M. F. 1991. "Practical economic forecasting for small regions." Business Economics, 26:3, pp. 49-55.

Flegg, A.T., Webber, C.D., Elliott, M.V. 1995. "On the appropriate use of location quotients in generating regional input-output tables." Regional Studies, 29:6, pp. 547-62.

Forst, C. V., Reidys, C., and Weber, J. 1995. "Evolutionary Dynamics and Optimization: Neurtal Networks as Model-Landscapes for RNA Secondary-Structure Folding-Landscapes, Santa Fe Institute Working Paper # 95-10-094."

Ghiglino, Christian. 2002. "Introduction to a general equilibrium approach to economic growth." Journal of Economic Theory, 105:1, pp. 1.

Ghosal, Amitava. "Use of Wiener's diffusion model in economic planning." Kybernetes, 25:7/8, pp. 141.

Gibson, Bill and Dirk Ernst Van Seventer. 2000. "A tale of two models: Comparing structuralist and neoclassical computable general equilibrium models for South Africa." International Review of Applied Economics, 14:2, pp. 149.

Giesecke, J. 2000. "Explaining regional economic performance: An historical application of a dynamic multi-regional CGE model." Papers in Regional Science, 81, pp. 247.

Gillespie, G., McGregor, P. G., Swales, J. K., Yin, Y. P.,. 2001. "The Displacement and Multiplier Effects of Regional Selective Assistance: A Computable General Equilibrium Analysis." Regional Studies, 35:2, pp. 125 - 39.

Grasso, M. 1998. "Ecological–economic model for optimal mangrove trade off between forestry and fishery production: comparing a dynamic optimization and a simulation model." Ecological Modelling, 112:2-3, pp. 131-50.

Greiner, R., Stoeckl, N., Stokes, C., Bachmaier, J., Herr, A., Lavery, D; and Rickert, A. (2002), "Natural resource management in the Burdekin Dry Tropics: social and economic Issues" – *Report for the Burdekin Dry Tropics NRM Board.* CSIRO Sustainable Ecosystems: Townsville.

Guo, H C, L Liu, G H Huang, G A Fuller, and et al. 2001. "A system dynamics approach for regional environmental planning and management: A study for the Lake Erhai basin." Journal of Environmental Management, 61:1, pp. 93.

Gustavson, K. R.; Lonergan, S. C., and Ruitenbeek, H. J. 1999. "Selection and modelling of sustainable development indicators: a case study of the Fraser River Basin, British Columbia." *Ecological Economics*, 28, pp. 117-32.

Hall, C.A.S., Perez, C.L., and Leclerc, G. (eds). 2000. *Quantifying Sustainable Development. The Future of Tropical Economics*. Academic Press: San Diego.

Harding, A., Lloyd, R., Bill, A., and King, A. 2003. "Assessing Poverty and Inequality at a Detailed Regional Level: New Advances in Spatial Microsimulation (Paper prepared for the Inequality, Poverty and Human Well-being Conference, Helsinki, Finland, 30-31 May 2003)." Vol. 2003. NATSEM.

Harris, R., and Liu, A. 1998. "Input-Output Modelling of the Urban and Regional Economy: The Importance of External Trade." *Regional Studies*, 32:9, pp. 851 - 62.

Hawden, D. and Pearson, P. 1995. "Input-output simulation of energy, environment, economy interaction in the UK." *Energy Economics,* 17:1, pp. 73-86.

Hendricks, L. 2001. "Growth, Death and Taxes." Review of Economic Dynamics, 4:1, pp. 26-57.

Hoffmann, Anders N. 2003. "Imperfect competition in computable general equilibrium models - A primer." Economic Modelling, 20:1, pp. 119.

Houser, Daniel and John Freeman. 2001. "Economic consequences of political approval management in comparative perspective." Journal of Comparative Economics, 29:4, pp. 692.

Huang, G.H., Anderson, W.P. and Baetz, B.W. 1994. "Environmental Input-Output Analysis and its Application to Regional Solid-waste Management Planning." Journal of Environmental Management, 42, pp. 63.

Hugget, M. 2003. "When are comparative dynamics monotone?" Review of Economic Dynamics, 6:1, pp. 1-11.

Hughes, D., and Holland. D. W. 1994. "Core-periphery economic linkage: A measure of spread and possible backwash effects for the Washington economy." *Land Economics*, 70:3, pp. 364-77.

Hyman, Robert C., John M. Reilly, Mustafa H. Babiker, Ardoin De Masin, and Henry D. Jacoby. 2003. "Modelling non-CO2 Greenhouse Gas Abatement." Environmental Modelling & Assessment, 8:3, pp. 175.

Ingenue Team 2000. *INGENUE, A MULTI-REGIONAL,COMPUTABLE GENERAL EQUILIBRIUM, OVERLAPPING-GENERATIONS MODEL*, paper (accessed on 15th Jan, 2003) and available at: http://www.bilkent.edu.tr/~sayan/Services/IFAC/INGENUE_Team.pdf

Janssen, M. A. and Jager, W. 2000. "Preface: the human actor in ecological-economic models." Ecological Economics, 35, pp. 307.

Janssen, M., and de Vries, B. 1998. "The battle of perspectives: a multi-agent model with adaptive responses to climate change." Ecological Modelling, 26:1, pp. 43-65.

Keynes, J. M.. 1936. *The General Theory of Employment, Interest and Money*, reprinted in 1961, MacMillan, London.

Knapman, B., Stanley, O., and Lea, J. 1991. Tourism and Gold in Kakadu: The impact of current and potential natural resource use on the Northern Territory Economy. Darwin: Northern Australia Research Unit, Australian National University.

Kokic, P., and Nelson, R. 2003. Predicting Farm Performance: An enhanced ABARE system for Australian broadacre agriculture. Canberra.: Australian Bureau of Agricultural and Resource Economics.

Laxton, D., Isard, P, Faruqee, H., Prasad, E and Turtelboom, B. 1998. *MULTIMOD Mark III: The Core Dynamic and Steady-State Models*, Occasional paper 164, International Monetary Fund, available at: http://www.imf.org/external/pubs/ft/op/op164/pdf/1op164.pdf, accessed 14th April, 2004

Leontief, W. and Duchin, F. 1986. *The dynamic input-output model. The future of automation on workers* . New York: Oxford University Press.

Levacic, R., and Rebmann, A.,. 1988. *Macroeconomics: An introduction to Keynesian-Neoclassical controversies, Second Edition*. Hong Kong: Macmillan.

Liew, C. J. 2000. "The dynamic variable input-output model: An advancement from the Leontief dynamic input-output model." The Annals of Regional Science, 34:4, pp. 591-614.

