Centre of Policy Studies Working Paper

No. G-240 February 2014

Structural change and income distribution: the case of Australian telecommunications

George Verikios and Xiao-guang Zhang

ISSN 1 031 9034

ISBN 978-1-921654-49-7

The Centre of Policy Studies (CoPS), incorporating the IMPACT project, is a research centre at Victoria University devoted to quantitative analysis of issues relevant to economic policy. Address: Centre of Policy Studies, Victoria University, PO Box 14428, Melbourne, Victoria, 8001
home page: www.vu.edu.au/CoPS/ email: copsinfo@vu.edu.au Telephone +61 3 9919 1877

STRUCTURAL CHANGE AND INCOME DISTRIBUTION:

THE CASE OF AUSTRALIAN TELECOMMUNICATIONS

George Verikios

Centre of Policy Studies, Victoria University

Xiao-guang Zhang

Productivity Commission

Abstract

The Australian telecommunications sector experienced substantial structural change during the 1990s, change that increased productivity and reduced costs. At this time, telecommunications was already an important item of household expenditure and input to production. We estimate the effect of the structural change on households depending on their location in the distribution of income and expenditure. Our estimates are calculated by applying a computable general equilibrium model incorporating microsimulation behaviour with top-down and bottom-up links. We estimate significant increases in real income and small increases in inequality from the changes; the pattern of effects is largely uniform across regions. Sensitivity analysis indicates that our results are insensitive to variations in model parameters.

JEL codes: C68, C69, D31, L99.

Keywords: computable general equilibrium, income distribution, microeconomic reform, microsimulation, telecommunications.

Acknowledgements

The views expressed here are the authors' and do not necessarily reflect those of the Productivity Commission or Victoria University. We thank Ken Clements and Ken Pearson for helpful comments on the paper.

Table of contents

Tables

Figures

1. Introduction

Telecommunications is a significant economic activity in Australia and other high-income countries: in 2002-03 it comprised 2.2% of total value-added for Australia (ABS, 2006), reflecting the importance of telecommunications in household expenditure and as a business input. Until 1991, there was a single government-owned provider (Telecom) of basic telecommunications services within Australia. Telecom had a monopoly on the installation, maintenance, and operation of the telecommunications network. Competition existed only in the provision of value-added services, private networks, customer equipment and cable installation. During the 1990s, reforms were implemented that removed entry barriers for competition in basic and mobile phone telecommunications services (PC, 2002). The telecommunications reforms were a subset of a wider set of reforms applied to infrastructure industries begun by Australian governments during the 1990s – the Hilmer reforms. Coincident with the reform process, there was rapid change in telecommunications products (e.g., email, internet, etc) and technologies (mobile, digital, satellite, etc.) during the 1990s (Giesecke, 2006). Together, the regulatory reforms and the rapid introduction of products and technologies led to major structural change in the telecommunications industry.

Infrastructure industries, such as telecommunications, are generally major service providers, so reform of and technological change in these industries can potentially have significant impacts on households, businesses and on other industries. For households, changes in infrastructure prices will directly affect household incomes via cost-of-living changes. But changes in infrastructure prices can also indirectly affect the cost structure and competitiveness of downstream industries. In turn, this will affect factor incomes to some extent. Changes in factor incomes will affect household incomes; unless such changes affect all households evenly, the distribution of income will also change. Our focus is on quantifying the direct and indirect effects of structural change in telecommunications on income distribution. As telecommunication services are directly purchased by households and are usually a significant share of household expenditure, *a priori*, the link between the telecommunications sector and income distribution seems straightforward and strong. The indirect links between the telecommunications industry and other industries also seem straightforward because telecommunications is typically consumed by all industries to some extent, but the strength of this link is not clear. Another indirect link is through the effects on factor market prices via movement of labour and capital across industries, but it is not clear how strong the factor market links are or whether they are positive or negative for households; some scholars contend that the factor market links are unequivocally negative for households, e.g., Quiggin (1997).

To quantify the direct and indirect links between structural change in telecommunications and income distribution, we apply an economywide framework with a high degree of sectoral detail and intersectoral linkages: i.e., computable general equilibrium (CGE). CGE analysis of reforming infrastructure industries is not common: examples include Argentina’s utilities sectors (Benitez et al., 2003); Bolivia’s gas sector (Andersen and Faris, 2002); Morocco’s rural areas (Löfgren et al., 1997); and liberalisation of trade in telecommunications and other services for Tunisia (Konan and Maskus, 2006), for Argentina, Brazil and Uruguay (Chisari et al., 2009), and globally (Verikios and Zhang, 2003). Analysing the distributional effects of such reforms within a CGE framework is even less common: Boccanfuso et al. examine the impact of electricity industry reform on income distribution in two low-income countries, Senegal (2009a) and Mali (2009b); Chisari et al. (1999) estimate the distributional effects of reforming telecommunications (among other utilities) in Argentina; and Verikios and Zhang (2013) analyse the effects of electricity reforms on income distribution in Australia.

