Regulatory Reform of the Queensland Sugar Industry: An Economy-Wide Perspective

Staff Research Paper
By

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The contents of this paper should not necessarily be taken to represent the opinions, views or policies of the Queensland Government or the Queensland Treasury. The authors thank Antony Skinner for comments provided on earlier drafts of this paper.

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1 Introduction

In December 2002, the Centre for International Economics (CIE) released their report[1] on the impact of reforming the *Sugar Industry Act 1999* ("the Act"). In their report the CIE employed a partial equilibrium[2] (PE) model to quantify the impact on the sugar sector stemming from two factors:

- potential changes to the Act; and
- various projections of the world sugar price.

To complement the information provided in the CIE report, the Office of Economic and Statistical Research (OESR) has undertaken an economy-wide analysis of potential changes to the Act. OESR's contribution consisted of using a General Equilibrium (GE) model, hereafter referred to as QGEM, to analyse the short and long-run effects on the broader Queensland economy of the sugar sector[3] restructuring scenario that was supplied by CIE. The issue of the direct impact of various projections for the world sugar price is not addressed in this paper.

An important issue that is pertinent to OESR's methodology for modelling this policy is the efficacy of combining the output of the CIE model with OESR's GE model. That is, to what extent is this QGEM-based analysis complementary to the CIE's PE modelling.

This also begs the question of whether the results from the PE analysis are necessary or useful. Indeed, if the PE analysis is insufficient for understanding the economic impact of the industry restructuring, then why not just proceed with the QGEM analysis, and ignore the output from the PE model? This issue can be addressed through understanding OESR's two possible alternatives for modelling this policy scenario:

- OESR could take the results generated from the CIE's PE model and impose these values into QGEM by endogenising the relevant supply and demand relationships within the GE model; or
- OESR could take the specific sugar-sector shocks (inputs) that the CIE imposed on their model, and allow the relevant supply and demand relationships within the GE model to determine the results for the sugar-sector.

Section 3.5 discusses how, despite primarily using the first approach, we combine elements of both these approaches to derive the maximum benefit from the complementarities between the CIE's PE research and OESR's GE modelling capacity. In light of this, we argue that the results from the PE analysis are useful, in that they provide information that is unlikely to be generated in a cost-effective manner using a GE framework. In particular, the benefit from CIE's rich treatment of potential scale economies in sugar milling and the competitive relationships, both within and between each layer, in the tightly vertically-integrated chain

[1] Centre for International Economics (2002) *Cleaning up the Act: The Impacts of Changes to the Sugar Industry Act 1999*

[2] A partial equilibrium, in the strictest sense, does not involve behaviour and interactions outside the sector under analysis. In a more general sense, a partial equilibrium analysis operates under the assumption that an economic change in one sector will not cause feedbacks to the initiating sector as the change works through the rest of the economy.

[3] The "sugar sector" refers to the harvesting, sugar cane growing, milling and refining industries.

from sugarcane farm to sugar refinery. It is in this sense then that OESR's analysis, using QGEM, can be seen as complementary to the CIE's modelling.

A second issue, that is pertinent to OESR's decision to use a GE modelling framework, is that many economists have argued, based on the results of past empirical research, that the PE result provides a close approximation of the GE result. This technical debate revolves around the implicit assumptions incorporated in the type of GE models used in the policy debates from the mid 1970's to the mid 1990's. However, the recent empirical literature[4], based on results generated using dynamic CGE models, casts significant doubt on this proposition.

A central theme of this recent literature is that it is the dynamic effects of allocative efficiency gains that provide evidence that the PE result is an inconclusive answer. However, Dixon and Rimmer (1999)[5] provides evidence that the issue of PE and GE effects cannot be limited to just the endogenous growth in aggregate technical change. In their 1999 paper the authors provide evidence of a divergence between the PE versus GE results caused by terms-of-trade effects that can only be demonstrated using a dynamic analysis. More importantly, Dixon and Rimmer demonstrate that not just the magnitude of the result depends on the choice of PE versus GE analysis, but also the sign of the result can be dependent on this choice.

If it was true that the PE result was always equal in sign and similar in magnitude to the GE result, then GE analysis would not be necessary. However, the literature cited above demonstrates that when various simplifying assumptions are relaxed, appropriately undertaken GE analysis can generate significantly different results to a PE analysis. More importantly, in some circumstances, appropriately undertaken GE analysis can generate results that invalidate the PE analysis. Yet it is important to recognise this invalidation is perhaps limited to the PE estimate of the whole of economy impact, not the PE estimate of the impact on the specific industries involved in the restructuring.

Whilst accepting the conclusions of this literature, OESR choose to use QGEM, a comparative static GE model to analyse the structural reform scenario. The decision to conduct a comparative static analysis using the results from the CIE report was based on two important factors:

- OESR's desire to make good use of the highly credible CIE analysis, which was based on an extremely detailed sugar sector model. This CIE model had a rich treatment of the each of the layers in tightly vertically integrated chain from sugar farm to sugar refinery; and
- The need to avoid the distraction of a debate about the robustness of forecasts of agricultural output and world agricultural commodity prices that would be necessary assumptions in undertaking any dynamic modelling analysis. Whilst such forecasts could be argued to be an essential component of a dynamic modelling analysis, they are not part of the objectives of OESR's research.

It should be noted however, that OESR's analysis, using both a short run and a long run modelling environment, can be seen as a 'middle-ground' position between a strictly short

[4] For example, Dixon, Parmenter & Rimmer, 1998, "Forecasting and policy analysis with a dynamic CGE model of Australia", Centre of Policy Studies, Monash University.
[5] Dixon & Rimmer, 1999, "Changes in indirect taxes in Australia: A dynamic general equilibrium analysis", The Australian Economic Review, Volume 32, No 4, pp 327-348.

run PE analysis, and a full dynamic GE analysis. The specifics of the short run and long run modelling environments are explained in detail in Sections 3.4 and 3.5. In addition, Section 4.3 includes a discussion of the importance, in terms of the effect on the results, of the choice of modelling environment.

In light of OESR's decision to conduct a comparative static modelling analysis, a direct comparison of the CIE's and OESR's results can not be interpreted as evidence that the PE answer is a close approximation of the whole-of-economy impact of the proposed industry restructuring. However, Section 5.3 includes a discussion of the comparison between the direct impact on the Queensland economy implied by the results from the CIE's sugar model, and the combined direct and indirect impact that is generated using QGEM.

In light of all these issues, the objectives of this paper are to:

- explain the methodology used by OESR to implement this strategy of incorporating the PE modelling results rather than explicitly respecifying the QGEM theory;
- present the results of OESR's quantitative modelling of sugar sector restructuring;
- provide a brief analysis of the short and long-run effects on the Queensland economy, including a comparison of the PE estimate and the results determined by the GE model;
- present regional (ie. Queensland's ten Statistical Divisions[6]) output and employment results for the short and long run scenarios. These regional results are generated using a 'top-down' methodology based on the Monash Regional Equation System approach[7].

Section Two of this paper provides a brief overview of the CGE modelling methodology which is used as the framework of this anlaysis. Section Three provides a description of OESR's QGEM model and a summary of the modifications made to QGEM for this modelling exercise. This section includes a discussion of the economic modelling environment assumed for this exercise. Section Four provides detail on the regulatory reform scenario modelled using QGEM and a discussion of the components of CIE's partial equilibrium analysis that were incorporated into QGEM. Section Four also includes information on our a-priori expectations for the policy simulations. Section Five presents an analysis of the results, with some concluding remarks presented in Section Six.

[6] Note that although there are 11 Queensland Statistical Divisions, the Brisbane and the Morton Divisions are combined in the dataset used in this analysis. A list of the ten Statistical Divisions is provided in Section 4.1

[7] Section 3.3 includes a brief explanation of this MRES methodology. Note that Dixon & Rimmer, 2003 cite Leontief et al, 1965 as the original source for this methodology.

2 Framework for Analysis

2.1 What is a CGE Model?

A Computable General Equilibrium model is a mathematical representation of an economy. At the core of the model is a set of equations describing the behaviour of various economic agents (such as, industries, households and governments) when faced with changes in key economic variables, for example, and most importantly, relative prices. This theoretical structure is usually derived from neoclassical microeconomics. Typically, households maximise their benefit or satisfaction that they obtain from the consumption of goods and services subject to a budget constraint, and industries minimise costs subject to a given production function. The core behavioural equations are supplemented with market clearing equations which equate supply and demand in all commodity and factor markets. The model is calibrated from a numerical database, the central core of which is a set of input-output (I-O) accounts showing, for a given year, the flows of commodities and primary factors between groups of economic agents.

In order to obtain a solution to the model, the model's equations are solved simultaneously. However, CGE models usually have more variables than equations, which means that the user must specify the values of some variables. This set of user-specified exogenous variables is referred to as the model's closure.

Although used as a mathematical tool to help solve the model, the closure plays a more fundamental role by creating the economic environment in which policy scenarios are set. In other words, the closure specifies some variables as exogenous to reflect various assumptions regarding the way economic agents behave, as well as any economy-wide constraints. For example, the closure typically reflects assumptions about the government's budget deficit, investor's capital formation, wages and foreign currency prices.

There are various types of CGE models and one way in which they can be distinguished is according to their treatment of time. A comparative static (CS) model, for example, compares the economy at two distinct points in time, without modelling any explicit time period or adjustment path. Typically, the two states compared are the state of the economy *with* a given policy change and the state of the economy *without* the policy change. Consequently, this method of analysis does not provide any detail of the adjustment path of the economy between the two points in time. However, a broad timeframe for these simulations is specified by the closure, for example, short-run or long-run. In CGE modelling, the *short-run* is generally taken to represent a period of approximately one to two years, while the *long-run* represents a period of approximately eight to ten years.

An alternative category of CGE models, recursive-dynamic, deals with time explicitly. These models perform year-to-year simulations with several links through time rather than calculating a snapshot of the economy before and after the policy implementation. Some examples of these linkages through time are accumulation relationships for capital stock and the resident population of each region. Therefore, these recursive-dynamic models are able to provide the user with information on the adjustment path resulting from any policy shock.

For some policy simulations, understanding the adjustment path can be as important to the policy analyst as the final outcome of the policy shock. In such cases, the results obtained from a recursive dynamic model are more informative and detailed than those obtained from a comparative static model. However, a recursive dynamic model is more complex than its comparative static counterpart and therefore more time and effort is required to design and interpret simulations.

Another area in which CGE models can be distinguished is according to their level of spatial detail. A CGE model could, for example, be a national or multi-region model. The level of disaggregation generally depends on user preference and the availability of suitable I-O data. In Australia for example, there are several CGE models that are disaggregated to the State level but no publicly available model exists at the sub-state level due to information constraints. In particular, a lack of official intra-state (inter-regional) trade flows.

