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The distributional effects of the Hilmer reforms on the Australian gas industry*

George Verikios and Xiao-guang Zhang†

We analyse changes in the Australian gas industry during 1990s that were motivated by the Hilmer Reforms. We estimate the effects on real household income of the changes by combining a computable general equilibrium model with a microsimulation model. Although the structural changes were significant in their effects on the gas industry, they are estimated to have had minor effects on real household income in all Australian regions owing to the small size of the gas industry and household gas consumption at that time, and low importance of gas as an input to other industries. The changes are estimated to have slightly increased income inequality owing to the redistribution of income from labour to other primary factors.

Key words: computable general equilibrium, gas, household income distribution, microeconomic reform, microsimulation.

1. Introduction

In the early 1990s, Australian governments introduced a series of microeconomic reform policies for infrastructure industries, for example, gas, ports and telecommunications; see Productivity Commission (PC) (2002) for a summary. The reforms were part of the process produced by the Hilmer Report (1993). The Hilmer Report's terms of reference focused on government businesses and regulations that had created protected enterprises: these had been a feature of industry policy in Australia for most of the 20th century. Hilmer argued for the introduction of competition policy in these areas to promote competition for the purpose of promoting community welfare, that is, encourage market competition that would lead to increased productivity and incomes, as well as better choice and services for consumers. Since the introduction of the reforms, the affected industries have undergone significant structural changes that are observable in their cost structure and output

* The framework applied here is an extension of that developed in Verikios and Zhang (2005, 2008). The views expressed here are the authors' and do not necessarily reflect those of the Productivity Commission or Monash University. Thanks are due to Ken Clements, Ken Pearson and two referees for helpful comments on this work.

† George Verikios (email: george.verikios@monash.edu) is at the Centre of Policy Studies, Monash University, Clayton, Victoria, Australia. Xiao-guang Zhang is at Productivity Commission, Melbourne, Victoria, Australia.

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prices; PC (2002) documents some of infrastructure price changes over the 1990s.

As major service providers, changes in infrastructure industries can potentially have far-reaching impacts on other industries and households. It has been noted that competition policy reforms were regarded by many in the community as being responsible for the increased economic divide between capital cities and regional Australia (e.g. Madden 2000). Related to this, there has also been natural community concern over the impact on income distribution of sectoral changes viewed as a result of the microeconomic reforms. This concern has also been expressed by some economists, for example, Quiggin (1997).

There is a paucity of Australian studies that have analysed the distributional effects of the Hilmer reforms with only two notable exceptions. In PC (1996a), an input–output model and household survey data are used to estimate the effects on household expenditure of price reforms by government-trading enterprises (GTEs) in the electricity industry and the water, sewerage and drainage services industry. In a companion article (PC 1996b), a more sophisticated approach is adopted by applying a computable general equilibrium (CGE) model in conjunction with an income distribution model to analyse the effects of a specific set of reforms on the sources of household income. Each of these studies concentrates on only one side of the household budget, so the overall impact on household real income remains unclear. Moreover, input–output models, as applied in PC (1996a), do not capture effects generated from sectoral reallocation of resources, particularly labour, that are considered important in capturing the distributional effects of a policy change. As a result, the effects of a policy change derived from such a model may be misleading.

As a response to the paucity and shortcomings of previous studies, we conduct a more comprehensive analysis of the effects of infrastructure industry changes on household income distribution. We analyse the distributional effects of sectoral changes in the gas industry that have occurred at the same time as the implementation of microeconomic reform policies, and in contrast to the previous studies described above, we integrate the income and expenditure sides of the household budget to capture the total (direct and indirect) effect on household real income. We do this by linking a multi-regional CGE model with a highly disaggregated microsimulation model. The CGE model is first simulated by gas-industry-specific changes during 1990s to generate changes in the prices of goods and services, and productive factor returns. The estimated changes are then applied to the microsimulation model for a detailed analysis of changes in individual household expenditure and income. Thus, this work advances the limited analysis of the distributional effects of the microeconomic reforms motivated by the Hilmer Report by applying a more comprehensive analytical framework. Further, this work adds a regional dimension to the analysis that is also lacking in previous studies.

2. Microeconomic reform during the 1990s

2.1. Australian infrastructure industries and the Hilmer Reforms

At the beginning of the 1990s, Australian governments began an extensive process of microeconomic reform of Australian infrastructure industries. The main objectives of these reforms were to increase competition and performance in these industries and thus bring about higher living standards (PC 2002). Prior to the commencement of the reform process, almost all infrastructure industries were dominated by GTEs providing services with monopoly rights. Thus, the reform process has been largely concerned with improving the performance of GTEs in four broad areas: commercialisation; corporatisation; capital market disciplines and competition policy (PC 2002).

Commercialisation involved GTEs taking a more market-driven approach to service provision and pricing via competitive tendering and contracting out of service provision. Community service obligations are now funded in a more direct and transparent way, and GTE regulatory functions have been transferred from GTEs to independent regulators. Corporatisation focuses on making GTEs autonomous entities with commercially oriented boards pursuing commercial objectives without ministerial interference. Price regulation has also been largely transferred from ministerial control to independent regulators. Capital market disciplines now require GTEs to either reduce negative rates of return or earn higher positive rates of return. Competition policy focussed on removing existing entry barriers to infrastructure industries and thereby stimulating competition and increasing contestability.

2.2. The Australian gas industry and the Hilmer Reforms

For historical and cost reasons, not all Australian households and industries use natural gas; at the end of last century, only 47 per cent of Australian households were connected to natural gas. This figure varies widely across regions. The historical development of transmission and distribution networks in each region determines the degree of access by households and industries. Further, less densely populated areas face higher distribution costs, which also limits the degree of access to gas (PC 2002).