Our analysis proceeds by incorporating household expenditure and income data within a multi-region CGE model of Australia. Within this framework, we simulate the changes in labour productivity and relative prices of telecommunication services during the 1990s to generate region-specific changes in commodity prices, factor returns and usage. The region-specific changes are linked in a top-down manner to expenditure prices, employment and factor returns at the household level. In contrast, labour supply and commodity demand is determined at the household level and is linked to the CGE model in a bottom-up manner. In the microsimulation literature, this approach is typically referred to as macro-micro (Hertel and Reimer, 2005). Within this class of analysis, it is most accurately sub-classed as a variant of the CGE microsimulation sequential approach (e.g., Chen and Ravallion, 2004), also known as CGE micro-accounting (Boccanfuso et al., 2009a). In CGE micro-accounting, the representation of households is purely an accounting framework with no behavioural responses. Our approach follows that developed by Bourguignon and Savard (2008) by going beyond a pure accounting framework and incorporating micro-feedback effects from labour supply and commodity demand determined at the household level. Incorporating a micro-feedback effect from labour supply and commodity demand determined at the household level addresses one of the main criticisms directed at the macro-micro approach (Bourguignon and Spadaro, 2006); it also represents an advance on the few studies that analyse the distributional effects of reforming infrastructure industries using a macro-micro approach (e.g., Boccanfuso et al., 2009a, b; Chisari et al. (1999); Verikios and Zhang, 2013).

2. Changes in telecommunications during the 1990s[1]

2.1 Microeconomic reform

The telecommunications industry in Australia provides cable and communication channel services, network communication services, radio relay stations, satellite communications services, telecommunications, telephone and other services. In 2002-03, about 40% of telecommunication services were for basic telephony, about 28% comprised mobile, paging and short messaging services, and about 20% were for data, text, internet, satellite and other services (ABS, 2006). Before the 1990s, a government trading enterprise (GTE), Telecom (later Telstra), had a monopoly on provision of basic telecommunications services, and on the installation, maintenance, and operation of the telecommunications network.

At the beginning of the 1990s, Australian governments began a process of reforming infrastructure industries as part of the process inspired by the Hilmer Report (Commonwealth of Australia, 1993). The objectives of the reforms were to increase competition and performance in infrastructure industries. Prior to the reforms, almost all infrastructure industries were dominated by GTEs providing services with monopoly rights; as such, the reforms were largely concerned with improving the performance of GTEs. With regard to telecommunications, the reforms during the 1990s consisted of:

- the introduction of competition with the removal of barriers to entry for new carriers;
- the introduction of legislation to allow carriers to access the public switched telephone network owned by Telecom/Telstra;

[1] Section 2.1 draws on PC (2002).

- the introduction of anti-competitive conduct provisions for telecommunication services;
- the partial privatisation of Telecom/Telstra; and
- the introduction of a universal service obligation (USO) requirement provided by Telecom/Telstra and funded by a proportional levy on carriers' revenue. The USO requires that standard telephone, payphone and digital data services be made available to all customers at uniform rates.

2.2. Structural change

As a reflection of the effects of the reform process and the introduction of new products and technologies, the economic structure of telecommunication services changed through the 1990s. The structural changes are reflected in information available on employment, output and prices for telecommunications. Following the approach taken by Chisari et al. (1999), we use these variables to make two calculations. First, we calculate the change in employment per unit of output over the 1990s, i.e., gross employment (in persons) divided by the quantity of output. This measures the labour intensity of the industry; its inverse is also a measure of labour productivity. Output is defined as value-added in constant prices. Second, we calculate the relative output price: the output price divided by the consumer price index (CPI), indicating movements in the relative price of telecommunication services.

Table 1 reports the changes in employment per unit of output and relative prices in telecommunications over the 1990s. We see that unit-output employment decreased significantly in all regions: this ranged from -36.9% in Tasmania (TAS) to -42.2% in Western Australia (WA). The estimated changes in unit-output employment reflect two trends for telecommunications over the 1990s: i) a near tripling of average output (176%); ii) a small reduction in average employment (12%). The changes in unit-output employment reported in Table 1 also reflect the relative size of telecommunications employment in communications employment, as our model does not distinguish telecommunications separately from communications.[2] The large improvements in labour productivity for telecommunications indicated by our estimates are

[2] The CGE model presented in the next section only contains an aggregate communications sector that comprises postal and telecommunications services. The changes in telecommunications unit-output employment are weighted by the share of telecommunications employment in communications employment when applied to the model ensure that we do not overestimate the effects on the wider economy of changes in telecommunications unit-output employment.

supported by the work of Bortolotti et al. (2002) and Giesecke (2006). The movements in unit-output employment are consistent with the entry of new players in the telecommunications market, the development of new products and services, and the increase in competition faced by the incumbent monopoly supplier (Telecom/Telstra).