Within the category of multi-region CGE models, a further distinction can be drawn as to how each region is modelled. One method[8] is to use a '*top-down*' procedure that allocates the aggregate national results proportionally across regions according to known regional economic statistics, such as employment by industry. One disadvantage of this approach is that it implicitly assumes that the cost and sales structures for a given industry, in each region, are the same as the national industry structure.

Alternatively, providing the I-O data is available, each region can be modelled according to a *bottom-up* procedure. Under this procedure each region is modelled as a separate economy with government and household budgets and *intra*-region, *inter*-region and international trade flows separately specified. The major advantage of this procedure when using a multi-region model, as opposed to the "top-down" procedure, is that each region has separately specified supply constraints. Therefore, a multi-region CGE model that uses the "bottom-up" procedure is ideally suited to determining the impact of region-specific economic shocks.

2.2 Alternative Economic Impact Methodologies

Another commonly used impact assessment tool, for industry-based policy analysis, is Input-Output modelling. For I-O modelling, the values in the I-O table are converted to fixed shares which, through the process of matrix manipulation, can be used to derive estimates of the gross economic stimulus resulting from some specified event or policy action. I-O analysis also involves the use of multipliers to calculate the gross economic impact of a project or policy change. Two types of multipliers are commonly used. Type I multipliers measure the industrial response to the change while Type II multipliers also include the consumption-induced response.

I-O analysis does not contain supply side and budget (Government and household) constraints. In a market economy constraints on the availability of inputs, such as skilled labour, require some means, for example prices, to act as an allocative device. Therefore, prices act as a signal that induces changes in the consumption patterns of producers and consumers. In I-O analysis, where all adjustments take place as changes in the quantities produced, this type of allocative response is assumed not to occur.

[8] This method, taken from the Monash Regional Equation System is explained in Section 3.3

It is worth noting that the major empirical component of a CGE model is an I-O table. However, in CGE analysis both the price and quantity components are allowed to adjust, with both components driven by different factors, in response to the economic event being analysed. For the CGE model, the estimated response will depend partially on the coefficients used to drive the behavioural relationships specified in the theoretical structure of the model. However, more importantly, it will depend on the model's economic environment which is specified by the user for each particular economic impact analysis.

Overall, the estimated economic impacts derived from an I-O analysis will usually be larger than those derived from a CGE analysis. This is the result of the I-O techniques' use of average rather than marginal responses, the absence of supply side and budget constraints and the lack of any price responses. It should be noted that this effect of I-O analysis overstating the economic impact is symmetrical. That is, a negative shock analysed within an I-O framework will overestimate negative effects for all industries and a positive shock will overestimate positive effects for all industries that are related to the initial industry. In this sense, I-O analysis can be seen as a biased estimator of economic impacts.

Having identified these deficiencies of I-O analysis, OESR rejected this framework as a possible alternative for this exercise.

3 The Queensland General Equilibrium Model (QGEM)

Treasury initiated the development of its own CGE model in 1993, in order to meet the increasing demand for detailed economic impact analysis focusing on the Queensland economy. Following on from this initial development, a new version of QGEM was created, based on the MONASH-MRF[9] multi-region model developed by the Centre of Policy Studies at Monash University (Peter et al, 1996). Since adopting the MMRF comparative static components[10], QGEM has undergone continual development to incorporate additional theoretical specifications and more recent data. In particular, the MONASH-MRF framework has been customised by OESR in the following ways:

1. QGEM provides a full economic specification for two regions – Queensland and the Rest-of-Australia (ROA), and utilises data developed by OESR;
2. QGEM provides extensive industry and commodity detail for each of the two fully specified regions incorporated in the model; and
3. QGEM provides a 'top-down' disaggregation facility[11] for deriving results at the Queensland Statistical Division level.

The current QGEM database[12] is based on OESR's 1996-97 Input-Output data for the Queensland and ROA economies (Thomas et al, forthcoming). For this modelling exercise, QGEM separately identified 40 commodities and 40 industries in each of the two fully specified regions and ten Queensland Statistical Divisions. A list of these commodities and industries is contained in Appendix A.

3.1 The Structure of QGEM

This section outlines the basic structure of the QGEM database, as well as the model's theoretical structure. This section of the paper draws heavily on (Peter et al, 1996).

Database Structure

Figure 1 is a schematic representation of QGEM's input-output database. The columns identify the types of agents in the economy, while the rows show the structure of purchases made by each of these agents.

[9] Peter M. W., Horridge M., Meagher G.A. and Naqvi, Fazana (1996) "The Theoretical Structure of Monash-MRF" Centre of Policy Studies Preliminary Working Paper #OP 85 Monash University April 1996

[10] A recursive dynamic version of QGEM is currently under development.

[11] Section 3.3 includes a brief explanation of this MRES methodology taken from the Monash model. Note that QGEM uses a modified version of this methodology in the sense that the Queensland estimates are derived from a 'bottom-up' method not top-down from the national result. However, results for the 10 Statistical Divisions are derived top-down from the Queensland result.

[12] Thomas M., Clark M., & Hartley J. (Forthcoming) "Construction of the 1996-97 QGEM Database" Office of Economic and Statistical Research, Queensland Treasury.

		ABSORPTION MATRIX					
		1	2	3	4	5	6
		Producers	Investors	Households	Export	Qld Govt	Federal Govt
	Size	J x Q	J x Q	Q	1	1	1
Basic Flows	I x S	BAS1	BAS2	BAS3	BAS4	BAS5	BAS6
Margins	I x S x R	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6
Taxes	I x S	TAX1	TAX2	TAX3	TAX4	TAX5	TAX6
Labour	M	LABR					
Capital	1	CPTL					
Land	1	LAND					
Other Costs	1	OCTS					

I = Number of Commodities
J = Number of Industries
M = Number of Occupation Types
R = Number of Commodities used as Margins
Q = Number of Regions (= 2)
S = Number of Regions plus a Foreign Import "region" (= 3)

Figure 1. The QGEM core input-output database

Each of the commodities in QGEM can theoretically be obtained from within Queensland, from the Rest of Australia, or imported from overseas. These source-specific commodities each have taxes associated with them, and have five potential uses:

- by industries as inputs to current production;
- by industries and governments as inputs to capital formation;
- consumption by households;
- consumption by governments;
- exports; and
- margin services.

There is a one-to-one mapping between industries and commodities in QGEM.
As well as intermediate inputs, current production requires inputs of three categories of primary factors: labour (divided into eight occupations), fixed capital, and agricultural land. The Other Costs category covers various miscellaneous industry expenses.

Theoretical Structure

The equations comprising QGEM's theoretical structure can be grouped according to the following classifications:

- producers' demands for commodities and primary factors;
- demands for inputs to capital creation (ie. investment);

- household demands;
- export demands;
- government demands;
- demands for margins;
- zero pure profits in production and distribution;
- market-clearing conditions for commodities and primary factors;
- indirect taxes; and
- regional and national macroeconomic variables and price indices.

The remainder of this section provides a broad explanation of these equation groups.

The Production Structure

QGEM recognises two broad categories of inputs: intermediate inputs and primary factors. Firms in each regional industry are assumed to choose the mix of inputs which minimises the cost of production for their level of output. They are constrained in their choice of inputs by a three-level nested production technology (Figure 2).

At the top level, individual intermediate goods and the bundle of primary factors are used in fixed proportions to output, in accordance with an assumed Leontief production function. These proportions are derived from input-output coefficients in the model's database. At the second level, firms substitute between imported and domestic versions of the good in question[13], and between land[14], labour and capital, according to constant-elasticity-of-substitution (CES) functions. At the third level, firms substitute between Queensland and ROA versions of the domestic-sourced good in question, and between the eight labour types, according to CES functions.
The latter two levels of decision-making in the QGEM production equations require a number of sets of elasticities to be maintained in the model's database:

- Elasticities of substitution between primary factors – QGEM sets these as constant across all industries, with a short-run default value of 0.5 and long-run default value of 1.28;
- Elasticities of substitution between domestic and imported goods – usually around 2.0
- Elasticities of substitution between goods from Queensland and goods from the Rest of Australia – usually around 5 to 10.

The higher the elasticity in a given CES function, the greater the effect of relative price movements on a firm's substitution decision. Like most of the parameters in QGEM, these elasticities are based on those in the MONASH model, as well as research by the Industry Commission (IC, 1994) in the construction of their SALTER model. It is anticipated that the values of these parameters will evolve over time as new research emerges.

[13] It is implicitly assumed that inputs of the same commodity type produced in different regions are not perfect substitutes for one another.
[14] A commonly assumed that the quantity of agricultural land and mining ore-bodies are a fixed factor of production in each relevant industry.

Firms also pay indirect taxes and other costs including working capital costs and imputed wages, and these are assumed to remain a fixed share of the firm's costs. Finally, each CES and Leontief function carries 'technical change' terms which can be set exogenously to shift the share of a given item in the relevant downstream aggregate.