For most of the 20th century, Australian governments owned gas utilities that controlled gas pipelines, distribution networks and retail businesses. In 1994, the Council of Australian Governments made a commitment to ‘free and fair trade in natural gas’, which marked the beginning of gas industry reforms. Following this, publicly owned gas utilities were either corporatised or privatised. Policy and regulatory impediments to interstate trade and retail competition were gradually reduced or removed (PC 2002).

As publicly owned gas utilities were corporatised or privatised, widespread structural changes took place in the gas industry across regions. Vertically integrated gas transmission and distribution activities were separated. Employment levels fell and work practices changed. The reduction in employment was accompanied by contracting out of services by gas utilities. To introduce competition in gas trade, gas prices were gradually deregulated. More customers were given the freedom to choose their gas retailer. In some regions, price rebalancing between customer classes was also undertaken to make gas prices more reflective of the costs of supplying different customer types and the price sensitivity of their demand (PC 2002).

3. Method

3.1. The history of linked models

Orcutt (1967) was the first to describe a process for linking models that operate at differing levels of aggregation. He envisaged multiple models, each describing part of the economy, being linked as modules that together would describe the overall system. More recently, Bækgaard (1995) identifies alternative approaches to linking micro and macro models. The most advanced of these is to build a model that includes both a micro and macro dimension. In principle, such a fully integrated model is preferred; in practice, most models in the literature take a recursive-linkage approach. This reflects the practical difficulties of including both dimensions within one model.

Recent examples of linked models developed to assess distributional issues include Aaberge *et al.* (2007) and Arntz *et al.* (2008). Within Australia, there have been only limited attempts to link micro and macro models. As far as we are aware, the earliest Australian example is Meagher and Agrawal (1986) in which output from a CGE model was used to reweight the 1981–82 National Income and Housing Survey. Polette and Robinson (1997) used the top–down approach to link an aggregated version of the MONASH model to a microsimulation model of the Australian income support system.

Of the two Australian studies that have analysed the distributional effects of the Hilmer reforms, PC (1996b) follows the pioneering work (in the Australian context) of Meagher and Agrawal (1986) using a CGE model in conjunction with an income distribution model to analyse the effects of some of the Hilmer reforms on the sources of household income. PC (1996a) applies an input–output model and household survey data to estimate the effects on household expenditure of price reforms by GTEs in the electricity industry and the water, sewerage and drainage services industry. But input–output models are inappropriate for analysing distributional effects as they assume all prices are fixed whereas, in reality, any reallocation in resources across sectors owing to structural change will alter factor prices and incomes. Further, both PC (1996a,b) concentrate on only one side of the household budget, so the overall impact on household real income is unclear.

3.2. Analytical framework

Most of the Australian studies mentioned above have focused on linking a CGE model to a detailed microsimulation model of household income, thus ignoring the differences in expenditure patterns across households and their effect on income distribution. Further, none of these studies employed a bottom-up regional model of Australia that can capture region-specific changes and thus derive region-specific changes in commodity and factor prices, and region-specific changes in resource allocation across industries. Allowing for region-specific changes in analysing structural change owing to microeconomic reform is important, as the reform process did not proceed at an even pace and was not of a similar nature across the Australian regions. As a response to these shortcomings, we develop a more comprehensive framework by (i) integrating both sides of the household budget to capture the direct and indirect effects on household real income and (ii) employing a bottom-up regional model to generate region-specific changes in commodity prices, factor prices and factor usage. We do this by first simulating a comparative-static multi-regional CGE model – MMRF (Naqvi and Peter 1996) – using industry-specific changes to generate region-specific changes in prices and quantities. The changes in prices and quantities are then applied to a microsimulation model – the MMRF Income Distribution (MMRF-ID) model – for analysis of changes in individual household expenditure and income.

3.3. The MMRF model

The MMRF model applied here represents the supply and demand side of commodity and factor markets in the eight Australian states. Each region contains five representative agents – producers, physical capital investors, households, governments and foreigners. There are 54 producers in each region, each producing one commodity. Commodities are traded between regions and are also exported. There is a single representative household in each region that owns all factors of production and thus receives all factor income: households can either spend or save its income. There are nine government sectors (eight regional and one national). Foreigners supply imports to each region at fixed c.i.f. prices and demand commodities (exports) from each region at variable f.o.b. prices.

3.3.1 A linear equation system

MMRF is represented by equations specifying behavioural and definitional relationships. There are m such relationships involving a total of p variables, and these can be compactly written in matrix form as

$$A\boldsymbol{v} = \mathbf{0} \tag{1}$$

where A is an $m \times p$ matrix of coefficients, $\boldsymbol{v}$ is a $p \times 1$ vector of percentage changes in model variables and $\mathbf{0}$ is the $p \times 1$ null vector. Of the p variables,

e are exogenous. Many of the functions underlying (Eqn 1) are highly nonlinear and thus computationally demanding. To aid computational efficiency, we rewrite (Eqn 1) in linear form as

$$\boldsymbol{n} = -A_n^{-1} A_x \boldsymbol{x} \tag{2}$$

where $\boldsymbol{n}$ and $\boldsymbol{x}$ are vectors of percentage changes in endogenous and exogenous variables, and A_n and A_x are matrices formed by selecting columns of A corresponding to $\boldsymbol{n}$ and $\boldsymbol{x}$. If A_n is square and nonsingular, we can compute percentage changes in the endogenous variables as in (Eqn 2). Although (Eqn 2) is subject to linearisation error, this is eliminated by applying a multistep solution procedure.[1]

3.3.2. Behavioural equations

Representative firms are assumed to treat the 10 factors of production (agricultural land, eight labour types and physical capital) as variable and take factor prices as given in minimising costs. Demands for primary factors are modelled using nested production functions consisting of three levels. At the top level, the j (= 1,…,54) firms in the r (= 1,..,8) regions decide on the (percentage change in) demand for the primary factor composite (i.e. an aggregate of land, labour and capital) qf^F_{jr} using Leontief production technology:

$$qf^F_{jr} = qf_{jr} + af_{jr} \tag{3}$$

where qf_{jr} is (the percentage change in) the (j, r)-th industry's activity level, and af_{jr} is technical change augmenting the use of all production inputs.