Table 1. Structural changes in telecommunications: 1989/90–1999/00 (percentage change)

Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Employment per unit of output	-37.5	-39.6	-41.9	-41.3	-42.2	-36.9	-41.5	-38.9
Relative price	-18.9	-18.5	-16.9	-19.9	-19.1	-18.1	-23.1	-19.0

Source: ABS (1990, 1991, 1992, 1993, 1994b, 1994c, 1995, 1996, 1997a, 1997b, 1998a, 1998b, 1999c, 2000a, 2000b, 2001a, 2001b, 2001b); SCNPMGTE (1995); PC (2001). See Chapter 4 of Verikios and Zhang (2005) for further details.

Table 1 shows that the relative price of telecommunications fell by around 20% in all regions, ranging from -16.9% in Queensland (QLD) to -23.1% in the Northern Territory (NT). The large relative reductions in the relative price of telecommunications reflects a broad pattern of small annual reductions in the price of telecommunications (-3% on average) compared with CPI growth of around 24% over the 1990s.[3] The general pattern of relative price reductions is consistent with the large improvements in labour productivity and is likely driven by the same structural changes already discussed above.

We apply the changes shown in Table 1 to the CGE model described in the next section. Unit-output employment is typically an endogenous variable in a CGE model. We accommodate applying exogenous changes in unit-output employment by setting labour-augmenting technical change as endogenous. The relative price of any commodity is also typically an endogenous variable in a CGE model. To apply a relative price change in our model we set it as exogenous and set all-input-augmenting technical change as endogenous. Thus, any relative price change will be attributed to a change in the technology affecting the use of all inputs in the production of telecommunications.

[3] As with our estimates of unit-output employment, the estimates of the relative price of telecommunications are weighted by the share of telecommunications output in communications output when applied to the CGE model.

3. Analytical framework

3.1 Overview

Linking models that operate at different levels of aggregation was first envisioned by Orcutt (1967). He described an approach where multiple models, each representing part of the economy, were linked as modules that together would describe the overall system. There is a variety of approaches to linking micro and macro models, which are variations on top-down and bottom-up linking methods. The most comprehensive, data intensive and computationally demanding approach is to build a model that inherently includes both a micro and macro dimension (Davies, 2004). A fully integrated model is preferable, in principle; but in practice most models take a less demanding approach due to the difficulties (e.g., data constraints and analytical complexity) of including both dimensions within one model.[4]

In distributional analysis, variations on top-down and bottom-up linking methods are generally referred to as the macro-micro approach, of which there are two approaches. The CGE micro-accounting approach is an example of the top-down method where the micro (household) model is adjusted to match an exogenous macro (CGE) aggregate (e.g., Chen and Ravallion, 2004). The CGE top-down/bottom-up microsimulation approach is where micro behaviour observed at the household level, such as consumption or labour supply, is integrated into the CGE model (e.g., Savard, 2010). Our approach follows Savard (2010), as we link a detailed multi-region CGE model with detailed regional household accounts on income and expenditure and incorporate micro-feedback effects from labour supply and commodity demand determined at the household level.

3.2 The macro dimension

At the macro level we employ a comparative-static multi-region CGE model of Australia – the Monash Multi-Region Forecasting (MMRF) model (Naqvi and Peter, 1996) – and incorporate within it individual household income and expenditure accounts (see Section 3.3). The MMRF model represents the supply and demand side of commodity and factor markets in the eight Australian regions (states and territories). Each region contains five representative agents – producers, physical capital investors, households, governments and foreigners. There are 54

[4] Examples of CGE models with fully integrated individual households include Cockburn et al. (2008) and Cogneau and Robilliard (2000).

producers in each region, each producing one commodity. Commodities are traded between regions and are also exported internationally. There is a single representative household in each region that owns all factors of production and thus receives all factor income (net of taxes): households can either spend or save their income. Saving contributes to the financing of domestic investment. 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.

MMRF represents each region in bottom-up form, giving region-specific commodity prices, factor returns and factor usage. Employing a bottom-up regional model allows us to capture region-specific structural changes, and thus we can 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 in telecommunications is important as Section 2.2 shows that structural change was not uniform across the Australian regions.

3.2.1 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

$$A\boldsymbol{v} = \mathbf{0}, \qquad (1)$$

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 $m \times 1$ null vector. Of the p variables, e are exogenous (e.g., input-output coefficients). The e variables can be used to shock the model to simulate changes in the $(p-e)$ endogenous variables. Many of the functions underlying (1) are highly nonlinear. Writing the equation system like (1) allows us to avoid finding the explicit forms for the nonlinear functions and we can therefore write percentage changes in the $(p-e)$ variables as linear functions of the percentage changes in the e variables: this reduces the computational burden. Computing solutions to an economic model using (1) and assuming the coefficients of the A matrices are constant is the method pioneered by Johansen (1960). Although (1) is linear, accurate solutions are computed by allowing the coefficients of the A matrices to be nonconstant through a simulation. This is accomplished by using a multistep solution procedure.[5] Below we present the behavioural equations that are important for the analysis undertaken here.