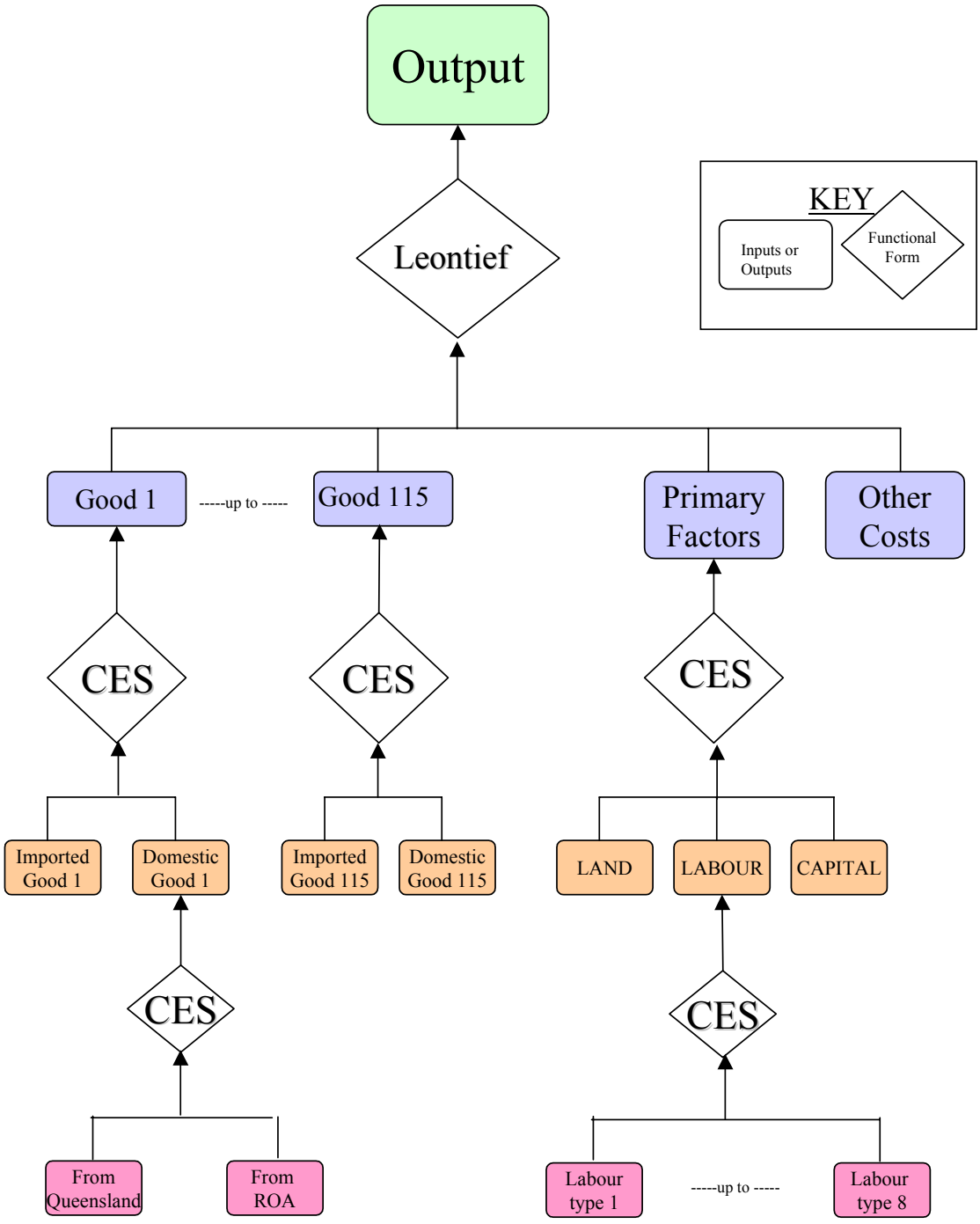


Figure 2. The structure of the QGEM production equations.

The Structure of Investment Demand

The structure of demand for investment goods is very similar to the production demand structure outlined in the previous section, with the important exception that the only inputs to capital creation are goods. That is, no primary factors are used directly as inputs to capital formation. The use of primary factors in capital creation is recognised through inputs of the construction-related commodities.

The structure of the QGEM investment demand equation nest is similar to that shown for intermediate input demand in Figure 2. At the top level, the total cost of investment goods is minimised subject to an assumed Leontief (ie. fixed proportions) function. At the second level, firms substitute between imported and domestic versions of the investment good in question in order to minimise costs, subject to CES functions. At the third level, firms substitute between Queensland and ROA versions of the domestic-sourced investment good in question in order to minimise costs, according to a CES function.

Similar to production, the relevant investment demand elasticities are provided in the QGEM database. A separate set of elasticities is maintained for investment, but the values are currently the same as for production.

The change in an industry's overall investment demand may be determined in two ways: exogenously, via the closure; or via a linear relationship with the change in the capital stock. The former approach is typically adopted in short-run simulations, the latter in long-run simulations.

Household Demands

Aggregate household consumption is determined by aggregate household disposable income, via a Keynesian consumption function. Household disposable income is determined as the difference between the sum of factor incomes, transfer payments, and income taxes.

The commodity composition of household demand is determined by a linear expenditure system (LES) based on a Stone-Geary utility function. Total consumption is divided into two components – a subsistence component and a luxury (or supernumerary) component. The relative quantities within the subsistence component do not vary with relative prices, and aggregate quantities vary only with the number of households (unless shifted exogenously). The subsistence/luxury split applies not only in aggregate, but to each commodity individually, and the model apportions the overall consumption of a commodity across the two components, using expenditure elasticities and a Frisch parameter[15] as a starting point.

Under the Stone-Geary function, household utility is derived only from the luxury component of consumption. 'Luxury' demand for a commodity is then determined by relative prices and the size of the overall budget for luxuries. The sourcing of the commodity is determined in a two-level CES optimisation process, see Figure 4, which similar to the lower two levels of the production demand structure.

[15] The Frisch parameter specifies an initial ratio between total expenditure and luxury expenditure. It is specified in the QGEM database with a value of 1.7

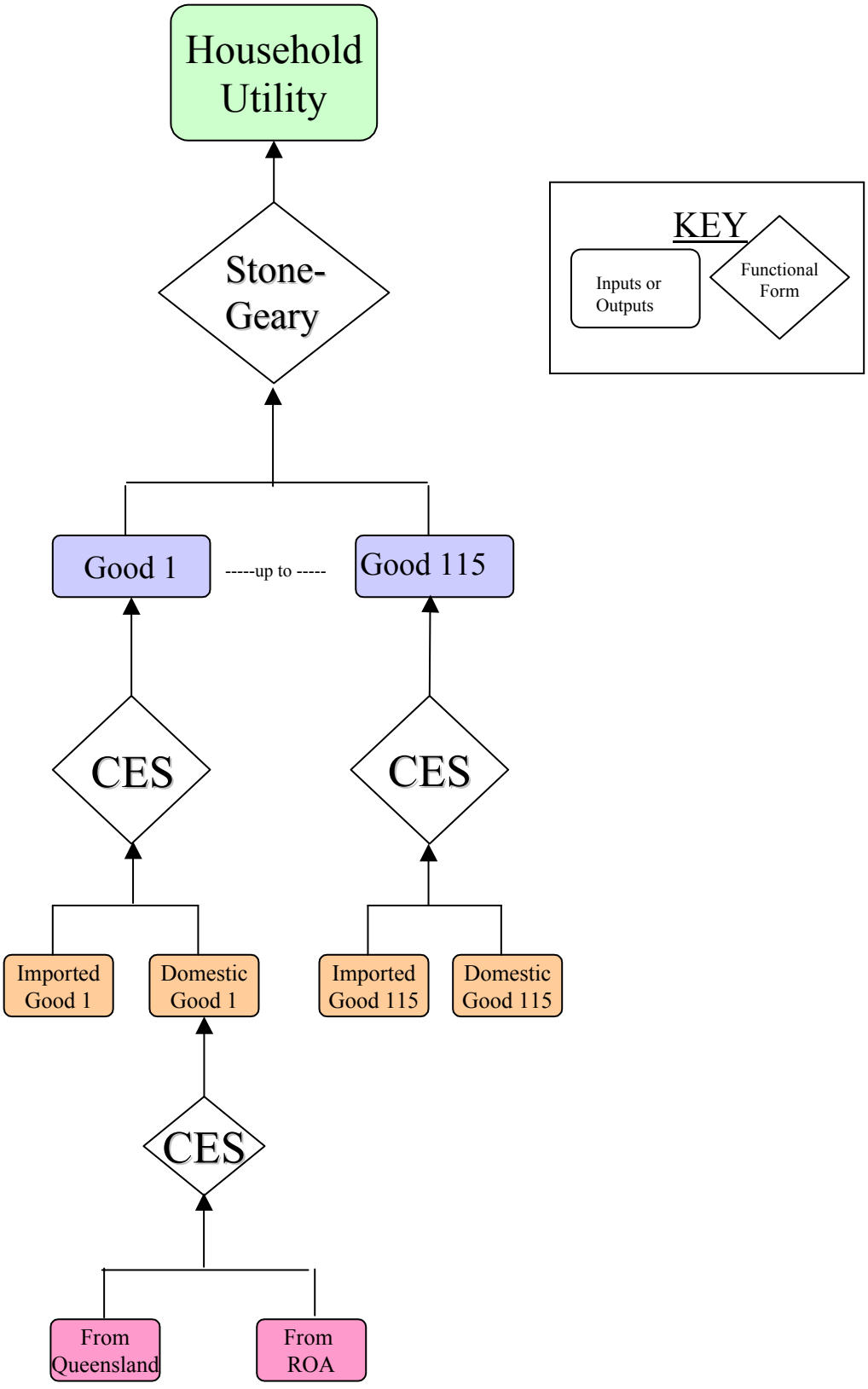


Figure 3. The structure of household supernumerary demand.

Export Demands

The QGEM structure implies two types of trade flows: inter-region and inter-nation (foreign). Since 'exports from Queensland to ROA' are the same as 'ROA imports from Queensland', it makes sense to only model one side of the equation. Hence inter-region exports in QGEM are imputed from inter-region import flows. To model foreign export demands, commodities in QGEM are divided into three groups:

- the traditional exports in agriculture and mining industries, which comprise the bulk of Queensland exports by value;
- foreign tourism export bundle (eg resturant, air transport, recreational and personal services); and
- the remaining commodities, non-traditional exports.

Exports account for relatively large shares of total sales for agriculture and mining, but for relatively small shares (generally less than 10 per cent) of total sales for non-traditional export commodities.

Traditional exporters are assumed to face downward sloping foreign demand functions, with changes in quantities being dependent on changes in prices and the relevant export elasticities. A number of shift variables are also incorporated into the equations to allow for individual and economy-wide horizontal and vertical shifts in the export demand schedules.

Foreign demand for non-traditional exports is determined in aggregate via their average export price and a single export elasticity. Hence the commodity composition of aggregate non-traditional exports is exogenised, with all of these commodities showing the same change in export volumes regardless of movements in their individual prices. Although this is not ideal from a theoretical perspective, it provides a large payoff in terms of model simplicity and reduced processing, in return for a very small reduction in accuracy. Additionally, a given commodity can be readily changed to traditional status if maximum accuracy with respect to exports and production is required for that commodity.

Government Activities

Embodied in QGEM is a large set of equations concerning the activities of the Queensland and Commonwealth governments. These equations support the accounting system described in the ABS publication *State Finance Statistics* (cat. no. 5512.0).

On the income side, there are two major categories: revenues, and financing transactions. Revenues include direct and indirect taxes, interest payments, Commonwealth grants (for the Qld government). Financing transactions capture the change in the governments' net liabilities and represent the difference between government revenue and government expenditure. For example, if expenditure exceeds revenue, then financing transactions increase as the governments' net borrowings increase.

Government expenditure includes five broad categories: goods and services, personal benefits, subsidies, and interest payments. Government expenditure on goods and services consists of government consumption expenditure and government investment expenditure. Government consumption expenditure is set to vary in accordance with changes in private consumption expenditure for the relevant region, unless a shift factor is activated. Similarly, Government investment expenditure varies in proportion with private investment in the

relevant region, subject to the influence of shift factors. It is assumed that the structure of government demand for goods and services does not change.