Maffezzoli, M. 2001. "Non-Walrasian Labour Markets and Real Business Cycles." Review of Economic Dynamics, 4, pp. 860-92.

Marquez, M.A., Ramajo, J., Hewings, G.J.D. 2003. "Forecasting in a small and unstable regional economy using regime shifting models: the case of Extremadura. (Spain)." Geographical Analysis, 35:2, pp. 110-33.

Mateos-Planas, X. 2002. "The Demographic Transition in Europe: A neoclassical Dynasitc Approach." Review of Economic Dynamics, 5:3, pp. 646-80.

McCann, P., and Dewhurst, J.H.L. 1998. "Regional size, industrial location and input-output expenditure coefficients." Regional Studies, 32:5, pp. 435-45.

McLeod, A. and MacGregor, B. 2003. "Integrated Economic/Environmental Models: Tools for Environmental Assessments in the Agricultural Sector." Proceedings report of the Environment and Trade Symposium, February 20, 2003, Vol. 2003: Ottawa.

Melhuish, T., Blake, M., and Day, S. 2002. "An Evaluation of Synthetic Household Populations for Census Collection Districts Created Using Spatial Microsimulation Techniques (Paper prepared for the 26th Australia & New Zealand Regional Science Association International Annual Conference, Gold Coast, 29 September - 2 October, 2002)." Vol. 2003. NATSEM.

Moffat, I. 1994. On measuring sustainable development indicators. *Journal of Sustainable Dev. World Ecol.* 1:97-109.

Murphy, C. 2002. "A guide to Econtech's Industry Model - Murphy Model 600 PLUS (MM600+)." Econtech, A.C.T, documention also available online at : http://www.econtech.com.au/07_Murphy_Models/01_Introduction.htm, accessed 20th Feb, 2004

Nabors, Ottie, George Backus, and Jeff Amlin. 2002. "Simulating Effects of Business Decisions on Regional Economy: Experience During the California Energy Crisis." Journal of Industry, Competition and Trade, 2:1-2, pp. 143.

NATSEM. 2003. "ARC Regional Dimensions Research Project: Work in Progress (presentation given at ANZRAI, Fremantle, 28th September - 1 October, 2003)." Vol. 2003.

NATSEM. 2004a. "Dynamic Modelling - Exploring the Future with Dynamic Models (the HARDING model, DYNAMOD-2 and GENSIM)."

NATSEM. 2004b. "STINMOD - predicting the impact of policy change on today's Australians." University of Canberra.

Nijkamp, Peter and Aura Reggiani. 1995. "Non-linear evolution of dynamic spatial systems: The relevance of chaos and ecologically-based models." Regional Science and Urban Economics, 25:2, pp. 183.

Office of Economic Statistics and Research
See OESR

Olsen, Joshua. 2002. "On the units of geographical economics." Geoforum, 33:2, pp. 153-64.

Pakko, Michael R. 2002. "What Happens When the Technology Growth Trend Changes? Transition Dynamics, Capital Growth, and the "New Economy"." Review of Economic Dynamics, 5:2, pp. 376-407.

Partridge, M. D., and Rickman, D. S. 2003. "The waxing and waning or regional economies: the chicken-egg question of jobs versus people." Journal of Urban Economics, 53, pp. 76-97.

Perez-Trejo, Francisco, Norman Clark, and Peter Allen. 1993. "An Exploration of Dynamical Systems Modelling as a Decision Tool for Environmental Policy." Journal of Environmental Management, 39:4, pp. 305-19.

Pezzey, J.C.V, and Lambie, N. R. 2001. CGE Models for Evaluating Domestic Greenhouse Policies in Australia: A Comparative Analysis. Canberra: Report to The Productivity Commission, AusInfo.

Ponti, Giovanni. 2000. "Continuous-time evolutionary dynamics: theory and practice." Research in Economics, 54:2, pp. 187-214.

Radzicki, Michael J. 2003. "Mr. Hamilton, Mr. Forrester, and a foundation for evolutionary economics." Journal of Economic Issues, 37:1, pp. 133.

Rasmussen, Tobias N. 2003. "Modelling the economics of greenhouse gas abatement: An overlapping generations perspective." Review of Economic Dynamics, 6:1, pp. 99-119.

Rey, S. J. 2001. "Spatial Empirics for Economic Growth and Convergence." Geographical Analysis, 33:3, pp. 195-214.

Robinson, H. M. and Duffy-Deno, K. T. 1996. "The role of the oil and gas industry in Utah's economy: an economic base/input-output analysis." *Resource and Energy Economics*, 18, pp. 201-18.

Rogers, Mark. 2003. "A survey of economic growth." Economic Record, 79:244, pp. 112.

Rose, A. 1995. "Input-output economic and computable general equilibrium models." Structural Change and Economic Dynamics, 6, pp. 295-304.

Stafford-Smith (editor), 2003. *Options for Understanding Regional Dynamics in Northern Australia*, Tropical Savannas CRC Project Final Report, May 2003, CSIRO, Alice Springs.

Walker, D "Actors, actions and impacts: an agent-based simulation approach to exploring regional dynamics", in Stafford-Smith (editor), *Options for Understanding Regional Dynamics in Northern Australia*, Tropical Savannas CRC Project Final Report, May 2003, CSIRO, Alice Springs.

Wang, S. 2001. "The neural network approach to input-output analysis for economic systems." *Neural Computing and Applications*, 10, pp. 22-28.

Wilcoxen, P. 2004. "A Quick Reference Guide to CGE Modelling." Maxwell School of Syracuse University, available at http://maxwell.insightworks.com/pages/785.html, accessed on 11th June 2004.

Woodwell, John C. 1998. "A simulation model to illustrate feedbacks among resource consumption, production, and factors of production in ecological-economic systems." Ecological Modelling, 112:2-3, pp. 227-48.

Woollett, G., Townsend, J. and Watts, G. 2003. "Development of QGEM-T - A Computable General Equilibrium Model of Tourism." A Working Paper of the Office of Economic and Statistical Research, Queensland Treasury, Vol. 2003.

Appendix A: Tabular summary of applied models (non-exhaustive list)

Input-Output Models

- GRIMP (from UQ)

Region covered	Australia
General description	IO
Other Information	Grit IMpact Program (developed by West - referred to in Berck and Hoffman, 2002)Cross-sectional data By industrial Sector. Unlikely to get much smaller than SD level although can get down to SLA level Can simulate impact on output (or employment or energy etc) of a change in final demand. Trickier to simulate change on supply side (see Berck and Hoffman, 2002: 144)

- IMPLAN

Region covered	USA (at county level)
General description	IO
Other Information	Software and data to run input-output simulations of effect of changes on economy (at county level). (see http://www.implan.com) Referred to in Nabors et al (2002) Typical IO applications: Employment and income data available at the state and county level. Provided at the full SIC or NAICS code level of detail. The non-disclosed elements have been adjusted through a procedure developed by MIG, Inc. All data elements in this series are disclosed. SIC based data is available for years 1988 to 2000. NAICS based data is available from 2001 on. Has BLS National Occupational by Industry data. When combined with IMPLAN employment by industry, can generate estimates of occupational distributions.