3.2.2 Behavioural equations

Representative firms are assumed to treat the three factors of production (agricultural land, labour 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) q_{jr}^{F} using Leontief production technology:

$$q_{jr}^{F} = q_{jr} + a_{jr}^{A}; \tag{2}$$

where q_{jr} is (the percentage change in) the (j,r)-th industry's activity level, and a_{jr}^{A} is technical change augmenting the use of all production inputs. By applying Leontief production technology, we are assuming that firms' use of the primary factor composite is a fixed share of output, reflecting the idea that the value added share of output is invariant to changes in relative prices and reflects characteristics intrinsic to the production of each good.

At the second level, firms decide on their demand for the *i* (=3) factors of production, q_{ijr}^{F}. All industries face CES (constant elasticities of substitution) production functions:

$$q_{ijr}^{F} = q_{jr}^{F} + a_{ijr}^{F} - \sigma\left(p_{ijr}^{F} + a_{ijr}^{F} - p_{jr}^{F}\right); \tag{3}$$

where $\sigma(=0.5)$ is the elasticity of factor substitution, a_{ijr}^{F} is factor *i*-augmenting technical change, and p_{ijr}^{F} is the price of the *i*-th primary factor. p_{jr}^{F} is the price of primary factor composite, i.e., $\sum_{i=1}^{3} S_{ijr}^{F} * p_{ijr}^{F}$ where S_{ijr}^{F} represents factor shares in valued added. For *i* = *Capital*, (3) represents stocks of capital used by each industry made up of past investment net of depreciation. Equation (3) consists of a scale term $\left(q_{jr}^{F} + a_{ijr}^{F}\right)$ and a substitution term $\left(p_{ijr}^{F} + a_{ijr}^{F} - p_{jr}^{F}\right)$. Thus, with no change in relative prices, changes in output will lead to changes in factor demands. With output fixed, changes in relative prices will lead to changes in factor

[5] The model is implemented and solved using the multistep algorithms available in the GEMPACK economic modelling software (Harrison and Pearson, 1996).

demands; this effect will be larger the greater the value of σ. Any change in a_{ijr}^F will affect both the scale and substitution term in (3). All of these effects reflect standard optimising behaviour by the firm. The choice of $\sigma(=0.5)$ is taken from the MMRF model: this is true for all our parameter choices unless otherwise specified. These parameter choices have been extensively applied in applications of the MONASH, MMRF and TERM models.[6]

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

$$q_{mjr}^L = q_{ijr}^F - \tau\left(p_{mjr}^L - p_{jr}^L\right),\ i = \text{labour} \tag{4}$$

where $\tau(=0.35)$ is the CES between any pair of labour types, and p_{mjr}^L is the unit cost to the firm of the *m*-th labour type inclusive of payroll tax. p_{jr}^L is the average cost of labour to the firm, i.e., $\sum_{m=1}^{8} S_{mjr}^L * p_{mjr}^L$, where S_{mjr}^L represents occupational shares in the total wage bill. Like factor demands in (3), equation (4) consists of scale and substitution terms reflecting optimising behaviour.

The labour income data in the household accounts we employ specify labour income by occupation. To exploit the richness of this data, we modify MMRF to allow for an occupation-specific price of labour in each region. To implement occupation-specific wage rates, we add a supply function for the (m,r)-th labour type supplied by household *c* in region *r*, l_{mr}^c,

$$l_{mr}^c = \beta^c * v_{mr}^c, \tag{5}$$

whereby

$$v_{mr}^c = w_{mr} - p_r^c, \tag{6}$$

where w_{mr} is the average (over all industries) post-tax wage rate received by the (m,r)-th labour type, and p_r^c is the household-specific consumer price index (HCPI) in region *r* (see Section 3.3.1). So the household supply of each labour type is a positive function of the real wage, v_{mr}^c, and β^c, the household labour supply elasticity. β^c is set at 0.15 reflecting econometric evidence on labour supply in Australia (Kalb, 1997).

6 See, for example, Adams et al. (2000), Dixon and Rimmer (2002), Dixon et al. (2011), Dwyer et al. (2003), Horridge et al. (2005), Wittwer et al. (2005), and Ye (2008).