Demands for Margins

Margin services are those required to transfer commodities from producers to users. In QGEM, up to nine domestically produced commodities are identified as margin services – Wholesale Trade, Retail Trade, Restaurants, Road Transport, Rail Transport, Water Transport, Air Transport, Services to Transport, and Insurance. Within the QGEM database, *margin* usage of commodities is distinguished from '*direct*' usage. For example, Rail Transport is used to take fruit to a market (margin usage), and to take commuters to work (direct usage). Demands for these commodities derived in earlier sections were for direct usage only, and a separate set of equations determines margin usage.

The margin demand equations in QGEM assume that the demands for margins are proportional to the commodity flows with which the margins are associated. It is also assumed that margins are produced in the destination region, with the exception that margins on exports and commodities sold to the Commonwealth government are produced in the source region.

Zero Pure Profits

QGEM contains a set of equations designed to enforce the assumptions of perfect competition and constant returns to scale. In these 'zero pure profits' equations, commodity prices are equated with the weighted sum of input costs. The following areas are targeted:

- Production – the percentage change in the price received per unit of output by a given industry is equal to the cost-weighted average of the percentage changes in input prices;
- Capital creation – as for production, the percentage change in the price of new units of capital in an industry is equal to the percentage change in the average cost of producing the unit;
- Importing – the price received by the importer for a commodity is equal to the product of the foreign price of the commodity, the exchange rate, and the power of the tariff (one plus the tariff rate); and
- Distribution – the percentage change in the purchaser's price of a commodity is equal to the weighted average of the percentage changes in the producer's price, the cost of margins, and commodity taxes.

Market Clearing Conditions

Market clearing conditions ensure that, in the fully modelled regions (Queensland and ROA), supply equals demand for domestically produced and imported commodities. For the factor markets, aggregate supply variables are equated to price-weighted demand summations for each factor. This gives the user of the model the option of setting the aggregate exogenously and allowing market-clearing prices to be determined by the model, or setting prices exogenously and allowing factor usage to be demand determined. The approach taken typically depends on whether the analysis is over the short or long run.

Capital is assumed to be mobile between industries, which negates the possibility of dismantling capital units and reallocating the components to other industries. Land is non-mobile between regions and industries.

Labour is assumed to be homogeneous within each skill group and mobile between industries and regions. QGEM's labour market equations are designed to reflect persistent observed differences in wages and unemployment between Queensland and ROA. Typical simulation approaches are to fix the wage differential and allow the model to determine the migration levels necessary to maintain it, or fix the regional population and allow the wage differential to vary.

Indirect Taxes

Indirect taxes include tariffs, sales taxes, and production taxes[16]. The QGEM database holds indirect tax data for producers, investors, households, exports, and both governments. For each user, the indirect tax equations allow for variations in tax rates across commodities, sources, and destinations.
Payroll tax rates for Queensland and ROA are stored in the database, and are modelled as an adjustment to the price of labour in a given industry and occupation.

3.2 Modifications to QGEM

For this modelling exercise, OESR implemented three database and theoretical modifications to QGEM. The primary purpose of these modifications was to incorporate and align QGEM with information provided by the CIE report. The second objective was to provide sub-state results, again in accordance with the information provided by the CIE report.

1. The first of the QGEM modifications was the disaggregation of several new industries from QGEM's original database. All data used in this modification process was supplied by CIE. The disaggregated industries were:
   - Harvesting;
   - Sugar Cane Growing;
   - Sugar Milling; and
   - Sugar Refining.

2. The second modification to QGEM for this specific modelling exercise was the development of a 'top-down' procedure to calculate the output and employment impacts on Queensland's ten Statistical Divisions. The 10 Queensland Statistical Divisions that are separately identified in QGEM are listed in Appendix B. This involved incorporating a modified form of the MONASH Regional Equation System (MRES) into QGEM to disaggregate the Queensland results down to the statistical division level. Section 3.3 provides a detailed description of this MRES procedure.
3. The third modification to QGEM for this modelling exercise was incorporating outputs from CIE's partial equilibrium modelling as simulation inputs. Some information on the appropriate economic environment for OESR's modelling was also provided by CIE. The purpose of obtaining both sets of information from CIE was to ensure consistency between the data supplied by CIE and the manner in which this data was utilised in

[16] Direct taxes consist mainly of income taxes.

QGEM. OESR also modelled CIE's sugar reform scenario using alternative economic environment assumptions.

3.3 MRES procedure

The MRES procedure implemented in QGEM is a simplified version of the Regional Equation System in the MMRF_Green model[17] developed by Dr Philip Adams at Monash University. The MMRF model bases its procedure on that used in the MONASH and ORANI models. Note that Dixon and Rimmer, 2003 give credit to Leontief et al, 1965 as the original pioneers of this approach.

The majority of data used in the QGEM version of the MRES procedure was developed by OESR, with only the sugar sector output and employment data supplied by CIE. The following information on MRES is sourced from Parmenter and Welsh (2001)[18].

MRES is a 'top-down' method that, with minimal requirements for regional data, provides the modeller with results for output and employment at the Queensland regional level. The standard QGEM equations determine state and national level results for numerous variables, including output and employment. The MRES procedure determines the regional (sub-state) level results directly from the state-wide output and employment results. This MRES approach involves first dividing the industries identified in QGEM into two groups, *national* industries and *local* industries. *National* industries produce commodities that are readily traded between regions. *Local* industries produce services and goods that are not traded between the regions.

In the MRES, the regional outputs of *national* industries are assumed to be independent of regional demand for them. Therefore, the Queensland projections from QGEM for the *national* industries are allocated to the ten regions based on regional employment shares. These regional employment shares are calculated from a combination of Queensland Treasury and CIE data.

The *local* industry projections for the regions are obtained indirectly via the input-output linkages with the national industries, and via local income effects. In computing a region's demand for local commodities, the system includes the intermediate and investment demands of the regions' national and local industries, household demand and government demand. As it does for national industries, this system ensures that the percentage changes in the region's outputs of local industries are consistent with the economy-wide percentage changes generated by QGEM.

It is important to note that this description, provided above, of standard MRES as a pure top-down procedure, does not adequately describe how the MRES procedure was implemented in OESR's modelling exercise. As described below, the availability of region-specific data (output and factor value changes) for the sugar-related industries allowed us to use MRES to implement regional supply-side shocks for the sugar-related industries.

Having added the MRES to our model we now have a theoretical structure that will support our goal of separately identifying the spatial breakdown of the various sugar-related

[17] Adams, Horridge & Parmenter, 2000, MMRF-Green: A dynamic, multi-sectoral, multi-regional of Australia, Preliminary Working Paper OP-94, Centre of Policy Studies, Monash University.
[18] Parmenter & Welsh 2001, Historical simulations with the Monash Regional Equation System, Productivity Commission Staff Working Paper.

industries. Without these equations containing sub-state factor income details, we would have to rely on calculating state-wide average regulatory changes, because we require an ability to implement region-specific productivity (supply-side) changes. Note that this need for region-specific supply-side equations would be necessary even if we were not interested in understanding the spatial distribution of the impact on aggregate economic welfare.

3.4 Economic Modelling Environment

The economic modelling environment (or model closure) embodies assumptions about economy-wide constraints and implicitly specifies the time-frame for the simulation. It also sets the choice of exogenous variables to simulate different assumptions regarding the way economic agents behave. OESR's objective was to model CIE's regulatory reform scenario to assess both the *short-run* and *long-run* economic impacts of a change in the regulation of the sugar sector.

It is conceptually easier to explain the long-run closure (environment) and then describe the short-run closure in terms of how it differs. The long-run closure represents the final impacts of any given policy change. This closure assesses the overall impacts after economic agents have had sufficient time to fully adjust their behaviour in response to the shock. The key assumptions used by OESR for this long-run closure are:

- No net 'policy-induced' household migration between regions. This facilitates interpretation of the modelling results, since the reported results for income, consumption, and GSP can automatically be interpreted as *per capita* results. That is, the results and analysis are not complicated by the need to adjust for policy-induced changes in the magnitude of the resident population.
- Real wages are assumed to adjust in order to preserve the pre-simulation level of national employment. In the long-run, employment in QGEM is determined by demographic variables, participation rates and the natural rate of unemployment, all of which are assumed to be unaffected by the policy change. This, in conjunction with the assumption of no net migration between regions, effectively preserves the levels of employment at the State level, while allowing movement in the real wage differential between Queensland and ROA.
- Differential growth in industry capital stocks is assumed to occur, in order to preserve pre-simulation industry rates of return. Industry investment expenditure is assumed to vary in line with changes in each industry's capital stock.
- It is assumed that the ratio of real State Government public consumption to real State private consumption is unchanged in the current scenario. Similarly, the ratio of real Federal Government consumption to real National private consumption is assumed to be unchanged.
- It is assumed that the Federal income tax rate adjusts in order to preserve the pre-simulation Federal Government budget position. It is also assumed that the Federal Government Current Grants to the States adjust in order to preserve the pre-simulation State Government budget position. That is, government (Federal and State) budgetary stance is implicitly assumed to be unaffected by the policy change. Therefore, with government expenditure tied to private consumption and income tax rates endogenous to maintain pre-policy budget positions, the fiscal impact on the broader economy is virtually non-existent.

The short-run closure, on the other hand, represents the initial impacts of a policy change or shock, simulating the initial adjustment pressures faced by agents in the economy. Therefore, some of the assumptions for this closure vary from the long-run assumptions. The following list of assumptions only includes those assumptions that are different for the short run:

- Nominal wages are sticky and do not immediately respond to labour market pressures. This "stickiness" can be considered as representing significant institutional lags in adjusting wages to incorporate changes in economic circumstances. These lags could occur because of the effect of enterprise bargaining and arbitrated award wage settlements.
- Firms adjust their demand for workers to meet short-run production needs and therefore the unemployment rate is endogenous.
- Additional investments have not yet been converted into productive capital stock. Therefore, the capital stock in each industry is fixed, with industry-specific rates of return varying in response to changes in demand.

3.5 Modelling Methodology

The modelling methodology outlined below is a modification to QGEM, in the sense that we are using information drawn from the CIE model to 'switch off' various supply and demand relationships within QGEM. This 'modelling-methodology' modification addresses the key aspects necessary for adequately modelling the proposed regulatory change. To understand the objective of this modification we need to be aware that:

- The cost and sales pattern of the sugar-related industries, as reflected in OESR's Input-Output database, describes the existing structural situation that is a product of the current regulatory environment (eg. the cane production area system); and
- The model contains data and theory describing the behaviour of governments (both State and Commonwealth) in terms of their financial interactions with industry through taxes but has only a limited ability to mimic enforced industry regulation.

The modelling methodology addresses these aspect because it allows us to incorporate external estimates of the productivity enhancing effects of the regulatory change. Secondly, it allows us to replace QGEM's standard pricing equations for the sugar-related industries with information that more adequately allocates the income flows to the various factors of production and across the various stages of the sugar value-chain.