At the second level, firms decide on their demand for the i (= 3) broad factors of production, qf^F_{ijr}. All industries apply CES (constant elasticity of substitution) production functions:

$$qf^F_{ijr} = qf^F_{jr} + af^F_{ijr} - \sigma f^F_{jr}\left(pf^F_{ijr} + af^F_{ijr} - pf^F_{jr}\right) \tag{4}$$

where σf^F_{jr} (= 0.5) is the CES between primary factors, af^F_{ijr} is factor i-augmenting technical change and $pf^F_{ijr}\left(pf^F_{jr}\right)$ is the individual (average) price of primary factors.

At level 3, firms decide on their use of the m (= 8) labour types (occupations) qf^L_{mjr} using CES production technology,

$$qf^L_{mjr} = qf^F_{ijr} - \sigma f^L_{mr}\left(pf^L_{mjr} - pf^L_{jr}\right), i = \text{labour} \tag{5}$$

where $\sigma f^L (= 0.35)$ is the CES between labour types, and $pf^L_{mjr}\left(pf^L_{jr}\right)$ is the individual (average) wage rate paid by producers.

[1] The model is implemented and solved using the GEMPACK economic modelling software (Harrison and Pearson 1996).

To exploit the richness of the labour income data in MMRF-ID, the MMRF model is modified to allow for an occupation-specific price of labour in each region. Thus, the pattern of occupational employment for an industry experiencing structural change will be reflected in the pattern of changes in occupational employment and wage rates.

We add to MMRF a labour supply function, ls_{mr},

$$ls_{mr} = \beta rw_{mr} \tag{6}$$

and

$$rw_{mr} = w_{mr} - cpi_r \tag{7}$$

where w_{mr} is the average post-income-tax wage and cpi_r is the consumer price index. Thus, the supply of each labour type is a positive function of the real wage, rw_{mr}, and β, the labour supply elasticity. β is set at 0.15, reflecting econometric evidence on labour supply in Australia (Kalb 1997).

The initial labour market equilibrium includes unemployment in each region. Changes in the equilibrium are determined by imposing a relation between real wages and employment l_{mr} of the form,

$$rw_{mr} = \gamma l_{mr} \tag{8}$$

where γ represents the employment elasticity of the real wage. In any perturbation of the model, γ determines the degree to which increases (decreases) in the demand for each labour type will be reflected in higher (lower) employment or the real wage. γ is set at 2 based on casual empiricism of the Australian labour market where real wages grow faster than employment. Equations (6) and (8) together determine the endogenous unemployment rate for each labour type.

Firms are also assumed to be able to vary the k (= 1,…,54) intermediate inputs they use in production, the prices of which they also take as given in minimising costs. In combining intermediate inputs, all firms are assumed to use three nested production functions. At level 1, all firms decide on their use of the intermediate input composite qf^I_{jr} using Leontief production technology;

$$qf^I_{kjr} = qf_{jr} + af_{jr} \tag{9}$$

At level 2, firms decide on their use of the k intermediate input composites from domestic region r qf^I_{kjr} using CES production technology,

$$qfd^I_{kjr} = qf^I_{kjr} - \sigma f^I_k \left(pfd^I_{kjr} - pf^I_{kjr} \right) \tag{10}$$

where σf^I_k is the CES for domestic intermediate input composites, and $pfd^I_{kjr} \left(pf^I_{kjr} \right)$ is the individual (average) price of domestic intermediate input composites. The values for σf_k^I range between 1 and 2 for most goods; the exceptions are low-value manufactured goods (e.g. textiles, clothing and footwear) that are set at 3 or more.

At level 3, firms decide on their use of individual intermediate inputs by source s (eight domestic sources and one foreign source qfs_{kjsr}^I) also using CES production technology,

$$qfs_{kjsr}^I = qfd_{kjr}^I - \sigma fd_k^I \left(pfs_{kjsr}^I - pfd_{kjr}^I \right), \; s = \text{domestic} \tag{11}$$

$$qfs_{kjsr}^I = qf_{kjr}^I - \sigma f_k^I \left(pfs_{kjsr}^I - pf_{kjr}^I \right), \; s = \text{domestic} \tag{12}$$

where σfd_k^I is the CES between any pair of individual intermediate inputs from domestic sources, and pfs_{kjsr}^I is the price of the k-th intermediate input from region s used by firm j in region r. The values for σfd_k^I range from 2.5 for high-value manufactured goods (e.g. scientific equipment), 8 for primary goods (agriculture) and 10 or more for low-value manufactured goods.

We define average technical change for a given industry as the share-weighted sum of the technical change terms already defined,

$$a_{jr} = af_{jr} + S_{ijr}^F af_{ijr}^F \tag{13}$$

where S_{ijr}^F is the cost share of the i-th factor.

All firms are assumed to operate in perfectly competitive markets, and so we impose a zero-pure-profits condition that is expressed as equating revenues with costs; this determines each industry's activity level (qf_{jr}). Output prices pf_{jr} are then determined by a market-clearing condition for each commodity.