Given that the changes we are modelling vary by region, the treatment of regional wage adjustment is important to whether a regional change is reflected mainly in regional employment and unemployment or nationwide employment and unemployment. Studies of the Australian labour market show that regional unemployment rates exhibit a high degree of persistence (Kennedy and Borland, 2000). For example, regional unemployment rates take more than 10 to 15 years to return to steady state levels after a negative shock to employment growth (p. 795). To reflect these characteristics, we represent the initial labour market equilibrium as including unemployment in each region. Any new (post-shock) labour market equilibrium will also include unemployment. So changes in labour market equilibrium are determined by imposing a relation between the pre-income-tax real wage rate rw_{mr} and employment q^L_{mr} of the form,

$$rw_{mr} = \gamma * q^L_{mr}, \qquad (7)$$

whereby

$$rw_{mr} = w_{mr} - p_r. \qquad (8)$$

Equation (8) defines rw_{mr} as the pre-income-tax wage rate deflated by the regional consumer price index. γ represents the employment elasticity of the real wage (i.e., the responsiveness of the real wage to changes in employment), and $q^L_{mr} = \sum_{j=1}^{54} S^L_{mjr} * q^L_{mjr}$ (i.e., employment of occupation *m* across all industries). In any perturbation of the model, γ determines the degree to which increases (decreases) in the demand for the (m,r)-th labour type will be reflected as higher (lower) employment or a higher (lower) real wage. Put another way, γ determines how much unemployment will fall (rise) when the demand for labour rises (falls). Such region-specific effects on labour demand are likely to be important for how income distribution changes across regions.

We parameterise γ by making it depend on whether the real wage is rising or falling. For $rw_{mr} \geq 0$, γ is set at 2 based on casual empiricism of the Australian labour market whereby the real wage rate grows faster than employment. For $rw_{mr} < 0$, γ equals 0.5 making real wage rates stickier downwards than upwards, which is also consistent with features of the Australian labour market whereby there is effectively a minimum wage for jobs in most industries (i.e., the award system). Equations (5) and (7) together determine the endogenous unemployment rate for the (m,r)-th 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 nested production functions. At level 1, all firms decide on their use of the intermediate input composite q^{I}_{jr} using Leontief production technology;

$$q^{I}_{kjr} = q_{jr} + a^{A}_{jr}. \qquad (9)$$

Equation (9) determines firms' use of the intermediate input composite as a fixed share of output, reflecting the idea that the intermediate input share of output is invariant to changes in relative prices and reflects characteristics intrinsic to the production of each good.

At level 2, firms decide on their use of the *k* intermediate input composites from domestic regions and foreign sources using CES production technology. The CES at this level 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. As before, optimising behaviour at this level reflects a scale and substitution effects.

At level 3, firms decide on their use of individual intermediate inputs from the *s* (=8) domestic sources also using CES production technology. The values for the CES at this level 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. These values are an order of magnitude larger than those at level 2, reflecting the greater ease of substituting similar goods from domestic sources as opposed to substituting similar goods from domestic and imported sources.

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 condition determines the each industry's activity level $\left(q_{jr}\right)$. Output prices are then determined by a market-clearing condition for each commodity.

3.2.3 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 approximate 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 we are concerned with the reallocation of existing factors rather than growth effects, the national supply of capital is fixed. This assumption means that any excess demands for capital at initial prices (due to structural change) 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 CPI is the numeraire, thus nominal price changes are measured relative to this composite price.

Simulating structural change is also likely to affect government revenue. To neutralise the effect of changes in government revenue in the analysis, 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 additional tax revenue raised due to structural changes will be automatically returned to households through a reduction in their income tax rates, and through higher pre-tax wage rates due to lower payroll tax rates on firms.

We also assume that real government consumption expenditure is a fixed share of real household consumption expenditure. In turn, household consumption expenditure is a fixed share of household disposable income. Similarly, government investment expenditure is a fixed share of total (private and public) investment expenditure. Private investment expenditure moves in line with changes in each industry's capital stock.

3.3 The micro dimension

3.3.1 Theory

Regional households in MMRF determine the optimal composition of their consumption bundles via the application of a linear expenditure system (LES) subject to a household budget constraint. The LES divides total consumption of the *i*-th commodity composite into two components: a subsistence (or minimum) part and a luxury (or supernumerary) part. The (percentage-change in) household demand for the *i*-th commodity composite of the *r*-th regional household $\left(q_{ir}^{H}\right)$ is then

$$q_{ir}^{H} = \left[1 - \alpha_{ir}\right] * hou_{r} + \alpha_{ir} * [qlux_{r}^{H} - p_{ir}^{H}] + f_{ir}^{H}\ ; \qquad (10)$$

where hou_r is the (exogenous) number of households in region *r*, $qlux_r^H$ is total luxury expenditure of the *r*-th household, p_{ir}^H is the consumer price for the (i,r)-th good, and f_{ir}^H is an exogenous shift term. α_{ir} defines the share of supernumerary expenditure on good *i* in total expenditure on good *i*. Thus, demand for the (i,r)-th good is a positive function of $qlux_r^H$ and a negative function of p_{ir}^H. The sum of these two effects on household demand is controlled by α_{ir}, which is defined as $\alpha_{ir} = \alpha * \varepsilon_{ir}$, where α is the 'Frisch parameter'[7] and ε_{ir} is the expenditure elasticity for the (i,r)-th good.