- CONWAY

Region covered	USA
General description	IO
Other Information	Looks at changes in and the effects on employment, income, population, taxes Details in Conway (2000): from p 4 … due to a paucity of data the county model is relatively simple and contains a limited number of variables (principally, employment, income, population and taxes).

Dynamic Input-Output Models

- REMI

Region covered	USA
General description	Dynamic IO
Other Information	Used in conjunction with an ENERGY model to investigate impact on regional economy of changes in energy market Specifically looks at migration, wages, energy prices and economic structure. Details in Nabors et al (2002)

- ENERGY2020/REMI

Region covered	Counties in the US
General description	Dynamic IO linked to Energy Model
Other Information	Uses a systems simulation model to estimate the regional economic impact of … wholesale energy rate increases. Nabors et al (2002). The macroeconomic portion of the analysis was performed using the REMI model (details in the IO section)… The energy dynamics are integrated with the macroeconomic analysis using ENERGY 2020. …. Both wholesale and retail prices by class are detailed and the price changes from the smelter closing are explicitly calculated and fed back in REMI. Changes in spot and wholesale prices, energy demand and state and regional economic output and employment are major variables tracked throughout the analysis.

CGE Models: Comparative Static Single Region

- ORANI

Region covered	Australia
General description	CGE: Comparative Static Single Region
Other Information	ORANI Developed by the Centre of Policy Studies Largely superseded by the MONASH suite of CGE models

- ORANI-E

Region covered	Australia
General description	CGE: Comparative Static Single Region with energy sector
Other Information	Typical IO applications plus links to energy sector 123 industry sectors which include detailed representations of the fossil fuel, electricity, transport and agricultural sectors; uses eight occupations

- MM600+ (Murphy Model)

Region covered	Australia
General description	CGE: Comparative Static Single Region (see http://www.econtech.com.au/07_Murphy_Models/01_Introduction.htm)
Other Information	The economic agents recognised include producers, consumers, a government, and foreign purchases and sellers. Consumers are represented by a household, and industry is disaggregated into 108 different sectors producing 672 products that are individually identified. Specifies the existing and new indirect tax systems in detail (ie GST considered for each of the 672 products). Also, the tax cuts on fuel are accurately allocated across the different transport modes. LES generalise Utility/Expenditure function. Income elasticities may vary; fixed marginal budget shares. Own-price elasticities may vary as can cross-price elasticities between groups. CES production function for goods and for energy with elasticity between 0 and 1; constant between all pairs of inputs. Has income tax; 11 indirect production taxes; and 12 different indirect product taxes (including GST) Uses an unpublished special series of input-putput tables from the ABS which contains information on 107 industries productng about 1000 products, as well as extra detail on indirect taxes. Currently, the 1994-95database is used; however, the 1996-97 database is due for release towards the end of 2000. The ABS data are adjusted to ensure economic concepts are correctly measured. As per the MMRF-Green, it assumes the economy faces fixed world prices for imports (using Armington assumption) and that demand for exports has constant own-price elasticities

- CRAM (Canadian Regional Agricultural Model)

Region covered	Canada
General description	CGE: Comparative Static Single Region with agriculture
Other Information	McLeod and MacGregor (2003:6) CRAM is a sector equilbrium model for Canadian agriculture that is disaggregated across both commodities (7) and space (22 regions). It is a static non-linear optimisation model that maximises producer plus consumer surplus. McLeod and MacGregor (2003:6) CRAM is capable of estimating the change in resource allocation into various enterprises in response to changes in technology, government programs and policies, or market conditions. Analysis is carried out by comparing activity levels for scenario verus a baseline.

CGE Models: Comparative Static, Multi-region

- ORANI- NT

Region covered	Australia and NT
General description	CGE, Comparative Static, Multi-region
Other Information	Based on ORANI

- QGEM (developed by Queensland treasury, 1994)

Region covered	QLD and rest of Australia
General description	CGE, Comparative Static, Multi-region Based on the MONASH-MRF multi-region model. Woolett et al (2003)
Other Information	Uses data developed by the OESR; The current QGEM model uses the 1996-97 I-O data. Provides extensive industry and commodity detail for the two regions: it separately identifies 108 commodities and 108 industries in each of the two regions. Generally used for policy impact analysis and for project impact analysis.

- QGEM-T

Region covered	QLD and rest of Australia
General description	CGE, Comparative Static, Multi-region QGEM with tourism sector. Woolett et al (2003).
Other Information	Tourism expenditure data has been dis-aggregated for each tourism category (details provided in document's appendix). Different behaviour of different tourists categories have been explicitly modelled: eighteen distinct tourism categories. The response of each category to economic stimuli varies according to the purpose of travel. There is substitution between destinations. The PUBLISHED analysis of change in transport safety assumes: No policy induced migration; flexible real wages; can have differential growth in industry K; G/C constant; t adjusts to keep G/T constant; no change to real exchange rate. However, assumptions can be altered.

- MMR (Murphy Model Regional)

Region covered	Australia, 8 states and territories or 32 regions , including: Far-North and North-West Statistical Division (QLD) Northern Statistical Division (QLD) Northern Territory Remainder-Balance WA Statistical Region (excludes Perth and lower Western WA Statistical Regions).
General description	CGE, Comparative Static, Multi-region see http://www.econtech.com.au/07_Murphy_Models/04_MMR(regional_policy).htm accessed on the 26th of Nov, 2003)
Other Information	Each region is modelled individually and contains 18 industries corresponding to the ANZSIC industry divisions used by the ABS. The model is calibrated using regional data for 1998/99. Distinguishes between industries that produce tradeables and industries that produce non-tradeables. Also, consumer spending is at a sustainable level so that the trade account for each region, taking into account both international and inter-regional trade, is in balance. Models a medium-term equilibrium for each regional economy, which would be broadly achieved over a period of about 3 years … far enough into the future for equilibrium to be attained in product markets but not far enough for labour market equilibrium; rather industry wage rates are taken as given. It is also not far enough into the future for businesses in each region to adjust their capital stocks. Individual industries can be treated as either producing tradeables (ie those that have a national or international focus, and production levels are driven by prices prevailing on national or world markets) or non-tradeables(focus on their own region and production levels depend on local demand).