The modelling methodology therefore facilitates the first two modifications in that it allows us to work with the disaggregated data and use the MRES in reverse. That is, is allows us to determine the state-wide impact, for the sugar-related industries as the sum of the individual regional results provided by the CIE model.

In general we can describe the QGEM results as being determined by the interaction of three aspects:

- The CIE data, such as industry output and profitability, that were incorporated into the QGEM simulations;
- OESR's methodology for incorporating the CIE data; and
- The QGEM theoretical structure and database.

As discussed below, the results from the CIE modelling of the sugar sector were directly incorporated into QGEM as a series of shocks to the Queensland economy. Table 1 contains the CIE's sugar model results that were incorporated into QGEM. Note that only the Queensland aggregates are reported in Table 1, not the region-specific shocks that were actually used in our simulations.

Table 1: CIE results incorporated into QGEM

QGEM component	% Change
Queensland Harvesting Industry	
Harvesting costs	-20.00
Queensland Sugar Cane Growing Industry	
Output	52.87
Land quantity	25.33
Land productivity[(a)] (yield)	-21.97
Payments to labour	27.84
Labour productivity[(a)]	-35.74
Capital quantity	25.33
Transport costs between the Sugar Cane and Sugar Milling Industries[(a)]	-10.00
Queensland Sugar Milling Industry	
Quantity of foreign exports	62.80
Payments to labour	41.28
Labour productivity[(a)]	-22.98
Capital quantity	21.33
Capital productivity[(a)]	-2.89

Notes:
(a) A negative productivity shock represents a productivity enhancement. For example, under this scenario, the Queensland Sugar Cane Industry requires 35.74 per cent less labour inputs per unit of output.

OESR's methodology involved two scenarios differentiated by our choice of economic environment (see Attachment A). That is, one scenario that reflects the short-run environment and a second scenario reflecting a long-run environment. Our analysis, using both a short-run and a long-run modelling environment, can be seen as a 'middle-ground' position between a strictly short-run partial equilibrium analysis, and a full dynamic CGE analysis.

The key to understanding OESR's approach is to recognise that the modelling undertaken by the CIE, using their sugar model, more closely resembles the short-run CGE modelling environment. To take advantage of this we needed to make several changes to the standard QGEM short-run environment. Our methodology for modelling the economic impact of the sugar sector reform is summarised in the following *seven step procedure*.

Short-run simulation

1. Set up QGEM starting with the standard short-run closure (see section 3.4).
2. Determine which elements of the CIE data were to be used as targets for QGEM. A full list of the implied CIE targets is shown in Table 1. Note that this list shows a mixture of targets used for either (or both) the short or long-run simulations. As discussed below,

some of these values are explicit targets in the long-run but are implicit from the CIE data in the short-run simulation.

3. The next step involves acknowledging that QGEM is primarily a state-based model, whilst the CIE model is based around the spatial aspects of the Queensland sugar industry. However, since the CIE report provides results at the statistical division level, we used the MRES procedure to import the CIE data into QGEM. Note that in the standard set up the MRES procedure is designed to allocate results, determined at the state level, down to the statistical division level. Our goal required us to essentially reverse this procedure for the sugar related industries (Harvesting, Cane farming, Sugar milling, Sugar refining) to accommodate the CIE data.

4. Our fourth task was to decide which aspects of QGEM's theoretical structure would need to be 'switched-off' to allow us to target the CIE data. That is, because each element of the CIE-supplied targets would normally be explained by the behavioural or accounting relationships within QGEM, we now have two estimates of each of these variables. Table C1 in Appendix C provides a full list of the swaps made to the standard QGEM short-run environment to allow us to target the CIE results. For example, with respect to sugarcane farming our goal was to target six CIE data items.

    - The CIE data on sugarcane output by statistical division was achieved by using the two common swaps listed in Table C1. These two swaps allow (n-1) statistical divisions to move independently, and force the nth Queensland statistical division result to be determined as a residual to balance the state result and a weighted sum of the statistical division results.

    - The second aspect of the sugarcane farming example was targeted by endogenising the demand story for sugarcane output. According to the QGEM database all sugarcane is sold to the Sugar milling industry. Therefore, targeting aggregate Queensland sugarcane output was achieved by endogenising the quantity of cane demanded by the sugar mills, per unit of milling output. This swap has the added advantage of allowing QGEM to match the increasing milling efficiencies identified in the CIE report.

    - CIE target for employment was targeted by endogenising labour productivity within the cane farming supply function.

    - CIE target for total payments to labour was achieved by matching their employment target and by endogenising the standard QGEM wage-pricing rule to allow the wage paid to farmers and cane workers to diverge from that occurring for other Queensland workers.

5. The fifth step is the purely mechanical task of running the simulation and recording the results, including the endogenised variables. That is the variables that would normally be exogenous in the standard closure but were swapped to allow us to hit the CIE targets. For example, the CIE sugarcane farming employment target of a 11.09% increase was achieved via an endogenous 21.97% labour productivity improvement per unit of cane farming output. This information will be necessary for our long-run (treatment) scenario.

Long-run simulation

6. Set up QGEM using the standard long-run closure (see section 3.4).
7. This step is the equivalent of step four in the short-run scenario since our task was to decide which aspect of the QGEM theoretical structure would need to be 'switched-off' to allow us to target the CIE data. Table C2 in Appendix C provides a full list of the swaps made to the standard QGEM long-run environment to allow us to target the CIE results.

Note that in the long-run, we believe that QGEM is better suited to determining some of the endogenous elements of the sugar-related industries in addition to determining the impact on the rest of the economy. Table C3 has list of short-run endogenous elements now exogenously targeted in long-run.

In addition, note that we are still targeting most of the real variables identified in the CIE sugar model. However, in this long-run simulation we are usually allowing the nominal value to now vary in accordance with relationships determined within QGEM. That is, we take the endogenously determined supply and demand shifts determined in the short-run simulation and impose these as shocks in the long-run simulation allowing traditional endogenous variables such as employment and basic prices to be determined by QGEM.

The seven-step procedure outlined above allowed OESR to use QGEM to target the chosen CIE data. However, it ensures that QGEM's general equilibrium relationships are able to determine the economic changes in the wider economy, whilst incorporating sufficient endogeneity to allow the economy-wide effects to have a greater feedback effect on the sugar industries. An example of this is allowing output of refined sugar to diverge away from the short-run estimates. This endogenous feedback has significant implications for the basic price in all sugar-related industries. For example, compare the short-run sugar price result (-2.68%) in Table 3 with the long-run price result (-3.62%) in Table 7.

4 Simulation Overview

4.1 The CIE Regulatory Change Scenario

In December 2002, the Centre for International Economics (CIE) released their report[19] on the impact of reforming the *Sugar Industry Act 1999* ("the Act"). The CIE employed a partial equilibrium model[20] to quantify the impacts on the sugar sector stemming from possible changes to the Act and various projections of the world sugar price. The CIE model has five regions – North Queensland, Herbert/Burdekin, Mackay, South and ROA. The CIE used their sugar industry model to quantify economic impacts under nine different scenarios. Most of CIE's scenarios examined the impact of partial regulatory reform of the Queensland sugar sector, under various assumptions about the world price of sugar.

From the nine CIE scenarios, OESR choose to model, using QGEM, the economy-wide impacts of complete regulatory reform of the Queensland sugar sector (referred to as Scenario 7 in the CIE report). CIE's Scenario 7 was chosen as the starting point for OESR's economy-wide modelling as it is the most comprehensive and informative of the CIE scenarios. That is, of the scenarios that related to reform of the legislation, Scenario 7 included the full set of predicted productivity changes and related the impact of these changes to the 1996-97 base-point rather than the hypothetical 2006-07 base-point.

For Scenario 7, CIE modelled the regional effects on the sugar sector of significant productivity increases by growers, harvesters and the mills. These productivity increases are partially due to actions such as improved irrigation or harvesting practices and others are due to regulatory changes such as a removal of the cane production area (CPA) system.

Overall, CIE's Scenario 7 consists of:

- A 20 per cent increase in cane yields and a 0.75 per cent increase in sugar content of cane (CCS). The CIE argue that despite declining relative CCS, due to the longer season length, overall CCS increases because of the productivity gains;
- Abolishment of CPAs, no milling formula and a potential 30 week milling season;
- A 20 per cent reduction in harvesting costs and a 10 per cent reduction in transport costs;
- A price of sugar of around $335 per tonne, the prevailing price in 1996-97.

The CIE's results represent the change in production, profit etc compared against a 1996-97 basecase. These sugar sector results were then imposed on OESR's CGE model, by applying the methodology described in Section 3.5, to determine the economy-wide impact of the regulatory reform. The results presented in Section 6 are therefore determined by a combination of the theory and data from both the CIE's sugar model and QGEM.

[19] Centre for International Economics (2002) *Cleaning up the Act: The Impacts of Changes to the Sugar Industry Act 1999*

[20] A partial equilibrium, in the strictest sense, does not involve behaviour and interactions outside the sector under analysis. In a more general sense, a partial equilibrium analysis operates under the assumption that an economic change in one sector will not cause feedbacks to the initiating sector as the change works through the rest of the economy.

4.2 CIE Results

According to CIE's partial equilibrium modelling, there is a significant economic impact on the sugar sector from regulatory reform. In summary, CIE estimate that:

- Sugar production is 51 per cent higher;
- Growers' profits rise by 88 per cent and millers' profits rise by around 100 per cent;
- The longer milling season is of substantial benefit to the mills; and
- Millers' variable costs rise in line with an increase in production but as fixed costs remain the same there is a 14 per cent reduction in average costs.

4.3 A-priori expectations

Since this modelling exercise is imposing a series of industry specific productivity improvements, overall we would expect a net positive economic impact due to the industry restructuring. To understand this *a-priori* estimate requires an explanation of the direct impact on Queensland's GSP of the imposed productivity shocks. In addition to these direct impacts[21] QGEM estimates a range of indirect impacts[22] that, when aggregated, will also increase Queensland's GSP.

The magnitude of the direct GSP impact of the imposed productivity shocks will depend on three key factors:

- The magnitude of the productivity shocks;
- The relative contribution, that is share of the Queensland economy, of the industries undergoing productivity improvements; and
- The magnitude of the assumed expansion in output of these industries as determined in the CIE sugar model.

Based on the magnitude of the implemented policy shock it is expected that the direct effect of the sugar sector productivity gains will increase GSP by approximately 0.22 per cent. That is, if no offsetting adjustments were to occur, the (assumed) sugar sector productivity improvement would increase GSP by the amount implied by the potential additional production (consumption) from the existing capital, labour and industry output.