3.3.3. Model closure

The model contains m equations and p variables, where $m < p$, so to close the model e $(= p - m)$, variables must be set as exogenous. The exogenous variables are chosen so as to approximately simulate a long-run environment. Thus, technical change, direct and indirect tax rates and industry depreciation rates are exogenous. To capture the overall scarcity of land, we also fix industry land usage. As this study is concerned with the reallocation of existing factors rather than growth effects, the national supply of capital is fixed. This means that any excess demands for capital at initial prices (owing to gas industry changes) are partly reflected in rental price changes and partly reflected in the reallocation of capital across regions and sectors: capital moves between industries and across regions to maximise its rate of return. The national consumer price index is the numeraire; thus, nominal price changes are measured relative to this composite price.

3.4. The MMRF-ID model

MMRF-ID is a microsimulation model that represents the distribution of real incomes across households in eight Australian regions.

3.4.1. Theory

Compensating variation (CV) is commonly used to compute the benefits that accrue from a price change: it applies a 'money-utility' concept rather than utility itself. A modified version of the CV is based on redefining real income as constant purchasing power; this measure of real income requires no specific assumptions about consumer preferences.

Typically, the computation of CV emphasises only the role of consumption patterns in determining the welfare impact of a price change. Here, we extend the modified CV to allow for nonconstant income. For a given household, real income can then be defined as nominal factor earnings and transfers received from different sources deflated by a household-specific consumer price index (HCPI). Then, the first-order approximation to the percentage change in the c-th household's CV, relative to the initial consumption bundle and factor ownership, can be expressed as

$$cv^c = -(i^c - p^c) \tag{14}$$

where i^c and p^c are the percentage changes in income and the HCPI for household c. p^c is the average percentage change in the prices of the n goods consumed p_n weighted by expenditure shares S_n^c:

$$p^c = \sum\nolimits_n S_n^c p_n \tag{15}$$

Differences in the sources of income i^c for the c-th household can be expressed as

$$i^c = \sum\nolimits_g S_g^c i_g q_g \tag{16}$$

where S_g^c is the share of income source g in total household income, and i_g (q_g) is the percentage change in the price (employment) of income source g. Thus, our modified CV assesses the impact of a policy change on a given household via the computation of the change in real income.

In computing real household income changes in MMRF-ID, price and quantity changes are mapped from less-detailed MMRF variables to more-detailed MMRF-ID variables. Commodity prices are mapped as $p_{nr} = \sum_{k=1}^{54} \mathrm{CM}_{kn} p_{kr}$, where a regional subscript has been added, and CM_{kn} is a (0,1)-integer matrix mapping from MMRF to MMRF-ID commodities. Factor prices are mapped as $i_{gr} = \sum_{i=1}^{10} FM_{ig} pf_{ir}^F$, where FM_{if} is a (0,1)-integer matrix mapping from MMRF to MMRF-ID income sources, and pf_{ir}^F is the average price of factor i across all industries in region r. Factor quantities are mapped as $q_{gr} = \sum_{i=1}^{10} FM_{ig} qf_{ir}^F$, where qf_{ir}^F is the average quantity employed of factor i across all industries.

3.4.2. Data
The MMRF-ID is calibrated using unit-record household survey data taken from the 1993–94 Household Expenditure Survey (HES93) (ABS 1994). The survey contains detailed information on household consumption patterns and income sources of 8389 sample households. On the income side, income sources include wages and salaries from eight occupations, nonwage income from investment and business sources, and various government transfer payments (see Table 1). The HES93 also contains expenditure data on more than 700 goods and services.

In reporting distributional effects from MMRF-ID, we group households according to regional income deciles. Table 2 presents the national share of household expenditure allocated to gas across income deciles. As expected, the share falls as household income rises, reflecting a low-income elasticity of demand for gas. Nevertheless, the expenditure shares vary significantly across region with the lowest shares in Tasmania and the highest shares in Victoria, reflecting the wide variation in access to gas across Australian regions. Table 2 also presents the distribution of household income across income sources for each decile. It shows that government benefits are the dominant source of household income for the first three deciles, whereas labour income is the most important income source for the remaining seven deciles. The data also show a steadily rising direct tax rate as income rises.

4. Calculating gas-industry-specific changes

Determining changes specific to the gas industry over the 1990s is an important input to this work. While it seems reasonable to attribute most of these gas industry changes over the 1990s to the reform process directed specifically to the gas industry, changes have occurred in the other parts of the economy that are likely to also have influenced the changes observed in the gas industry. To isolate all gas-industry-specific changes, we use the only information available: employment, output and prices.

Table 1 Mapping of household income sources from MMRF to MMRF-ID

MMRF model	MMRF-ID model
Labour income sources	Managers, Professional, Para-Professional, Trades Persons, Clerks, Sales Persons, Plant/Machine Operators, Labourers
Nonlabour income sources	Interest, Investment, Property Rent, Superannuation, Business, Workers Compensation, Accident Compensation, Maintenance, Other Regular Sources, Private Scholarship, Government Scholarship, Overseas Pensions
Government benefits	Sickness Benefits, Family Allowance, Veteran's Pensions, Unemployment Benefits, Age Pensions, Widows Pensions, Disable Pensions, Sup Par Benefits, Wife's Pensions, Other Australian Government Benefits, AUSTUDY Support, Carer's Pensions, Other Overseas Government Benefits
Income tax	Direct tax