CGE Models: Dynamic, Multi-region

- FEDERAL-F

Region covered	Tasmania and Mainland
General description	CGE – dynamic 2-region (bottoms up) model Derived from FEDERAL which was derived from ORANI (although FEDERAL F incorporates dynamic features and closure options used in MONASH)
Other Information	Has detailed fiscal dimension, linking single period equilibria via stock-flow relationships. It has 37 representative cost-minimising firms; each producing one of 37 commodities; there is perfect competition; two tiers of government; utility maximising households; and migration.

- QGEMF-T

Region covered	Australia, + Queensland with tourism sector
General description	CGE – dynamic 2-region (bottoms up) model
Other Information	Under development – see Woolett et al (2003)

- Monash Model

Region covered	Australia (8 states and territories or 57 SDs)
General description	CGE – dynamic multi region (top-down) model Derived from ORANI http://www.monash.edu.au/policy/monmod.htm
Other Information	Region specific quantities but not prices; region specific demand side shocks but not supply-side shocks; No state govt accounts, 113 industries, 56 regions and 340 occupations. Dynamics done using sequences of annual solutions connected by accumulation relationships for capital stocks: • equations relating investment to capital in year-to-year simulations, • equations explaining the relationship between year-to-year capital growth and rate-of-return expectations, and equations that facilitate the running of forecasting and dynamic policy simulations; • industry investment/capital ratios, for industry rates of return and for dynamic adjustment parameters The model is used to analyse the likely effects of changes in economic policy, especially changes in taxes, tariffs, environmental regulations and competition policy. High level of microeconomic detail and strong **forecasting** capability

- MMRF- Green (Monash Model)

Region covered	Aust states and territories can get within-state top-down breakdown to SD's
General description	CGE – dynamic multi region (hybrid: bottom-up for states, top-down to SD's within states) model . See the MMRF page. . Derived from the comparative static MMRG model and the MONASH model. with energy sectors
Other Information	Uses a multi-regional IO table generated from a disaggregation of the national IO table used in the Monash Model . 8 or 57 Australian regions; 40 industry sectors per region; 45 products and 15 energy sectors. Has PAYE tax with 8 occupations, non-wage and 'other direct' taxes. Includes 5 indirect production taxes and 2 indirect product taxes (tariffs and differential state/territory taxes). ABS regional data are used for government revenue and expenditure, demographics, employment and the labour force. The disaggregation of industry sectors into subregions is achieved using base year data for the value added by each industry in each subregion. Capabilities for some environmental analysis Roughly 40 sectors, up to 144 commodities/industries. Detailed data on state and Federal governments' budgets. • domestic producers classified by industry and domestic region; • investors similarly classified;

	• up to eight region-specific household sectors; • an aggregate foreign purchaser of the domestic economy's exports; • up to eight state and territory governments; and • the Federal government. Outputs from the model include projections of: • GDP and aggregate national employment; • sectoral output, value-added and employment by region; • export earnings, import expenditure and the balance of trade. • State and Territory revenues and expenditures; • regional gross products and employment; and • regional international export earnings, international import expenditures and international balance of payments. Explicit representations of intra-regional, inter-regional and international trade flows based on regional input-output data developed at CoPS

- TERM (Monash model – under development)

Region covered	Australia 57 SD's
General description	Based on parts of the existing monash suite of models. Will be genuine bottom-up CGE of 57 regions within Australia Under development (CoPS)
Other Information	Region specific prices and quantities. Region specific demand and supply-side shocks; State govt accounts. Exports and imports distinguished by port of exit/entry. Sectoral and regional aggregation tailored to particular simulations

Forecasting Model:

- Murphy Model 2 (MM2); MM2; and -Demographic MM2-States

Region covered	Australia (states and territories)
General description	Dynamic multi-region forecasting model linked to demographic module
Other Information	A quarterly forecasting model of the Australian economy. Its economic forecasts are at the national, industry and state levels, while its demographic forecasts are at the national and state levels Keynesian short-run for forecasting; Neoclassical long-run for policy analysis. Forward-looking financial sector for realism MM2 produces quarter-by-quarter nine-year-ahead forecasts across states and territories for 18 sectors. The whole suit of models MM2-Demographic (which makes predictions about population for country and for states) MM2 (uses demographic input), MM2-States (uses demographic predictions and output of MM2, allocating the output across states)

CGE Model: Multi-region global models including Australia

- GTEM` G-Cubed

Region covered	Global models with Australia
General description	CGE Multi-region global models including Australia (as a single region)
Other Information	see http://www.msgpl.com.au/msgpl/msghome.htm for information about GTEM (ABARE/DFAT) and McKibbon and Wilcoxen for information about **G-Cubed**

CGE Model: Multi-region global models

- IMAGE

Region covered	The Netherlands
General description	CGE with market imperfections and overlapping generations
Other Information	The model explicitly incorporates market imperfections and Dutch institutions and is calibrated to the 1999 Netherlands economy. Because each generation has a different expected remaining lifetime, their objectives and constraints differ. It allows users to study the effects of schooling subsidies, minimum wage and progressive taxation. Because of its explicit modelling of the demographic structure and Dutch institutions it also allows users to study the effect that changing demographic structures have on the demand for old-age pensions, and on pension finance, etc. Eg. It will be possible to gain insight into the following issues: (source of quote: http://www.few.eur.nl/few/research/ocfeb/image/papers/docimage1_2107.pdf See also http://www.few.eur.nl/few/research/ocfeb/image/index.html)

- INGENUE

Region covered	Europe and the rest of the world
General description	CGE, Multi region with Overlapping Generations
Other Information	The model is designed to shed light on current debates in ageing richer areas of the world, and most specifically in Western Europe, about the future of pay-as-you-go pension schemes, and on the longrun economic consequences of various possible institutional reforms of public pensions. The major difference with other existing studies of economic consequences of pension reforms lies in the international interdependence and capital flows: instead of being bottled up in the region undertaking pension re-form, the effects on private savings — and hence on interest rate, capital accumulation, aggregate and age-specific consumption, etc. — are, in this model, spread over the entire world, and henceforth diluted in worldwide supply of capital. (INGENUE Team, 2000)

- MULTIMOD

Region covered	Multi-country model of the world economy
General description	Dynamic, multi-country Macro model of world economy
Other Information	Developed by researchers at the IMF. Designed to study the transmission of shocks across countries as well as the short-run and medium-run consequences of alternative monetary and fiscal policies. It has several variants, the current versions of which are referred to as the Mark III generation. The core Mark III model includes explicit country submodels for each of the 7 largest industrial countries and an aggregate grouping of 14 smaller industrial countries. The remaining economies of the world are then aggregated into two separate blocks of developing and transition economies. Extended versions of MULTIMOD include separate submodels for many of the smaller industrial countries, and work has been initiated on expanding the analysis of the developing and transition economies (Laxton et al, 1998, available at: http://www.imf.org/external/np/res/mmod/index.htm)