In addition to this is the impact on GSP of the assumed expansion in the output of the, now more productive, sugar sector[23]. That is, this contribution to the increase in GSP stems from the fact that the sugar sector is now a larger share of the Queensland economy (relative to what they would otherwise have been). Based on the magnitude of the implemented policy shock this component is expected to have the direct effect of increasing GSP by approximately 0.10 per cent. The third direct contribution to the change in GSP would flow from the CIE determined increase in cane yield, which *a-priori,* is expected to have the effect of increasing GSP by approximately 0.04 per cent.

[21] That is, technical efficiency effects.
[22] Predominantly allocative efficiency effects.
[23] This should not be confused with an increase in GSP that would be implied by a simple expansion in any industry.

Therefore, the *a-priori* estimate of the direct impact on GSP of these three components is approximately 0.36 per cent. However, to the extent that producers and consumers are assumed to respond to these productivity shocks, GSP is expected to increase by more than the direct effect would imply. That is, the model assumes that economic agents (households and firms) undertake to optimise their economic situation by changing their production decisions, what they purchase, and from what source, within certain constraints. Given that agents are given the flexibility to undertake this constrained optimisation we would expect that household incomes, and thus GSP, would increase by slightly more than that implied by the direct a-priori estimate.

Finally, the direct impact of the productivity gain will also induce some indirect effects, apart from the allocative efficiency response noted previously. Some of these indirect effects will have a positive impact and some will have a negative impact on the GSP estimate. The negative impacts should be interpreted as relative to what would otherwise be the case. In this sense, a –x per cent result for an industry's activity can be interpreted as the industry *growing* x per cent *less than* it would otherwise have done over the time-span of the simulation. Therefore, to the extent that some industries will now expand less than they would have in the absence of the restructured sugar sector, this will detract from the GSP estimate.

Overall, given the package of shocks listed in Table 1 and the closure assumptions as described in Section 3.5, it is expected that the short-run effect on GSP will be larger than the long-run estimate. More specifically, in the short-run, a flexible employment response is assumed to occur from the large employment shocks to the sugar sector.

In the long-run, on the other hand, the employment response is assumed to be zero change. Therefore, the impact of the large employment shocks in the sugar sector flows through to increases in real wages. In addition, any capital-intensive industries that are being crowded-out in the short-run, due to expansions in the sugar sector, would be expected to reduce their capital stock in the long-run.

Although the divergence between GSP estimates in the short and long-run is expected to be significant, the divergence between economic welfare estimates, over these two time-frames, is not expected to be as significant. Again, this is due to the interaction between the employment-wage trade-off and the capital stock-profitability trade-off. That is, in the long-run, the increase in household income from the increase in real wages will increase welfare, but the adjustment in capital stock and the fall in capital stock-profitability will detract from consumer welfare. In the short-run, on the other hand, wages are constrained but the capital stock-profitability is flexible.

Finally, regional output results for the sugar sector from the CIE report were directly incorporated into QGEM as a series of Queensland Statistical Division specific shocks. Therefore, the Queensland regional results will be broadly consistent with the results presented in the CIE report. However, QGEM's regional disaggregation procedure also incorporates input-output linkages and some local income effects which facilitates some reallocation of resources within and implicitly between regions. Therefore, due to the indirect regional effects of this regulatory reform scenario, it is expected that OESR's regional results will differ from CIE's regional estimates.

5 Simulation Results

As noted in the previous section, the simulation results reported in this section represent the state of the economy *with* the policy change relative to the state of the economy *without* the policy change. They therefore should be interpreted as percentage changes relative to basecase, or business-as-usual. The same scenario is modelled twice, using alternate economic environments, as explained in Section 3.5. Furthermore, in the following sections all results reported are expressed in percentage change terms, unless specifically notified otherwise.

5.1 Short-run Results

As explained in Section 3.5, the short-run economic environment assumed that economic agents have not had sufficient time to fully adjust their production decisions and input purchases in response to the shocks. Table 2 outlines the projected changes to the macroeconomic aggregates for each of the two regions modelled by QGEM, and Tables 3 to Table 5 provides the short-run industry and regional results for Queensland.

Table 2: Short-run results for Queensland and Rest-of-Australia

	Queensland	Rest-of-Australia
	% Change	*% Change*
Real GSP	0.81	0.02
Real Household Consumption Expenditure	0.36	0.05
Employment	0.69	0.03
Real Investment Expenditure	0.05	0.00
International Export Volumes	4.22	-0.17
International Import Volumes	0.71	0.06
Capital Stock (rental weights)	0.26	0.00
Real appreciation		0.09
Terms of Trade		-0.07
Change in International Trade Balance ($A Millions)	565	-189

At the macroeconomic level, Queensland's real GSP is estimated to increase by 0.81 per cent. As noted in Section 4.3, the direct impact of the productivity shocks would contribute 0.36 percentage points to this change in GSP. With the 0.69 per cent increase in Queensland's employment in the short-run delivering 0.38 percentage points towards the increase in GSP, the results imply that a residual 0.07 percentage point gain in GSP stems from economy-wide indirect effects.

On the income side of GSP, the assumed increase in the quantity and profitability of fixed capital in the sugar sector combines to give an aggregate rise in capital profitability. This increased capital profitability is sufficient to offset the negative contribution to GSP from the 0.07 per cent fall in the terms of trade. The regional employment gain is slightly offset by the estimated 0.48 per cent fall in real wages, however real labour income still provides the strongest contribution to the growth in GSP in the short-run. Furthermore, small gains in income are generated by the increase in agricultural land income from the assumed rise in yield in the Sugar Cane industry.

On the expenditure side of GSP, the 0.36 per cent increase in private household consumption (the household economic welfare measure in QGEM) is significantly less than the increase in GSP. This is due to several factors:

- The productivity improvement is estimated to lead to consumption prices rising faster than overall production prices thereby implying a smaller increase in real income;
- In the short-run, real wages, a major determinant of household income, are falling due to the rise in domestic prices and the assumption of sticky nominal wages;
- Household income, which is assumed to determine household consumption, is partially determined by factors, such as Commonwealth transfer payments, stemming from the rest-of-Australia where the real income change is close to zero.

International export movements are dominated by the assumed growth in raw sugar exports. Indeed, the growth in sugar exports alone exceeds the 4.22 per cent estimate for the total change in Queensland's exports. This is due to the crowding out of other traditional export commodities driven by the real appreciation in the exchange rate. To understand the components that determine these macroeconomic results requires an examination of the industry influences. Table 3 presents selected industry effects for Queensland.

Table 3: Selected short-run industry results for Queensland

Industry	Output (Value Added)	Employment	Export Volumes	Basic Prices
	% Change	*% Change*	*% Change*	*% Change*
Harvesting	52.87	19.70	na	-20.00
Sugar Cane	52.87	11.09	na	-6.72
Sugar Milling	50.15	42.00	62.80	-5.24
Sugar Refining	10.83	21.53	29.57	-2.68
Water	1.96	6.26	na	3.74
Food Manufacturing	-0.10	-0.15	-2.08	0.11
Coal	-0.08	-0.24	-0.19	-0.02
Wholesale & Retail	0.69	0.85	na	0.34

The industries reported in Table 3 were selected on the basis that they are representative of the various categories of industry influences. That is, the pattern of industry results can be grouped into the following broad categories:

- The sugar industries directly targeted in accordance with the CIE estimates;
- Industries that are major inputs into sugar industries (eg Water);
- Industries that are major purchasers of refined sugar; (eg Food Manufacturing)
- Export orientated industries that are affected by the appreciation of the exchange rate due to the expansion of raw sugar exports (eg Coal); and
- Industries that are strongly influenced by the estimated rise in household income (eg Wholesale and Retail Trade services).

To understand the direct industry effects, it is necessary to recognise the vertical integration within the sugar sector. That is, all Harvesting services are supplied to the Sugar Cane industry and all sugar cane is sold to the Sugar Milling industry. Therefore, the potential for flow-on effects is to some extent limited relative to what would be expected given the large

output increase for these industries. This effect is also enhanced by the fact that the majority of output from the Sugar Milling industry is exported without further processing.

The Water industry provides a significant proportion of the inputs into the Sugar Cane industry. Therefore, as the output of the Sugar Cane industry rises, the production input demand for Water also rises. Under the assumption that the industry's capital stock is fixed, this leads to a significant price rise.

Whilst the Food Manufacturing industry benefits from the reduced cost of a major input, sugar, the crowding out of the industry's exports due to the real exchange rate appreciation leads to a fall in Food Manufacturing output.

The fall in output and exports for the Coal industry, which results from the appreciation in the real exchange rate, whilst small in magnitude, has a significant impact on Queensland due to Coal comprising 30 per cent of the value of non-tourism related exports[24].

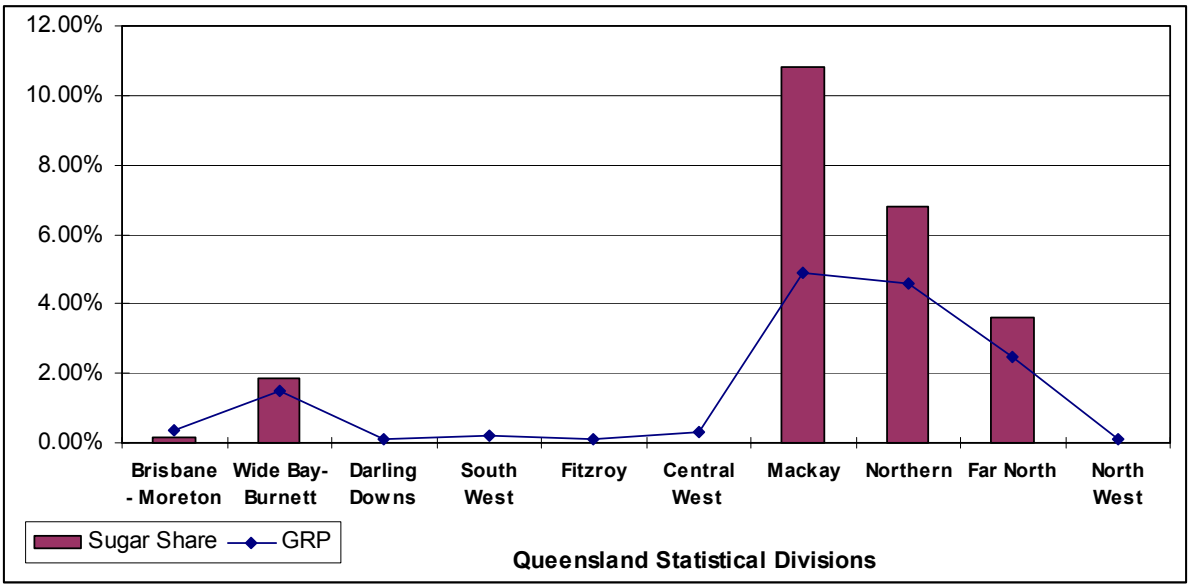
Output and employment in the Wholesale and Retail Trade sector is projected to rise broadly in line with the increase in GSP. Given that this industry contributes approximately 17 per cent of Queensland employment[25], it is a major determinant of the total employment increase. This result is particularly important at the regional level, since this service industry's output is not something that is easily imported. Therefore, this industry provides a regional stimulus effect from the rising incomes in the sugar producing regions.