To determine household demand by commodity at the household level, q_{icr}, we add an equation similar to (10):

$$q_{icr} = [1-\alpha_{icr}] * hou_r + \alpha_{icr} * [qlux_r^H - p_{ir}^H]; \qquad (11)$$

where α_{icr} is the share of supernumerary expenditure on good *i* in total expenditure on good *i* for the *c*-th household, and is defined as $\alpha_{icr} = \alpha * \varepsilon_{icr}$. The values of ε_{icr} deviate from ε_{ir} according to the deviations between the budget shares at the household and regional levels.[8]

To switch from household consumption determined at the aggregate level (equation (10)) to household expenditure determined at the individual household level (equation (11)), we set f_{ir}^H as endogenous and add the equation

$$q_{ir}^H = \sum_c S_{icr} * q_{icr}, \qquad (12)$$

where S_{icr} is the budget share for the *c*-th household. Thus, commodity demand at the aggregate level will be driven by commodity demand at the household level.

To evaluate household welfare, we consider two measures commonly used to compute the benefits that accrue from a price change: compensating variation (CV) and equivalent variation (EV). Both compute the amount of money that would bring the consumer back to their original utility level prior to a price change; CV values this amount at new prices whereas EV values it using original prices. Both CV and EV apply a 'money-utility' concept rather than utility itself. A modified version of the CV is based on redefining real income as constant purchasing power. Applying the modified CV concept to measure changes in real income means there is no need to make any specific assumptions about consumer preferences or utility functions.

---

[7] That is, minus the ratio of total expenditure to luxury expenditure.

[8] An alternative would be to assume that ε_{icr} is constant across households, e.g., Bourguignon and Savard (2008).

The computation of CV normally assumes unchanging household income and, therefore, emphasises only the role of each household's consumption patterns in determining the welfare impact of a price change. But in a general equilibrium framework household income is not constant, so we extend the modified CV to account for changing income. For a household, real income can then be defined as nominal factor earnings and transfers received from different sources deflated by the 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

$$cv_c = -(i_c - p_c), \tag{13}$$

where i_c and p_c are the percentage changes in income and the HCPI for *c*-th household. p_c is the average percentage change in the prices of the *n* goods consumed p_n weighted by expenditure shares, $p_c = \sum_n S_{cn} * p_n$.

Differences in the sources of income i_c for the *c*-th household can be expressed as

$$i_c = \sum_x S_{cx} * i_x, \tag{14}$$

where S_{cx} is the share of income source *x* in total household income, and i_x is the percentage change in the price of income source *x*. The elements of the set of income sources *x* (=33) applied here are listed in Table 2, rows 1-4.

Table 2. Mapping between MMRF income sources and household income sources

MMRF	Size	Household accounts	Size
1. Labour income sources	*m* (= 8)	Managers, Professionals, Para-Professionals, Tradespersons, Clerks, Salespersons, Plant/Machine Operators, Labourers	*m* (= 8)
2. Non-labour income sources	*s* (= 2)	Interest, Investment, Property Rent, Superannuation, Business, Workers' Compensation, Accident Compensation, Maintenance, Other Regular Sources, Private Scholarship, Government Scholarship, Overseas Pensions	*t* (= 12)
3. Unemployment benefits	*u* (= 1)	Unemployment Benefits	*u* (= 1)
4. Other government benefits	*g* (= 1)	Sickness Benefits, Family Allowance, Veteran's Pensions, Age Pensions, Widows' Pensions, Disability Pensions, Supplementary Parent Benefits, Wife's Pensions, Other Australian Government Benefits, AUSTUDY Support, Carer's Pensions, Other Overseas Government Benefits	*h* (= 12)
5. Income tax	*d* (= 1)	Direct tax	*d* (= 1)
Total	13	Total	34

The income side of our modified CV is the amount of money that would encourage households to supply the same amount of factors as prior to any price change. But the general equilibrium effects of industry changes will lead to changes in factor supply and employment, as well as factor returns. To account for such changes, we redefine i_c as

$$i_c = \sum_x S_{cx}\left(i_x + q_x\right), \qquad (15)$$

where q_x is the percentage change in the employment of income source *x*. Thus, our modified CV assesses the impact of a policy change on a given household or household group via the computation of the change in real income.

In computing real household income changes, price and quantity changes are mapped from less detailed MMRF variables to more detailed variables in the household accounts. Commodity prices are mapped as $p_{cnr} = \sum_{k=1}^{54} CM_{kn} * p_{kr}$, where a regional (*r*) subscript has been added and CM_{kn} is a (0,1)-integer matrix mapping from MMRF commodities to household expenditure data. The household-specific price index p_{cr} is then equal to $\sum_n S_{cnr} * p_{cnr}$ where S_{cnr} is the $\left(c,r\right)$-th household's budget share for the *n*-th good.

Table 2 lists the mapping from MMRF income sources to the income sources in the household accounts, including the indices and their sizes; we refer to these indices in the explanation of the mapping that follows. Wages for the *m* (=8) occupations are mapped as $i_{cmr} = w_{mr} + q_{mr}^L$. The *t* (=12) non-labour income sources are mapped as $i_{ctr} = \sum_{s=1}^{2} S_{sr}\left(p_{sr}^F + q_{sr}^F\right)$, where p_{sr}^F and q_{sr}^F are the rental rate and quantity of the $\left(s,r\right)$-th non-labour factor (i.e., capital and land), and S_{sr} is the *s*-th factor's share in non-labour income.