Table 2 Gas expenditure and income shares in MMRF-ID, national

Income decile	Share of gas expenditure in total expenditure	Household income shares			Direct tax rate (%)
		Nonlabour income*	Labour income	Government benefits	
Lowest	0.008	−0.125	0.318	0.778	3.0
Second	0.007	0.074	0.393	0.476	6.0
Third	0.008	0.124	0.318	0.498	6.4
Fourth	0.007	0.084	0.459	0.373	9.3
Fifth	0.006	0.143	0.556	0.179	14.0
Sixth	0.006	0.119	0.633	0.106	16.5
Seventh	0.006	0.128	0.651	0.066	18.5
Eighth	0.005	0.105	0.700	0.026	20.2
Ninth	0.005	0.098	0.704	0.014	22.5
Highest	0.004	0.147	0.621	0.006	29.1

Source: MMRF-ID database. *Nonlabour income sources are defined in Table 1. They are based on taxable income; thus, they include losses from business and property income. Such losses dominate nonlabour income for the lowest-income decile as a whole.

To remove the effect of economy-wide output growth on gas industry employment, we calculate employment per unit of output. Unit-output employment is calculated as observed employment divided by output (petajoules supplied). In imposing the changes in unit-output employment in MMRF, this typically endogenous variable, qfl_{jr}, is set as exogenous. This is accommodated by setting labour-augmenting technical change $af^{F}_{ijr}(i = labour)$ as endogenous. Thus, a change in unit-output employment is assumed to be due to a change in labour productivity.

In calculating the gas price changes, we remove the effects of nongas industry factors by calculating a 'real price index': the market price divided by the consumer price index (CPI), indicating movements in relative price of gas. The real price of gas is typically an endogenous variable in a CGE model. To impose the price change in MMRF, we set it as exogenous, and all-input-augmenting technical change af_{jr} is set as endogenous. Thus, a change in the relative price is assumed to be due to a change in the technology affecting the use of all inputs.

Like many infrastructure industries, the gas industry charges different prices for different customers, for example, residential, commercial and industrial users (ABS 2001a). Price data indicate that, over the 1990s, gas firms have rebalanced prices for different customer groups (PC 2002). To account for price rebalancing, we apply separate price changes for producers and households. The movement in the supply price of gas is then a weighted average of the two prices.

Changes in the gas industry are also likely to affect government revenue; to neutralise this effect, we fix the federal budget deficit and endogenise the income tax rate. We also fix the budget deficit for all state governments and endogenise their payroll tax rates. This assumes that for a given level of public expenditure, any increased (decreased) tax revenue owing to the

Table 3 Estimated changes in gas industry variables (percentage change)

Variable	NSW	Vic	Qld	SA	WA	Tas*	NT	ACT
Employment per unit of output	−76.7	−88.7	−86.3	−44.5	−42.7	na	−39.4	−93.1
Real business price†	−13.5	−1.7	−1.2	0.7	−5.7	na	1.7	−4.7
Real household price	2.1	−3.0	−9.5	11.2	−11.1	na	20.1	15.0

Source: ABS (2001a,b) and AGA (1991, 1992, 1994, 1995, 1996, 1997, 1998, 1999, 2000). *Tasmania does not have a gas supply industry. †Business prices were calculated as the consumption-weighted average of reported commercial and industrial prices in ABS (2001a,b).

changes in the gas industry will be automatically recycled to households through a decrease (increase) in their income tax rates, and higher (lower) pre-tax wage rates owing to lower payroll tax rates on firms.

5. Results

5.1. Economy-wide effects

Table 3 reports the gas industry changes: these are estimated from published statistics (see Verikios and Zhang 2005 for further details). Unit-output employment decreased significantly in all regions for the period 1989/90–1999/00; some of these reductions in are in order of 76% or more. Nevertheless, gas sales rose over this period in all regions except Victoria.[2] Real business prices fell in most regions, but only slightly, and real household prices show no distinguishable pattern, but they did increase significantly in SA (South Australia) (11%), NT (Northern Territory) (20%) and the ACT (Australian Capital Territory) (15%).

A CGE model captures both the direct and indirect effects of a given shock to the economy. The major determinant of the direct effects of changes in the gas industry is its importance in the economy as a whole. Our model data indicate that gas output comprised around 0.3% of national output around the time the Hilmer Reforms began; the share of gas output in total output was largest in Victoria (0.5%) and smallest in the ACT (0.03%). This suggests that changes in the gas industry will lead to small direct effects, but of varying magnitudes across regions.

The changes in unit-output employment will determine the changes in labour-augmenting technical change. The changes in business and household prices are aggregated in MMRF, weighted by their shares in total sales, to determine the changes in the basic price of gas. In turn, the change in the basic price determines the change in all-input-augmenting technical change. The change in labour- and all-input augmenting technical change is summed to give average technical change a_{jr}. This change is closely related to the change in the basic price for the industry. Table 4 shows that a_{jr} is estimated

[2] Commercialisation of gas suppliers would have given management the opportunity to outsource some services previously insourced: it is probable that some of the reductions in employment per unit of output reflect this.

to have improved in New South Wales (NSW), Victoria, Queensland and Western Australia (WA); in these regions, the share-weighted average of business and household prices fell in real terms. By contrast, a_{jr} is estimated to have deteriorated in SA, the NT and the ACT; in these regions, the share-weighted average of business and household prices rose in real terms.

The national changes in relative occupational incomes (Table 5) indicate the occupations favoured by the changes; these show large relative reductions for Tradespersons, Clerks and Labourers and related workers (LRW). Two-thirds of wage payments in the gas industry are made to these three occupations. Thus, when significant labour shedding occurs in this industry, it is primarily Tradespersons, Clerks and LRW who are affected, and consequently the wage rates for these occupations must fall for those workers to be reemployed in other industries. But not all workers are reemployed as unemployment rates are not held constant. Occupations that are least used in the gas industry experience the largest increases in relative incomes; these are Managers and administrators and Salespersons and personal service workers.