Microsimulation models

- STINMOD (Natsem)

Region covered	Australia
General description	Microsimulation
Other Information	Simulates the impact of major federal government cash transfers, income tax and the medicare levy on individuals and families in Australia. Two key components: The first is the microdata, which contain detailed data on the characteristics of a representative sample of Australian households (obtained from household surveys of income and housing costs undertaken by the Australian Bureau of Statistics, and updated by NATSEM). The second is the computer code which simulates the rules of the government. Can be used to analyse the distributional and fiscal impact of both current and new policy (see http://www.natsem.canberra.edu.au/research/stinmod/stinmod.html

- HARDING (Natsem)

Region covered	Australia
General description	Dynamic Microsimulation
Other Information	A dynamic cohort model. Projects lifetime characteristics for a cohort of people born in a given year, according to prevailing steady-state conditions in areas such as demography, education and the labour market. It has been used primarily for the analysis of lifetime tax-transfer analysis and for analysis of policy concerning the Higher Education Contribution Scheme (HECS). http://www.natsem.canberra.edu.au/research/dynamic/dynamic.html

- DYNAMOD 2 (Natsem)

Region covered	Australia
General description	Dynamic Microsimulation
Other Information	Based on DYNAMOD (an earlier version of the model) A dynamic microsimulation model of the Australian population The base data for the model is drawn largely from the 1986 Census one per cent sample file (a sample of about 155 000 individuals), with the model operating in monthly steps for most demographic and labour market processes and in annual steps for education and earnings. Designed to project characteristics of the population over a period of up to 50 years. Major elements of the model include demographics, international migration, education, the labour market and

- GEMSIM (under development - Natsem)

Region covered	Australia
General description	Dynamic Microsimulation
Other Information	Will extend DYNAMOD 2 to allow for longitudinal processes such as asset accumulation and retirement income. Will be of use to those who wish to take a longer-term view, and to examine the future characteristics of the population or the projected impact of policy change.

- SYNAGI– SYNthetic Australian Geo-demographic Information (under development - Natsem)

Region covered	Australia
General description	Spatial MicroSimulation
Other Information	Under development – will give regional 'synthetic' data; that can be combined with models to simulate regional impacts of changes in policies. Also developing a model that joins MONASH's CGE with regional data so can look at average and distributional effects of changes in policy on data listed – for small regions. See papers by NATSEM (2003); Harding et al (2003) and Melhuish et al (2002)

Appendix B: Organisations participating in the Stakeholder Issue Survey

Organisation	Town	State
Agforce QLD	Brisbane	QLD
Alcan	Nhulunbuy	NT
Apunipima Cape York Health Council	Cairns	QLD
Aramac Shire Council	Aramac	QLD
Argyle Diamond Mine	Kununurra	WA
ATSIC - Cairns & District Regional Council	Cairns	QLD
ATSIC - Central Qld Regional Council	Rockhampton	QLD
ATSIC - Garrak-Jarru Regional Council	Katherine	QLD
ATSIC - Gulf and West Queensland Regional Council	Mount Isa	QLD
ATSIC - Malarabah Regional Council	Derby	WA
ATSIC - Miwatj Provincial Governing Council	Nhulunbuy	NT
ATSIC - Ngarda-Ngarli-Yarndu Regional Council	South Hedland	WA
ATSIC - Peninsula Regional Council	Cairns	QLD
ATSIC - Townsville Regional Office	Townsville	QLD
ATSIC - Wunan Regional Council	Wyndham	WA
ATSIC - Yapakurlangu Regional Council	Alice Springs	QLD
ATSIC - Kullarri Regional Council	Broome	WA
Aurukun Shire Council	Aurukun	QLD
Barcaldine Shire Council	Barcaldine	QLD
Belyando Shire Council	Mornanah	QLD
Billabong Sanctuary	Townsville	QLD
Bowen Shire Council	Bowen	QLD
Broome Council	Broome	WA
Broome Enterprise Centre Inc	Broome	WA
Bulkanu Cape York Development Corp	Cairns	QLD
Burdekin Dry Tropics	Townsville	QLD
Burdekin Shire Council	Ayr	QLD
Burke Shire Council	Burktown	QLD
Cape York Land Council	Cairns	QLD
Cape York Land Council - Cook Town	Cook Town	QLD
Cape York Land Council - Weipa	Weipa	QLD
Carpentaria Land Council	Mount Isa	QLD
Carpentaria Shire Council	Normanton	QLD
Central Highlands Development Corp	Emerald	QLD
Chamber of Commerce	Darwin	NT
Chamber of Commerce	Karratha	WA
Chamber of Commerce - East Arnhem	Nhulunbuy	NT
Chamber of Commerce - Katherine	Katherine	NT
Charters Towers & Dalrymple Tourism Assoc	Charters Towers	QLD

Organisation	Town	State
Charters Towers City Council	Charters Towers	QLD
Chief Ministers Department	Darwin	NT
Chief Ministers Department	Darwin	NT
Cloncurry Shire Council	Cloncurry	QLD
Comalco	Weipa	QLD
Comalco	Weipa	QLD
Comalco	Weipa	QLD
Croydon Shire Council	Croydon	QLD
Dalrymple Shire Council	Charters Towers	QLD
Darwin City Council	Darwin	NT
DBIRD	Katherine	NT
DBIRD	Tennant Creek	NT
DBIRD Cattle Exports	Darwin	NT
DBIRD Pastoral	Darwin	NT
Dee Jay Engineering	Katharine	NT
Department of Agriculture	Derby	WA
Department of Agriculture	Kununurra	WA
Department of Land Management and Conservation	Perth	WA
Department of Natural Resources and Mines	Brisbane	QLD
Department of Natural Resources and Mines	Brisbane	QLD
Department of Planning and Infrastructure	Perth	WA
Dept. Concervation and Land Management	Kununurra	WA
Derby Enterprise Centre	Derby	WA
Desert Upland	Barcaldine	QLD
DPI	Charters Towers	QLD
Eacham Shire Council	Malanda	QLD
Emerald Shire Council	Emerald	QLD
Environmental Health Services	Port Hedland	WA
Etheridge Shire Council	Georgetown	QLD
Flinders Shire Council	Hughenden	QLD
Frosty Mango	Townsville	QLD
Gemco	Groote Eylandt	NT
Gilnockie Station	Katherine	NT
Gulf Savannash Development Group	Cairns	QLD
Hedland Business Information Centre Inc	Port Hedland	WA
Heytesbury	Darwin	NT
Imparja Television	Alice Springs	NT
Jabiru Council	Jabiru	NT
Julalikari Council Aboriginal Corporation	Tennant Creek	NT
Kakadu National Park	Jabiru	NT
Katherine Council	Katherine	NT