For income source *u* = unemployment benefits, $i_{cur} = p^H + e + n_r$, where p^H is the national consumer price index, e is the federal government's personal benefits receipts rate, and n_r is the number of unemployed in region *r*. For the *h* (=12) other government benefits, income is mapped as $i_{chr} = p^H + e + s_r$, where s_r is population in region *r*. Note that p^H is the numeraire, and e and s_r are assumed to be exogenous. Thus, the *u* (=1) + *h* (=12) government benefit payments will only be affected via changes in the number of unemployed. Household income from all income sources is then $i_{cr} = \sum_{x=1}^{33} S_{cxr} * i_{cxr}$, where S_{cgr} is the share of income source *x* in total income for the $\left(c,r\right)$-th household. Real household disposable income, y_{cr}, is then

$y_{cr} = SI_{cr} * i_{cr} - ST_{cr}\left(i_{cr} + r\right) - p_{cr}$, where r is the income tax rate, and SI_{cr} is the share of total income in disposable income and ST_{cr} is the share of income taxes in disposable income.

3.3.2 Data

The household accounts are based on unit-record household data from the 1993–94 Household Expenditure Survey (HES93) (ABS, 1994a). The survey contains detailed information on household consumption patterns and income sources of 8,389 sample households in existence around the beginning of the 1990s across the eight Australian states and territories; this gives a representation of household income and expenditure around the beginning of the reform period. The HES93 contains income data on the 33 sources listed in Table 2 and expenditure data on more than 700 goods and services.

In reporting distributional effects we group households according to regional income deciles. Given the focus here is the effect of structural change in telecommunications, Table 3 presents the national share of household expenditure allocated to telecommunications across income deciles. We notice that the share falls slightly as household income increases with the average share being 1.9%. Table 3 also presents the national distribution of household income across income sources for each decile. Note 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. The data patterns are as expected.

4. Results

4.1 Direct effects: microsimulation

Here we apply only the changes in the relative price of telecommunications (Table 1) to household expenditure. In doing so, we allow households to alter the composition of their expenditure as captured by the LES represented in equation (11), but we hold total household consumption fixed in nominal terms for each household. Table 4 reports the aggregate effects by income decile on real income and its components.

Table 3. Selected expenditure and income shares, national

Income decile	Share of telecommunications expenditure in total expenditure	Household income shares			Direct tax rate (%)
		Non-labour income[a]	Labour income	Government benefits	
Lowest	0.024	-0.091	0.327	0.764	3.0
Second	0.022	0.099	0.417	0.485	6.0
Third	0.025	0.142	0.338	0.520	6.4
Fourth	0.023	0.109	0.501	0.390	9.3
Fifth	0.020	0.181	0.633	0.186	14.0
Sixth	0.019	0.156	0.737	0.107	16.5
Seventh	0.019	0.158	0.771	0.071	18.5
Eighth	0.017	0.133	0.842	0.025	20.2
Ninth	0.017	0.126	0.863	0.012	22.5
Highest	0.016	0.195	0.802	0.003	29.1

Source: MMRF household accounts. [a] Non-labour income sources are defined in Table 2. They are based on taxable income; thus, they include losses from business and property income. Such losses dominate non-labour income for the lowest income decile as a whole.

Table 4. Direct effects on household real income and its components (percentage change)

Income decile	(1) Nominal income	(2) Price index	(3) Real income
Lowest	0.00	-0.52	0.52
Second	0.00	-0.48	0.48
Third	0.00	-0.53	0.53
Fourth	0.00	-0.50	0.50
Fifth	0.00	-0.44	0.44
Sixth	0.00	-0.42	0.42
Seventh	0.00	-0.40	0.40
Eighth	0.00	-0.36	0.37
Ninth	0.00	-0.35	0.36
Highest	0.00	-0.33	0.34

Source: Authors' simulation.

All income deciles experience a welfare gain and this is completely due to the fall in the price of the consumption basket as nominal income is assumed to remain unchanged by the price changes. The fall in the price of consumption is purely due to lower prices for telecommunications as the price of all other goods is held fixed for this simulation. The welfare gain averages around 0.4% for all households, but lower income deciles experience above average gains and higher income deciles experience lower income gains. This reflects the greater importance of telecommunications in the consumption basket for lower income deciles. Detailed results by region are presented in Table 5. We see that households in all regions are better off and by similar proportions: this reflects the largely uniform pattern of price reductions for telecommunications across the Australian regions. In contrast to the welfare effects across regions, the within-region effects are noticeably progressive; in some regions (VIC and ACT), the lowest income decile gains twice as much as the highest decile. Again, this reflects the greater importance of telecommunications in the consumption basket for lower income deciles. The progressivity of the income effects are reflected in the fall in the national and regional Gini coefficients.