The national pattern of relative changes in occupational incomes is repeated at the regional level but with different absolute changes across regions, for example, labour incomes rise in NSW, WA and NT and fall in other regions. In general, the relative movements in labour income across regions reflect movements in relative technical changes across regions; relative improvements in technical change lead to higher relative labour incomes and vice versa. An exception is the NT, where labour income rises by more than in other regions. This reflects the general expansion in NSW and its higher demand for mining goods imported from NT.

Nonlabour income also increases nationally, reflecting increased demand for capital and land. The relative changes in nonlabour income across regions reflect the pattern of movements in labour income across regions. Unemployment benefits fall in regions that experience higher employment and rise in regions that experience lower employment. Note also that the reforms show a consistent pattern of a redistribution of income from labour to nonlabour primary factors. This is consistent with the significant improvements in labour-augmenting technical change observed in all regions.

Table 4 Gas industry effects from changes in unit-output employment and relative prices (percentage change)

Variable	NSW	Vic	Qld	SA	WA	Tas	NT	ACT
Labour-augmenting technical change*	−92.6	−98.6	−98.1	−68.7	−60.0	0.0	−64.9	−99.5
All-input technical change*	8.7	22.0	12.2	21.9	1.1	0.0	24.0	42.5
Basic price	−9.6	−2.2	−3.6	4.6	−7.1	0.0	7.4	4.7
Average technical change*	−9.6	−2.2	−3.6	4.6	−7.2	0.0	7.3	4.7
Value-added	9.1	23.1	13.9	19.2	3.3	−0.1	19.4	37.2

Source: MMRF simulation. *This is the input requirement per unit of output; thus, a negative sign signifies an improvement.

Table 5 Economy-wide effects of gas industry changes (percentage change)

Variable	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Aust
Labour income	0.07	−0.10	−0.06	−0.12	0.06	−0.03	0.10	−0.17	−0.02
Managers & administrators	0.22	0.27	0.06	0.09	0.07	0.01	0.09	−0.05	0.17
Professionals	0.11	−0.04	−0.06	−0.13	0.09	−0.03	0.13	−0.09	0.02
Para-professionals	0.08	−0.09	−0.06	−0.14	0.08	−0.01	0.13	−0.15	−0.01
Tradespersons	−0.04	−0.36	−0.14	−0.22	0.02	−0.07	0.07	−0.41	−0.15
Clerks	0.01	−0.20	−0.11	−0.17	0.04	−0.03	0.10	−0.15	−0.08
Salespersons & personal service workers	0.20	0.24	0.02	0.04	0.08	−0.02	0.07	−0.02	0.15
Plant & machine operators; drivers	0.09	−0.13	−0.05	−0.11	0.08	−0.03	0.14	−0.35	−0.01
Labourers & related workers	−0.07	−0.45	−0.13	−0.23	0.01	−0.02	0.06	−0.38	−0.18
Nonlabour income	0.10	0.16	0.05	0.05	0.13	0.05	0.22	−0.13	0.10
Unemployment benefits	−0.14	−0.03	0.06	0.24	−0.11	0.07	−0.11	0.42	−0.03
Other government benefits	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct tax rate									0.01
Real household disposable income	0.03	−0.01	−0.02	−0.11	0.04	−0.03	0.02	−0.15	0.00
CPI	0.03	−0.05	−0.02	0.04	0.02	0.02	0.06	0.02	0.00
Real GDP	0.08	0.10	0.0	−0.05	0.04	−0.03	0.04	−0.08	

Source: MMRF simulation.

Besides the changes in primary factor incomes, the direct tax rate will also affect household post-tax income. With the assumption of a fixed federal budget deficit and an endogenous direct tax rate, changes in the direct tax rate are driven by the effect of changes in the gas industry on total tax revenue. Changes in total tax revenue are driven by the effect of changes in the gas industry on the level of economic activity. While technical change improves on average in some regions and falls in others, there is a small contractionary effect in net terms on economic activity nationally, and so the direct tax rate rises slightly (0.01%).

The changes in the gas industry also affect the prices of goods. The CPI effects indicate that the relative cost of household expenditure rises in all regions except Victoria and Queensland. For most regions, this reflects the direct impact of the change on the household price of gas and the reinforcing effect of changes on nongas prices.

5.2. Household effects

The changes in goods prices and factor incomes estimated by the MMRF model are applied to the MMRF-ID model to compute changes in individual household real income (Table 6). At the national level, all income deciles gain except the first and second deciles. Regardless, the gains from the changes in the gas industry are small, consistent with the small economy-wide effects. The slightly regressive pattern of changes is confirmed by the rise in the national Gini coefficient (0.01%).

The first two deciles experience lower or stagnant real incomes because of lower government benefits (because of the reductions in the number of unemployed) and lower labour income for occupations that experience lower wages: Tradespersons, Clerks and LRW who are highly represented in these deciles. In aggregate, the lowest-income decile derives around three-quarters of its income from government benefits. The fifth decile experiences stagnant real incomes because of lower labour income for Clerks and Para-professionals who are highly represented in this decile.

The national pattern of slightly regressive results is only replicated in NSW and Victoria: the Gini coefficient is constant in all other regions. Although not reported, the detailed results show price effects to be just as important as the income effects in determining the changes in real income for most deciles. Thus, the direct and indirect effects are of about equal importance in determining the effect on household real incomes.