Organisation	Town	State
Kestrel Coal Mine	Emerald	QLD
Kimberley Aboriginal Pastoralist Assoc	Kununurra	WA
Kimberley Area Consultative Committee	Broome	WA
Kimberley Development Commission	Kununurra	WA
Kimberley Land Council	Broome	WA
Kimberley Tourism Association	Broome	WA
Kowanyama Land and Natural Resources Management Office	Kowanyama	QLD
Land Council Borroloola	Borroloola	NT
Land Council East Arnhem	Nhulunbuy	NT
Land Council Katherine	Katherine	NT
Land Council Ngukurr	Ngukurr	NT
Land Council Tennant Creek	Tennant Creek	NT
Land Council Victoria River Dist	Timber Creek	NT
Land Council West Arnhem	Jabiru	NT
Longreach Shire Council	Longreach	QLD
Mabunji - Resource Agency	Borroloola	NT
MacArthur River Mine	Borroloola	NT
Mareeba Shire Council	Mareeba	QLD
McKinlay Shire Council	Julia Creek	QLD
Mount Isa City Council	Mount Isa	QLD
N.T. Environmental Laboratories	Darwin	NT
N.T. Minerals	Darwin	NT
NFF	Canberra	ACT
NLC Land and Sea Management	Darwin	NT
NLC Land and Sea Management	Darwin	NT
North Australia Assay Co	Pine Creek	NT
Northern Territory Tourism Commission	Darwin	NT
NPWS - Brisbane	Brisbane	QLD
NPWS - Emerald	Emerald	QLD
NPWS - Mt Isa	Mount Isa	QLD
NPWS - Townsville	Townsville	QLD
NQ Conservation Council	Townsville	QLD
NT Buffalo Industry Council Inc	Winnellie	NT
NT Cattleman's Association Inc	Darwin	NT
NT Industrial Capability Network	Darwin	NT
NT landcare Council	Darwin	NT
NT landcare Council	Katherine	NT
NT Office of Territory Development	Darwin	NT
Office of Aboriginal Economic Development	Broome	WA
Pasminco Century Mine	Townsville	QLD
Peak Downs Shire Council	Capella	QLD

Organisation	Town	State
Peak Downs Shire Council	Capella	QLD
Peak Downs Shire Council	Capella	QLD
Pilbara Development Commission	Port Hedland	WA
Pilbara Land Council	Port Hedland	WA
Qld Dept of Primary Industries	Brisbane	QLD
Qld Dept of State Development	Brisbane	QLD
Qld Rail	Townsville	QLD
Queensland Conservation Council	Brisbane	QLD
Ranger Uranium Mine	Jabiru	NT
Rockhampton City Council	Rockhampton	QLD
Shire of Wyndham East Kimberly	Kununurra	WA
Southern Gulf Catchments	Cloncurry	QLD
Tambo Shire Council	Tambo	QLD
Telstra	Brisbane	QLD
Telstra	Townsville	QLD
Telstra	Brisbane	QLD
Thuringowa City Council	Thuringowa	QLD
Tourism Council of the NT	Darwin	NT
Tourism Top End	Darwin	NT
Tourism Tropical North Queensland	Cairns	QLD
Townsville City Council	Townsville	QLD
Townsville Enterprise	Townsville	QLD
Undara Experience	Mount Surprise	QLD
WA Dept of Premier and Cabinet	Perth	WA
WA Tourism Council	Perth	WA
Wilderness Society	Hobart	TAS
Wunan Foundation	Kununurra	WA

Appendix C: Tropical Savannas Stakeholder Issue Survey– Information Sheet

Tropical Savannas

Stakeholder Issue Survey

Letter of Introduction

Dear Stakeholder

The Tropical Savannas Cooperative Research Centre (TS CRC) has invested in research that is looking at prospects for developing a computer model of the Australian Savannas. The model could – potentially – simulate the effect (on the environment, on regional communities and on regional economies) of specific ‘changes’, providing valuable information to those who wish to assess the pros and cons of ‘change’ in the Australian Savannas.

Background work has already begun. Researchers from the University of Queensland, CSIRO and QLD DPI are looking at biophysical/environmental and demographic modelling issues, and researchers from JCU are focusing on economic issues. It is hoped that insights from these initial background investigations can be used in a future project that will progress the development of a truly integrated model of the Australian Savannas.

There are many different types of computer simulation models – and they often ask different questions about different issues (i.e. they ‘model’ different types of ‘change’). Different models also consider different time horizons, and look at different geographic scales. Researchers can assess the ‘theoretical soundness’ of different models – and whether or not there is enough data to run them. But they are not always well placed to determine which issues are most important to those who must make regular decisions that affect the environment, the economy, and/or the community of the Australian Tropical Savannas (hereafter called stakeholders).

Hence this letter.

We write in the hope that your organisation will agree to participate in our survey of ‘TS Stakeholder Issues’. The survey seeks to determine <u>which questions</u> stakeholders are most likely to ask about <u>which economic issues</u> in <u>which regions</u> over <u>what period(s) of time.</u> Your answers could help us decide which type of modelling approach is most likely to generate useful information to those who live, work and care about the great “Top End”.

The survey will be conducted by telephone but a copy is provided to you with this letter. We would be grateful if you could signal your organisation’s consent to participate and nominate someone to answer the survey questions on behalf of your organisation. This can be done by completing the attached ‘consent’ form, and then returning it via the reply paid envelope. A member of the JCU research team will telephone your ‘nominee’ to arrange a day and time that is convenient for him/her to answer the questions over the phone. We estimate that this should take no more than 15-20 minutes, and hope to complete all interviews before the end of April, 2004.

Data obtained in this survey will be treated as strictly confidential. No information will be attributed to any single organisation (unless at the request, or with the permission of the organisation involved), and results will only be released in aggregate form (*eg. The survey indicates that local governments are mostly concerned with issues about …… whereas business organisations are more interested in ……*'). Responses to the survey will be stored separately from the names and addresses of organisations and individuals, so that no link can be made between them.

Should you have any queries about the study, please do not hesitate to contact either of the Chief Investigators for the JCU (economics) component of the project. Details are provided below.

On behalf of the JCU research team – and the TS CRC – we thank you for your time.