Further Queensland regional results are presented in Table 4.

As explained above, the key industry-level feature of this modelling is the productivity enhancements in the sugar sector, which results in a price decline for these industries. The key to understanding the flow-on impacts of this regulatory reform scenario to the Queensland Statistical Divisions is therefore the relative importance of the sugar sector within each region[26]. To this end, Figure 4 shows the share of the sugar sector output as a proportion of total output in each region, according to QGEM's database. Figure 4 highlights the relationship between this proportion and each region's change in Gross Regional Product (GRP).

[24] Source: QGEM database, based on 1996-97 Queensland data.
[25] Source: QGEM database, based on 1996-97 Queensland data.
[26] No information was available in the CIE report on the relative share of sugar sector output between the Brisbane-Moreton and Wide Bay-Burnett regions. Therefore the total sugar sector output for these two regions was split using 50:50 shares between the two regions.

Figure 4: Share of sugar sector output and GRP by Queensland Statistical Division – Short-run



In the short-run, as demonstrated by Figure 4, the simulation results show a close correlation between changes in GRP for each region and the respective shares of sugar sector output for that region. For example, the Mackay region has the largest proportion of sugar sector output to total region output and therefore GRP in this region is increasing relative to the remaining regions. On the other hand, the regions that have zero sugar sector output exhibit the smallest relative changes in GRP. Table 4 presents the changes in total activity for these regions.

Table 4: Short-run regional activity results

Statistical Division	Output
	% Change
Brisbane and Moreton	0.36
Wide Bay-Burnett	1.49
Darling Downs	0.11
South West	0.18
Fitzroy	0.09
Central West	0.31
Mackay	4.88
Northern	4.56
Far North	2.50
North West	0.08
Queensland Total	0.88

In the short-run, total activity in each region increases. In the more sugar-intensive regions, for example Mackay and Northern, the increase in activity exceeds the Queensland average increase. On the other hand, activity in the regions with less sugar intensive industries increases by less than the Queensland average. The overall positive impacts for each region flow from the overall positive impact of the regulatory reform on the Queensland economy.

Table 5: Short-run regional employment results

Statistical Division	Employment
	Change in FTE
Brisbane and Moreton	3945
Wide Bay-Burnett	805
Darling Downs	182
South West	27
Fitzroy	173
Central West	22
Mackay	1988
Northern	1975
Far North	1638
North West	27
Queensland Total	10781

As previously discussed, the regulatory reform of the sugar sector is projected to cause a 0.69 per cent increase (see Table 2) in full-time equivalent employment in Queensland. Table 5 shows that the aggregate employment increase occurs with increased employment in all Queensland Statistical Divisions.

The relative difference in employment effects in each region is also significant. The Brisbane-Moreton region, for example, experiences the largest increase in employment, although its activity increase is below the Queensland average. This large increase is due to the relative size of employment in this region, as compared with the other regions. The Central West region, on the other hand, with a relatively small share of employment and a small increase in activity, experiences the smallest employment rise from this policy change. This result also reflects the reallocation of resources from this region to the other regions due to the relatively small rise in activity.

5.2 Long-run Results

As explained in Sections 3.4 and 3.5 the long-run economic environment assumed that economic agents have had sufficient time to fully adjust their production decisions and input purchases in response to the shocks. Table 6 provide the projected changes to the macroeconomic aggregates for each of the two regions modelled by QGEM, and Table 7 to Table 9 provide the industry and regional results for Queensland.

The long-run macroeconomic results for the sugar reform scenario are presented in Table 6.

Table 6: Long-run results for Queensland and Rest-of-Australia

	Queensland	Rest-of-Australia
	% Change	*% Change*
Real GSP	0.42	0.02
Real Household Consumption Expenditure	0.29	0.03
Employment	0	0
Real Investment Expenditure	0.05	0.05
International Export Volumes	2.22	-0.25
International Import Volumes	0.29	0.06
Capital Stock (rental weights)	0.18	0.05
Real Appreciation		0.11
Terms of Trade		-0.05
Change in International Trade Balance ($A Millions)	291	-252

At the macroeconomic level, real GSP for Queensland increases but by less than that estimated for the short-run. In the long-run the estimated increase in GSP is not significantly greater than the 0.36 percentage point contribution[27] stemming from the direct productivity shocks to the sugar sector. That is, the net economy-wide gain from the expanding sugar sector provides approximately a 0.06 percentage point contribution to the growth in GSP.

As noted previously, the tight vertical integration of the sugar sector, coupled with the falling average sugar price,[28] provides for a subdued indirect response to the reform scenario. The falling sugar price is the major component determining the estimated 0.05 per cent fall in Australia's terms of trade. This terms of trade decline is, in turn, a major determinant of the subdued indirect economy-wide impacts.

As explained in Section 4.3, the relative difference in GSP between the short-run and long-run reflects the different assumptions regarding the relative contribution of labour and capital. Whereas employment increased in the short-run, in the long-run it is assumed that the economic gain to Queensland households will occur through rising real wages which returns the employment rate back to the initial level.

Similarly, the capital intensive industries that are crowded out in the short-run are assumed in the long-run to be able to adjust their capital stock to return their profitability to the long-run economy-wide level. The net effect of this is that the aggregate level of the capital stock in non sugar-related industries falls relative to the short-run position. Therefore, with the relatively lower economy-wide capital profitability, capital income contributes less to the increase in GSP in the long-run than in the short-run[29].

[27] As explained in Section 4.3

[28] As shown in Table 1 and sourced from the CIE report.

[29] The predominant cause of the relatively lower economy-wide capital profitability in the long-run is that, relative to the short-run, capital is the more abundant factor. That is, the significant rise in short-run employment led to capital being the scarce factor in the short-run but the reverse is true in the long-run.

On the expenditure side of GSP, as in the short-run, the dominant effect is the impact on international exports driven by the assumed increase in sugar exports. As explained in Section 4.3, the smaller rise in GSP, relative to the short-run, is not so apparent for real consumption. Therefore, the increase in private household consumption of 0.29 per cent demonstrates that the sugar reform delivers significant economic benefits to Queensland households in both the short and long-run.

In a similar manner to the short-run results the pattern of industry results in the long-run can be grouped into three broad categories.

- Sugar related industries that are targeted in accordance with CIE estimates;
- Industries that are positively influenced by expansion of the sugar sectors; and
- Export-orientated industries that are crowded out by the assumed increase in sugar exports.

Table 7 presents selected industry effects for Queensland. The reported industries were selected on the basis that they are representative of the three broad categories.

Table 7: Long-run industry results, Queensland

Industry	Output (Value Added)	Employment	Export Volumes	Basic Prices
	% Change	*% Change*	*% Change*	*% Change*
Harvesting	52.87	11.04	na	-28.14
Sugar Cane	52.87	9.06	na	-12.45
Sugar Milling	50.89	38.57	62.80	-5.26
Sugar Refining	17.59	29.58	41.97	-3.62
Food Manufacturing	-1.30	-1.79	-5.48	0.28
Water	2.91	3.40	na	0.70
Metal Products	-2.27	-3.18	-5.48	0.13

The most significant insight from the industry results is that the crowding out effect of sugar expansion is even more acute in the long-run than was the case in the short-run results.

The output of the Food Manufacturing industry, which represents 4.5 per cent of the Queensland economy[30], is estimated to be 1.30 per cent less than it would otherwise be in the absence of the policy shocks. The primary cause for this is the real appreciation impact crowding out its export sales, which comprise 10 per cent of Queensland's non-tourism related exports.

Similarly, the Metal Products industry is estimated to have a 2.27 per cent fall in output in the long-run. As noted in Section 4.3 this should be interpreted as the industry growing 2.27 per cent less, than it otherwise would, over a 10 year period. Given that this industry has experienced strong employment growth over the last decade, the estimated 3.18 per cent fall in employment would likely imply that the level of employment in the industry would still continue to expand over the next decade, but not quite at the same rapid pace.

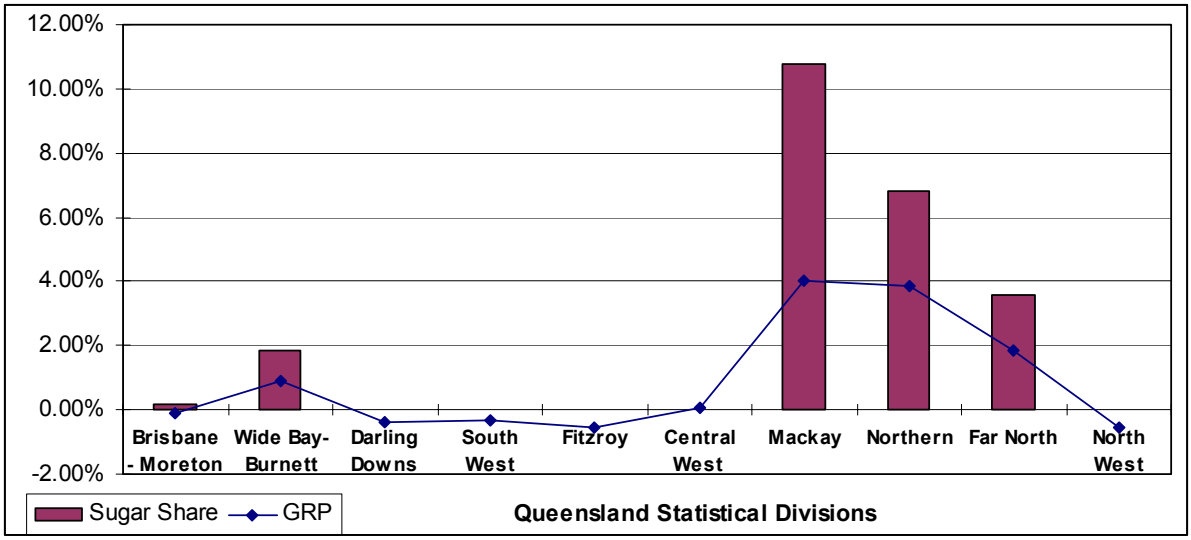
[30] Source: QGEM database which is based on 1996-97 Queensland Input-Output data.

As with the Food Manufacturing industry, the primary cause of the reduced output in the Metal Products industry is the crowding out of its exports, which comprise[31] approximately 11 per cent of Queensland's non-tourism related exports.

Flowing from these Queensland industry results are the Queensland regional impacts. These are presented below.

In the long-run, the simulation results also show a close correlation between changes in GRP for each region and the respective shares of sugar sector output for that region. This is illustrated in Figure 5.