6. Sensitivity analysis

Here, we investigate the sensitivity of the results with respect to key model parameters in order to evaluate the effects of independent uncertainties about the values of model parameters. Table 7 reports the estimated means (the first two rows) and standard deviations (rows three and greater) for real household income and inequality if the parameters vary symmetrically following a triangular distribution. The calculation of means and standard deviations was carried out using the systematic sensitivity methods automated in the GEMPACK economic modelling software (Harrison and Pearson 1996). These methods rely on a Gaussian quadrature to select a modest number of different sets of values for the varying parameters (DeVuyst and Preckel 1997). The model is solved using each different set of parameter values, and the means and standard deviations are calculated over the several solutions of the model.

Table 6 Changes in household real income and inequality (percentage change)

Income decile	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Aust
Lowest	−0.05	0.06	−0.01	−0.09	0.02	0.00	0.02	−0.07	−0.01
Second	0.00	0.02	−0.01	−0.12	0.09	0.00	0.02	−0.09	0.00
Third	0.00	0.06	0.01	−0.09	0.07	−0.01	0.03	−0.16	0.02
Fourth	0.00	0.03	−0.01	−0.08	0.09	0.00	0.01	−0.19	0.01
Fifth	0.02	0.01	−0.02	−0.09	0.09	−0.01	0.08	−0.17	0.00
Sixth	0.04	0.01	−0.02	−0.13	0.09	−0.02	0.07	−0.14	0.01
Seventh	0.04	0.04	−0.02	−0.12	0.09	−0.02	0.02	−0.16	0.02
Eighth	0.05	0.02	−0.04	−0.12	0.08	−0.03	0.02	−0.13	0.01
Ninth	0.06	0.02	−0.02	−0.13	0.09	−0.02	0.02	−0.11	0.02
Highest	0.10	0.07	−0.01	−0.08	0.09	−0.02	0.05	−0.16	0.05
All deciles	0.04	0.04	−0.02	−0.11	0.09	−0.02	0.04	−0.14	0.02
Gini coefficient	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01

Source: MMRF-ID simulation.

Table 7 Systematic sensitivity analysis of household real income and inequality (percentage change)

Variable	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Aust
Mean									
All deciles	0.04	0.04	−0.02	−0.11	0.09	−0.02	0.02	−0.14	0.02
Gini coefficient	0.02	0.01	0.00	0.00	0.00	0.00	−0.01	0.00	0.01
Elasticity of substitution between occupations									
All deciles	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.000
Gini coefficient	0.001	0.002	0.000	0.001	0.000	0.000	0.000	0.001	0.001
Elasticity of primary factor substitution									
All deciles	0.012	0.010	0.014	0.014	0.016	0.010	0.025	0.029	0.012
Gini coefficient	0.003	0.005	0.003	0.005	0.005	0.003	0.003	0.004	0.004
Elasticity of import-domestic substitution									
All deciles	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gini coefficient	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Elasticity of intra-domestic substitution									
All deciles	0.001	0.001	0.002	0.001	0.002	0.004	0.005	0.002	0.000
Gini coefficient	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000
Elasticity of export demand									
All deciles	0.001	0.003	0.000	0.000	0.004	0.001	0.004	0.000	0.001
Gini coefficient	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.000
Elasticity of employment with respect to the real wage									
All deciles	0.001	0.002	0.001	0.004	0.002	0.001	0.002	0.009	0.000
Gini coefficient	0.000	0.001	0.001	0.003	0.001	0.001	0.000	0.000	0.001
Elasticity of labour supply									
All deciles	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Gini coefficient	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000

The results indicate that our estimates of household real income effects are remarkably robust with respect to variations in nearly all model parameters; the estimated standard deviations are much smaller than the simulation results. The only exception to this is the elasticity of primary factor substitution. The results also show our estimates of inequality are invariant to model parameters. Thus, we can be fairly confident of the size of the overall effect on households' welfare and inequality, at the regional and national level, from the estimated changes in the gas industry.

7. Concluding remarks

The Australian gas industry experienced significant structural change during the 1990s; the changes were mainly due to microeconomic reform motivated by the Hilmer Report. Here, we analyse the distributional impacts of the changes. The analytical framework we apply combines a computable general equilibrium model and a microsimulation model. A notable feature of the structural change was a significant improvement in labour-augmenting technical change. Thus, we estimate that the reforms lead to a redistribution of income from labour to nonlabour primary factors. The redistribution of income away from labour is concentrated on those workers who were intensively employed in the gas industry at that time: Tradespersons, Clerks and

Labourers (and related workers): these workers experience lower wages and lower employment relative to all other workers.

Unsurprisingly, the redistribution of income away from labour leads to a redistribution of income from low-income to high-income households but only slightly so; nationally, the Gini coefficient is estimated to have increased by 0.01%. Amongst regions, inequality is estimated to have increased in New South Wales and Victoria and to be unchanged elsewhere. The changes in the gas industry are estimated to have raised overall household income in real terms by 0.02%. This increase is distributed unevenly across regions; households in New South Wales, Victoria, Western Australia and the Northern Territory benefit whereas they lose in Queensland, South Australia, Tasmania and the Australian Capital Territory. At the sub-state level, households in which Tradespersons, Clerks and Labourers are concentrated are adversely affected by the changes relative to all other households. Sensitivity analysis indicates that the distributional and welfare impacts are largely insensitive to variations in model parameters.