Yours sincerely,

Dr Owen Stanley
Associate Professor in Economics
School of Business
James Cook University
Townsville
QLD 4814
Tel: 07 4781 5393, Fax: 07 4781 4019
Email: Owen.Stanley@jcu.edu.au

Dr Natalie Stoeckl
Economics Program
School of Business
James Cook University
Townsville
QLD 4814
Tel: 07 4781 4868, Fax: 07 4781 4019
Email: Natalie.Stoeckl@jcu.edu.au

Should you have any complaints or questions about the conduct of this survey, please feel free to contact:

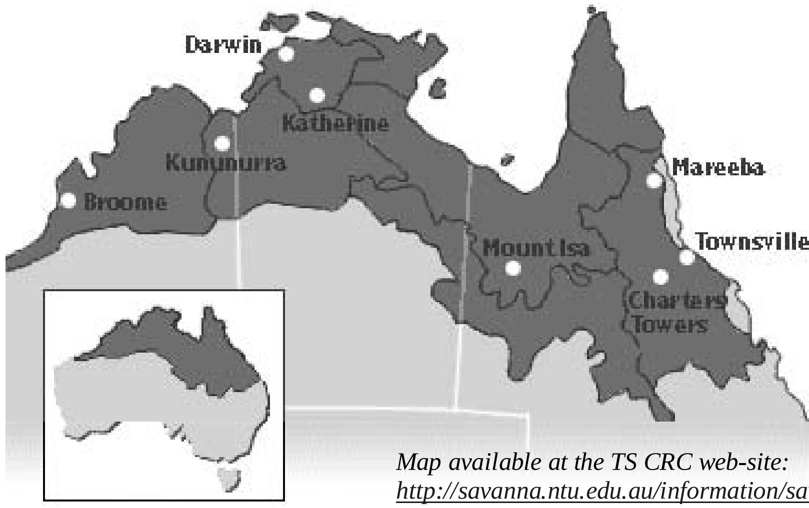
Tina Langford
Ethics Administrator
Research Office
James Cook University
Townsville
QLD 4811
Tel: 07 4781 4342
Fax: 07 4781 5521
Email:Tina.Langford@jcu.edu.au

Appendix D: Tropical Savannas Stakeholder Issue Survey

1. Which type of organisation are you representing in this survey *(please ✔ as many boxes as apply)***?**

- ❒ Indigenous Association/Community
  - Which type of Indigenous association? *(please ✔ as many boxes as apply)*
    - ❒ Land Council
    - ❒ Regional Council
    - ❒ Other (*please specify)* ______________________________
- ❒ Government
  - Which level of Government**?** *(please ✔ as many boxes as apply)*
    - ❒ Local
    - ❒ State / Territory
    - ❒ Federal
- ❒ Industry/Business Association
  - What type of industry/Business association? *(please ✔ as many boxes as apply)*
    - ❒ Agricultural
    - ❒ Mining
    - ❒ Tourism
    - ❒ Other (*please specify)*________________________________
- ❒ Non-government, not-for profit association
  - What type of association? *(please ✔ as many boxes as apply)*
    - ❒ Community
    - ❒ Environmental
    - ❒ Other (*please specify)*________________________________
- ❒ Business, corporation, firm, or partnership
  - How would you describe the type of 'industry' your business is involved in? *(please ✔ as many boxes as apply)*
    - ❒ Agriculture, Forestry and Fishing
    - ❒ Mining
    - ❒ Manufacturing
    - ❒ Electricity, Gas and Water Supply
    - ❒ Construction
    - ❒ Wholesale Trade
    - ❒ Retail Trade
    - ❒ Accommodation, Cafes and Restaurants
    - ❒ Transport and Storage
    - ❒ Communication Services
    - ❒ Finance and Insurance
    - ❒ Property and Business Services
    - ❒ Government Administration and Defence
    - ❒ Education
    - ❒ Health and Community Services
    - ❒ Cultural and Recreational Services
    - ❒ Personal and Other Services
    - ❒ Other (*please specify)* _____________________
- ❒ Other (*please specify)* ………………………………

2. **In what town is the organisation's "head office"** *(if head office is not in a town, please note nearest town &/or regional centre)***?** ____



Map available at the TS CRC web-site:
http://savanna.ntu.edu.au/information/savannaexplorer.htm l

3. **Is the organisation's head office in Australia's Tropical Savannas** *(i.e. within the shaded part of the map above)***?**

   ❒ Yes

   ❒ No

   ↳ Does your organisation have branches &/or people permanently located in Australia's Tropical Savannas?

   ❒ No

   ❒ Yes → Where (please specify nearest town) ______________

4. **How many people are members of the organisation (or employed by it, or associated with it)?**

(if answering this survey on behalf of a an elected council – eg. a regional council, or local government- then please indicate the number of people working in the council)

❒ 1 - 9 persons

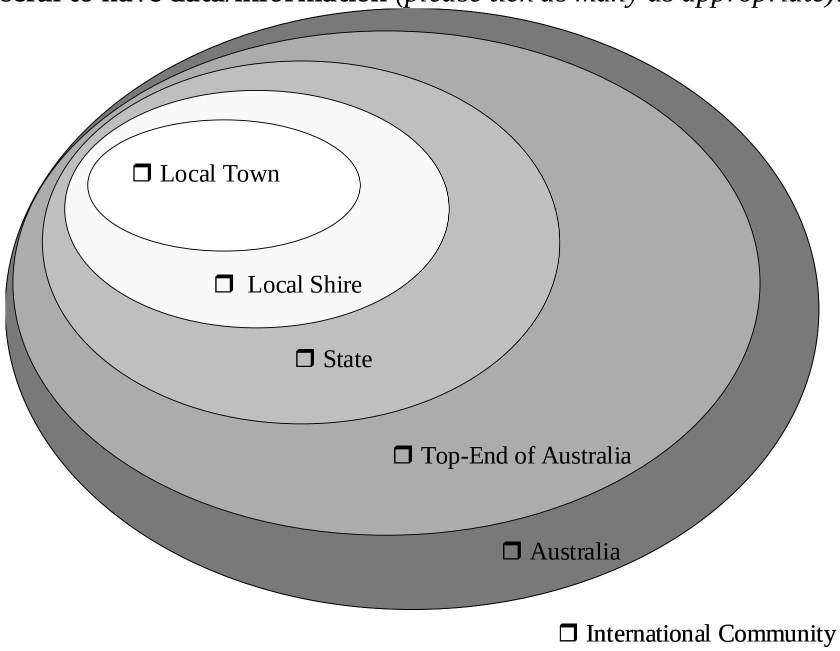
❒ 10-19 persons

❒ 20-99 persons

❒ 100 or more

❒ Unsure

5. **Different simulation models use, and generate, information at different geographic scales – eg unemployment within a small town, unemployment across all of Australia. At which of the following geographic scales would you, or others within your organisation, find it useful to have data/information** *(please tick as many as appropriate)***?**