Figure 5: Share of sugar sector activity and GRP by Queensland Statistical Division – Long-run



The most noticeable difference between the short-run and long-run results is the impact on GRP. In the short-run, even regions with zero sugar sector production were estimated to experience positive changes in GRP. However, in the long-run, these regions are projected to experience a small fall in GRP relative to the base case of no regulatory change. This is perhaps best explained by examining the activity results for each region. These estimates are contained in Table 8.

[31] Source: QGEM database which is based on 1996-97 Queensland Input-Output data.

Table 8: Long-run regional activity results

Statistical Division	Output
	% Change
Brisbane - Moreton	-0.08
Wide Bay-Burnett	1.00
Darling Downs	-0.38
South West	-0.33
Fitzroy	-0.54
Central West	0.06
Mackay	4.32
Northern	4.14
Far North	2.02
North West	-0.55
Queensland Total	0.43

In the long-run, all economic agents are assumed to have had sufficient time to fully adjust their behaviour in response to the regulatory reform. As discussed in the industry analysis section, the output of a number of Queensland industries is projected to fall in the long-run due to increases in the cost of production and/or reduction in international export demand. Conversely, output in the Queensland sugar sector increases due to the productivity enhancements from the regulatory reform. Therefore, for the regions with a significant proportion of output from the sugar sector, for example Mackay, the increase in sugar production offsets the reduction in output from other industries, and therefore total regional output increases.

On the other hand, the regions without a significant proportion of sugar sector output experience a decline in total regional output, resulting from the economic effects of the regulatory reform scenario. As noted earlier, this should be interpreted as these regions expanding activity at a slower rate than they otherwise would over a ten year period.

The changes in employment in each region in the long-run, from this regulatory reform, are contained in Table 9.

Table 9: Long-run regional employment results

Statistical Division	Employment
	Change in FTE
Brisbane - Moreton	-1549
Wide Bay-Burnett	116
Darling Downs	-422
South West	-81
Fitzroy	-459
Central West	-15
Mackay	1011
Northern	913
Far North	623
North West	-136
Queensland Total	0

At the State level, employment is *assumed* to remain at existing levels and therefore the change in total Queensland employment is zero (this assumption is explained in Section 3.4). Therefore, the employment change in each region is the combined influence of two key mechanisms:

- a reallocation of resources due to relative changes in output; and
- a state-wide labour supply constraint operating at, the now higher, real wage level.

Generally, Queensland's sugar producing regions are projected to experience an increase in employment in the long-run. On the other hand, the region most adversely affected by the regulatory reform is the Brisbane-Moreton region. This is due to several factors. Firstly, with a low proportion of sugar sector output, the Brisbane-Moreton region does not directly benefit from the increase in productivity in the sugar sector. Furthermore, with employment constrained at the State level, employment resources are reallocated to the regions experiencing the growth in activity.

6 Conclusion

To complement the information provided in the CIE report, OESR undertook an economy-wide analysis of potential changes to the Act. This analysis employed OESR's general equilibrium model to estimate the short and long-run effects of regulatory reform in the sugar sector on the broader State and regional economies. In order to achieve this, OESR incorporated, into QGEM, information derived from the CIE sugar model that related to the direct impacts of restructuring on the sugar sector.

As noted in the introduction, the objectives of this paper were to:

- explain the methodology used by OESR to implement this strategy of incorporating the PE modelling results rather than explicitly respecifying the QGEM theory;
- present the results of OESR's quantitative modelling of sugar sector restructuring;
- provide an analysis of the short and long-run effects on the Queensland economy, including a comparison of the PE a-priori estimate and the results determined by the GE model; and
- present regional output and employment results for the short and long run scenarios.

In light of the discussion in Section 3.5 concerning OESR's methodology for incorporating the PE modelling results, OESR's economy-wide modelling shows that regulatory change in the Queensland sugar sector would deliver significant economic benefits to the Queensland economy and the nation as a whole.

Having due regard for the earlier discussion of the limitations of comparative static CGE modelling, in terms of its ability to incorporate all of the potential sources of economy-wide gains from regulatory change, overall, the additional indirect economy-wide gains are small in comparison to the direct income gains to the sugar sector. That is, when excluding the potential effect of dynamic allocative efficiency gains and the dynamic terms of trade influence, the indirect effect gains appear relatively minor.

From OESR's modelling, the GSP results show that whilst the direct PE gain was only 45% of the short run GE result, it was approximately 85% of the long run GE result. The more moderate long-run GSP impact was explained as being determined by the combined effect of OESR's modelling assumptions and OESR's methodology for incorporating the CIE inputs. More importantly, OESR's modelling projected that the economic welfare result is relatively similiar in both the short and long-run.

A consequence of the long run result, where the additional indirect economy-wide gains are small in comparison to the direct income gains to the sugar sector, the major beneficiaries of this regulatory reform are those firms and employees closely linked to the sugar value-added chain, and Queenslanders employed in the sugar producing regions.

In both the short-run and long-run, the primary source of economic benefit is the regulatory reform-induced productivity improvements. In the short-run, the economic benefits flow to Queensland in the form of an increase in employment. In the long-run, the economic benefits flow from an increase in household incomes, primarily through rising real wages.

At the regional level, the short-run impact of the regulatory changes is positive, in terms of both output and employment, for all regions. All sub-sectors of the sugar sector and Queensland's major sugar producing regions, in particular Mackay, Northern and Far North Statistical Divisions, are projected to gain from the industry restructuring. That is, the gains are projected to be highly concentrated in the regions of Queensland that specialise in sugar production. Furthermore, in the long-run, the impact on the sugar regions is considerable with employment, on a full-time equivalent basis, increasing by around 2,500 jobs.

In the long run, as employment (wages) and capital across the Queensland economy adjust to the productivity improvements in the sugar sector, and the associated appreciation of the real exchange rate impacts on non-sugar exports, non-sugar producing regions experience net economic losses in terms of both output and employment. However, as noted earlier, these net changes should be interpreted as relative to what would otherwise be the case. In this sense, a projected loss for a region's employment can be interpreted as the region's employment *growing* by *less than* it would otherwise have done over the time-span of the simulation.

From OESR's modelling results, the following points are evident with respect to the long-run impact of reform:

- The level of Queensland's gross state product will rise by 0.42 per cent, or $491 million;
- Queensland real household consumption, a direct measure of household's economic gain, increases by 0.29 per cent, or $202 million; and
- The State's trade balance with the rest of the world improves by $291 million.

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Appendix A: QGEM-Sugar industry and commodity disaggregation

Industries and Commodities of the Sugar project version of QGEM	
Sheep	Miscellaneous manufacturing
Grains	Electricity Supply, gas and water
Beef Cattle	Water
Dairy cattle and pigs	Residential building construction
Other Agriculture	Other construction
Harvesting	Trade
Sugar cane growing	Accommodation, cafes and restaurants
Forestry and Fishing	Road transport
Coal; oil and gas	Rail and pipeline transport
Non-ferrous metal ores	Other transport
Other mining	Communication services
Food Manufacturing	Finance, property and business services
Sugar Milling	Ownership of dwellings
Sugar Refining	Government administration and defence
Textiles, clothing and footwear	Education
Wood and paper manufacturing	Health services
Chemicals, petroleum and coal products	Community services
Non-metallic mineral products	Cultural and recreational services
Metals, metal products	Personal and other services
Machinery, appliances and equipment	Non-Competing Imports

Appendix B: QGEM Statistical Divisions for the MRES procedure

Statistical Divisions	
Brisbane and Moreton	Sugar: Targeted – H, SC, SM, R
Wide Bay-Burnett	Sugar: Targeted – H, SC, SM, R
Darling Downs	Sugar: Not Targeted
South West	Sugar: Not Targeted
Fitzroy	Sugar: Not Targeted
Central West	Sugar: Not Targeted
Mackay	Not in Sugar SET: Targeted – H, SC, SM, R
Northern	Sugar: Targeted – H, SC, SM
Far North	Sugar: Targeted – H, SC, SM
North West	Sugar: Not Targeted

Appendix C: Economic environment for incorporating CIE data

Table C1: Changes made to the standard Short-run environment

INDUSTRY	Component of QGEM model
All Sugar industries	
Endogenise	Automatic-link to Queensland-wide industry output
Exogenise	Output for all sugar-producing Statistical Divisions
Endogenise	Automatic-link to National industry output
Exogenise	Switch to enforce rule that State result is weighted sum of Divisions
Harvesting	
Endogenise	All input saving technical change
Exogenise	Basic price
Sugarcane farming	
Endogenise	Nominal industry-specific wage rate
Exogenise	Nominal industry-specific total wage cost
Endogenise	Labour saving technical change
Exogenise	Industry employment
Endogenise	Sugar-Milling intermediate-input saving technical change
Exogenise	Industry output
Sugar Milling	
Endogenise	Nominal industry-specific wage rate
Exogenise	Nominal industry-specific total wage cost
Endogenise	Capital saving technical change
Exogenise	Nominal industry-specific total rental cost
Endogenise	Labour saving technical change
Exogenise	Industry employment
Endogenise	Foreign export demand for Sugar Milling (RoA)
Endogenise	Industry supply curve (Other cost inputs) Sugar Milling (QLD)
Exogenise	Quantity of exports from QLD and RoA
Sugar Refining	
	Nothing apart from the common elements

Table C2: Changes made to the standard Long-run environment

INDUSTRY	Component of QGEM model
All Sugar industries	
Endogenise	Automatic-link to Queensland-wide industry output
Exogenise	Output for all sugar-producing Statistical Divisions
Endogenise	Automatic-link to National industry output
Exogenise	Switch to enforce rule that State result is weighted sum of Divisions
Harvesting	
	Nothing apart from the common elements
Sugarcane farming	
Endogenise	Automatic link to Queensland-wide wage rate
Exogenise	Nominal industry-specific total wage cost
Endogenise	Automatic link to Queensland-wide rate of return on capital
Exogenise	Industry capital stock
Endogenise	Sugar-Milling intermediate-input saving technical change
Exogenise	Industry output
Sugar Milling	
Endogenise	Automatic link to Queensland-wide wage rate
Exogenise	Nominal industry-specific total wage cost
Endogenise	Capital saving technical change
Exogenise	Nominal industry-specific total rental cost
Endogenise	Industry supply curve (Other cost inputs) Sugar Milling (QLD)
Exogenise	Quantity of exports from Queensland
Sugar Refining	
	Nothing apart from the common elements

Table C3: Variables endogenously determined in SR that are exogenous & shocked in LR

INDUSTRY	Component of QGEM model
Harvesting	
	All input saving technical change
Sugarcane farming	
	Labour saving technical change
Sugar Milling	
	Labour saving technical change
	Capital saving technical change