An interesting feature of our results is that although most Australian gas industries experienced significant structural change over the 1990s, the changes only led to a slight increase in income inequality. This is mainly because of the relatively small size of the gas industry and household gas consumption at that time, and low importance of gas as an input to other industries. Contemporaneous criticisms of the Hilmer reforms emphasised that although the reforms might lead to productivity gains, '...the dominant flow-on effects...will be negative, arising from the fact...some of the workers directly displaced by the reforms will be permanently displaced from the employed labour force' (Quiggin 1997, p. 256). In the case of the gas industry, we find that while labour productivity increases significantly, total factor productivity improves by much less. We also find that while it is likely that some displaced workers are reemployed at lower wages, other workers become part of the pool of long-term unemployed. Consequently, our work suggests that the dominant flow-on effect of the reforms on the gas industry is not necessarily negative. Rather, it depends on the welfare measure used to evaluate the net social benefits from the reforms. Applying the welfare metric of real household income in this work suggests that the reforms lead to benign welfare effects.

This work makes a number of contributions. One, it adds to the few Australian studies that have attempted to estimate the distributional effects of structural changes owing to microeconomic reform motivated by the Hilmer Report. Two, it represents a methodological advance on these existing studies by estimating the effects on both sides of the household budget. Three, this work adds a regional dimension to the analysis that is also lacking in previous studies. Thus, this work advances the limited analysis of the distributional effects of the microeconomic reforms motivated by the Hilmer Report by applying a more comprehensive analytical framework. Four, we have estimated the effects on one industry of a policy change that was strongly resisted for nearly a century by Australian governments, their constituents and many economists. We have shown that a previously state-owned monopoly industry can experience significant structural change without leading to significant adverse impacts on national or state household income and income inequality: this is an important research finding. Nevertheless, our results may not generalise to other industries experiencing similar changes if (i) these industries represent a much larger share of output than the gas industry, and (ii) net social benefits are evaluated by metrics other than real household income and its distribution.

References

Aaberge, R., Colombino, U., Holmøy, E., Strøm, B. and Wennemo, T. (2007). Population ageing and fiscal sustainability: integrating detailed labour supply models with CGE models, in Harding, A. and Gupta, A. (eds), *Modelling Our Future: Social Security and Taxation, Vol. I*. Elsevier, Amsterdam, pp. 259–290.

Arntz, M., Boeters, S., Gürtzgen, N. and Schubert, S. (2008). Analysing welfare reform in a microsimulation-AGE model: the value of disaggregation, *Economic Modelling* 25 (3), 422–439.

Australian Bureau of Statistics (ABS) (1994). *1993–94 Household Expenditure Survey, Australia: Unit Record File*, Cat. No. 6535.0. ABS, Canberra.

Australian Bureau of Statistics (ABS) (2001a). *Consumer Price Index, Australia*, Cat. No. 6401.0. ABS, Canberra.

Australian Bureau of Statistics (ABS) (2001b). *Electricity, Gas, Water and Sewerage Industries, Australia, 1999–00*, Cat. No. 8208.0. ABS, Canberra.

Australian Gas Association (AGA) (1991, 1992, 1994, 1995, 1996, 1997, 1998, 1999, 2000). *Gas Statistics Australia*. AGA, Canberra.

Bækgaard, H. (1995). Integrating micro and macro models: mutual benefits, in Binning, P., Bridgman, H. and Williams, B. (eds), *International Congress on Modelling and Simulation Proceedings, Volume 4 (Economics and Transportation)*. University of Newcastle, Newcastle, Australia, pp. 253–258.

Commonwealth of Australia (1993). *National Competition Policy*, Report by the Independent Committee of Inquiry (Hilmer Report). Commonwealth Government Printer, Canberra.

DeVuyst, E.A. and Preckel, P.V. (1997). Sensitivity analysis revisited: a quadrature based approach, *Journal of Policy Modeling* 19 (2), 175–185.

Harrison, W.J. and Pearson, K.R. (1996). Computing solutions for large general equilibrium models using GEMPACK, *Computational Economics* 9 (2), 83–127.

Kalb, G. (1997). An Australian model for labour supply and welfare participation in two-adult households. Ph.D thesis, Monash University.

Madden, J.R. (2000). The regional impact of national competition policy, *Regional Policy and Practice* 19 (1), 3–8.

Meagher, G.A. and Agrawal, N. (1986). Taxation reform and income distribution in Australia, *Australian Economic Review* 19 (3), 33–56.

Naqvi, F. and Peter, M.W. (1996). A multiregional, multisectoral model of the Australian economy with an illustrative application, *Australian Economic Papers* 35 (66), 94–113.

Orcutt, G.H. (1967). Microeconomic analysis for prediction of national accounts, in Wold, H., Orcutt, G.H., Robinson, E.A., Suits, D. and de Wolff, P. (eds), *Forecasting on a Scientific Basis: Proceedings of an International Summer Institute*. Centro de Economia e Financas, Lisbon, pp. 67–127.

Polette, J. and Robinson, M. (1997). Modelling the impact of microeconomic policy on Australian families, Discussion Paper 20, National Centre for Social and Economic Modelling, University of Canberra.

Productivity Commission (PC) (1996a). GBE price reform: effects on household expenditure, Staff Information Paper.

Productivity Commission (PC) (1996b). Reform and the distribution of income: an economy-wide approach, Staff Information Paper.

Productivity Commission (PC) (2002). Trends in Australian infrastructure prices 1990–91 to 2000–01, Performance Monitoring, AusInfo, Canberra.

Quiggin, J. (1997). Estimating the benefits of Hilmer and related reforms, *Australian Economic Review* 30 (3), 256–272.

Verikios, G. and Zhang, X-G. (2005). Modelling changes in infrastructure industries and their effects on income distribution, Research Memorandum MM-44, Productivity Commission, September.

Verikios, G. and Zhang, X-G. (2008). Distributional effects of changes in Australian infrastructure industries during the 1990s, Staff Working Paper, Productivity Commission, January.