❒ Other (*please specify*) ______________________________________

6. **Different simulation models make 'predictions' about the impact of change over different time horizons. Over which time horizons would you, or others within your organisation, find it useful to have predictions about** *(please tick as many as appropriate)***?**

❒ Over the next 1-12 months
❒ Over the next 1-2 years
❒ Over the next 2-5 years
❒ Over the next 5-10 years
❒ Over the next 10-25 years
❒ Over the next 25-100 years
❒ Over the next 100+ years
❒ Other (*please specify)*

7. **Different simulation models make predictions about the impact of different types of 'change'. How interested would you – or others within your organisation – be in a simulation model that could make predictions about the impact of each of the changes below?** *(please tick box that indicates level of interest for each 'change')***:**

	Extremely interested	*Moderately interested*	*nterested*	*Unsure*
Changes 'caused' by government, eg:				
a. Changes in tax rates	☐	☐	☐	☐
b. Changes in import and export duties	☐	☐	☐	☐
c. Changes in public infrastructure (eg. new roads, railways, airports, etc)	☐	☐	☐	☐
d. Changes in welfare payments	☐	☐	☐	☐
e. Changes in other levels of public spending (eg. spending on defence, health, education, etc)	☐	☐	☐	☐
Changes in the business world, eg:				
f. Changes in the demand for an industry's product (eg. growth in tourism or in the demand for beef)	☐	☐	☐	☐
g. The introduction of a major new firm/business in the area (eg. a new mine)	☐	☐	☐	☐
h. Changes in transport costs	☐	☐	☐	☐
i. Changes in labour costs (eg. in wages)	☐	☐	☐	☐
Changes 'caused' by the 'outside world' eg:				
j. Changes in technology (eg. faster machines, better communications)	☐	☐	☐	☐
k. Changes in exchange rates	☐	☐	☐	☐
l. Changes in interest rates	☐	☐	☐	☐
m. Changes trading agreements between nations	☐	☐	☐	☐
n. Changes in population (eg. regional migration)	☐	☐	☐	☐

Please list other 'changes' (not necessarily economic) that you, or your organization would find it useful to be able to 'model' the impact of:

o. ______________________________

p. ______________________________

q. ______________________________

r. ______________________________

s. ______________________________

t. ______________________________

u. ______________________________

8. Different simulation models make predictions about the impact of different types of 'change' on different variables (e.g the impact of 'change' on unemployment rates, or the impact of 'change' on the price of cheese). How interested would you – or others within your organisation – be in a simulation model that could make predictions about the impact of 'change' on any of the following variables? *(please tick box that indicates level of interest for each 'variable')*

		Extremely interested	*Moderately interested*	*ıterested*	*Unsure*
a.	Employment (total)	☐	☐	☐	☐
b.	Employment by industry/sector				
	if only one industry/sector, please specify ______	☐	☐	☐	☐
c.	Unemployment	☐	☐	☐	☐
d.	Income & Production (total)	☐	☐	☐	☐
e.	Income & Production by industry/sector				
	if only one industry/sector, please specify ______	☐	☐	☐	☐
f.	Income distribution				
	(eg. the gap between rich and poor)	☐	☐	☐	☐
g.	Business Profitability (total)	☐	☐	☐	☐
h.	Business Profitability by Industry/Sector				
	if only one industry/sector, please specify ______	☐	☐	☐	☐
i.	Producer prices / costs of production	☐	☐	☐	☐
j.	Wages	☐	☐	☐	☐
k.	House prices / rental costs	☐	☐	☐	☐
l.	Consumer prices	☐	☐	☐	☐

Imagine that it is possible to construct a model that could make predictions about the impact of 'change' on other variables. What type of 'variables' (not necessarily economic) would you, or others within your organisation, be interested in making predictions about (**feel free to list as many as you like***)*?

m. ______________________________

n. ______________________________

o. ______________________________

p. ______________________________

q. ______________________________

r. ______________________________

s. ______________________________

t. ______________________________

u. ______________________________

9. **How frequently do you, or others within your organization, deal with each of the following items?** *(for each item, please tick box that indicates frequency)*

	Never	*Once or twice a decade*	*Once every 1 -3 years*	*Once or twice a year*	*Once a month*	*Unsure*
a. Employment (total)	☐	☐	☐	☐	☐	☐
b. Employment by industry/sector *if only one industry/sector, please specify* ______	☐	☐	☐	☐	☐	☐
c. Unemployment	☐	☐	☐	☐	☐	☐
d. Welfare (Unemployment benefits, CDEP, disability pensions, etc)	☐	☐	☐	☐	☐	☐
e. Income & Production (total)	☐	☐	☐	☐	☐	☐
f. Income & Production by industry/sector *if only one industry/sector, please specify* ______	☐	☐	☐	☐	☐	☐
g. Income distribution (eg. the gap between rich and poor)	☐	☐	☐	☐	☐	☐
h. Business Profitability (total)	☐	☐	☐	☐	☐	☐
i. Business Profitability by Industry/Sector *if only one industry/sector, please specify* ______	☐	☐	☐	☐	☐	☐
j. Producer prices / costs of production	☐	☐	☐	☐	☐	☐
k. Exchange rates	☐	☐	☐	☐	☐	☐
l. Inflation	☐	☐	☐	☐	☐	☐
m. Interest rates	☐	☐	☐	☐	☐	☐
n. Wages	☐	☐	☐	☐	☐	☐
o. House prices / rental costs	☐	☐	☐	☐	☐	☐
p. Consumer prices	☐	☐	☐	☐	☐	☐
q. Local Taxes (e.g. rates)	☐	☐	☐	☐	☐	☐
r. State Taxes (e.g. Stamp duties)	☐	☐	☐	☐	☐	☐
s. Federal taxes, tariffs, import duties	☐	☐	☐	☐	☐	☐

Please list other important issues (not necessarily economic ones) that you, or others within your organisation deal with regularly

t. ……………………………………………	☐	☐	☐	☐	☐	☐
u. ……………………………………………	☐	☐	☐	☐	☐	☐
v. ……………………………………………	☐	☐	☐	☐	☐	☐
w. ……………………………………………	☐	☐	☐	☐	☐	☐
x. ……………………………………………	☐	☐	☐	☐	☐	☐
y. ……………………………………………	☐	☐	☐	☐	☐	☐
v. ……………………………………………	☐	☐	☐	☐	☐	☐

Thank you for your help ☺