Table 5. Direct effects on household real income and inequality (percentage change)

Income decile	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Aust
Lowest	0.53	0.57	0.53	0.47	0.47	0.34	0.50	0.62	0.52
Second	0.50	0.50	0.46	0.44	0.41	0.46	0.61	0.54	0.48
Third	0.53	0.54	0.50	0.61	0.52	0.58	0.54	0.54	0.53
Fourth	0.42	0.52	0.54	0.58	0.62	0.73	0.54	0.36	0.50
Fifth	0.46	0.42	0.41	0.40	0.44	0.58	0.61	0.38	0.44
Sixth	0.41	0.45	0.43	0.37	0.41	0.43	0.41	0.28	0.42
Seventh	0.41	0.42	0.38	0.37	0.41	0.34	0.46	0.36	0.40
Eighth	0.39	0.37	0.33	0.36	0.39	0.35	0.26	0.33	0.37
Ninth	0.35	0.34	0.34	0.41	0.40	0.35	0.47	0.33	0.36
Highest	0.33	0.28	0.44	0.34	0.31	0.32	0.49	0.31	0.34
All deciles	0.42	0.42	0.42	0.41	0.42	0.41	0.49	0.38	0.42
Gini coefficient	-0.04	-0.06	-0.02	-0.04	-0.04	-0.06	-0.02	-0.04	-0.04

Source: Authors' simulation.

4.2 General equilibrium effects

A CGE model captures both the direct and indirect effects of a given shock to the economy. The direct effects on household welfare are a pure function of the change in the cost of the consumption basket due to a change in price of telecommunications; the indirect effects are a function of changes in the prices of non-telecommunications services and factor returns. The major determinant of the indirect effects is the importance of telecommunications in the economy as a whole, in terms of its own output and its importance as an input to other industries. Our model data indicates that value-added for telecommunications comprises around 2% of national value-added. This varies from 1.5% in the TAS to 2.2% in Victoria (VIC). Of this output, around two-thirds are sold to other industries as an intermediate input. Thus, *a priori*, we would expect the indirect effects from structural change to be significant.

The macroeconomic effects are reported in Table 6. Most regions experience a significant increase in output ranging from 0.8% (QLD) to 1% (NSW, VIC and ACT); NT is an exception with an increase of 1.6%. National real GDP increases by about 1%. The changes in output are a function of productivity and factor usage. Productivity rises in all regions by around 0.35% due to structural change in the telecommunications industry. As productivity improves in the telecommunications sector, resources are released to other industries but more labour is released than capital due to the increase in the efficiency with which labour is used; this drives down the relative price of labour. Thus, although total factor usage increases in all regions the capital-labour ratio falls in most regions as labour is substituted for capital by the non-telecommunications industries. The exception is NT where the capital-labour ratio rises. This is because, unlike in other regions, the pattern of effects in NT favour the largest capital-using industries, i.e., mining industries. Although mining industries in all regions benefit from the fall in the price of telecommunications, the mining industries in NT employ around one-quarter of the capital stock compared to a national average of around 6%. So when the NT mining industries expand they draw enough capital from other regions to raise the capital-labour ratio for the NT economy as a whole. Below we explain in more detail the microeconomic origins of the macroeconomic effects.

Table 6. Macroeconomic effects of structural change in telecommunications (percentage change)

Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Aust
Employment	0.31	0.13	0.20	0.23	0.31	0.36	0.74	0.32	0.25
Capital	0.06	-0.16	-0.03	0.04	0.06	0.14	0.94	0.16	0.00
Productivity	0.33	0.39	0.30	0.32	0.29	0.27	0.39	0.35	0.34
Price of labour relative to capital	-0.97	-1.12	-1.16	-1.14	-1.09	-1.12	-0.86	-0.91	-1.06
Real wage rate	0.46	0.48	0.26	0.33	0.30	0.25	0.61	0.54	0.41
Real GDP	1.01	0.98	0.84	0.93	0.93	0.94	1.66	1.02	0.96

Source: MMRF simulation.

The effects on the telecommunications industries are reported in Table 7. The estimated changes in unit-output employment will determine the changes in labour productivity: these vary between 40% and 50%. Table 7 also reports the average productivity change for each industry; these changes are very similar to the changes in the supply price. The supply prices fall in all regions by similar proportions, i.e., between 15% (QLD) and 22% (NT). The reductions in the supply prices are determined by the changes in the relative price of telecommunication imposed on the model (see Table 1).

Table 7. Effects on telecommunications sector due to changes in unit-output employment and relative output prices (percentage change)

Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Labour productivity[a]	-40.8	-45.3	-51.2	-46.4	-49.6	-41.1	-43.0	-42.7
Average productivity[a]	-17.9	-17.4	-15.8	-18.7	-18.0	-17.1	-22.1	-18.3
Supply price	-18.9	-18.5	-16.9	-19.9	-19.1	-18.1	-23.1	-19.0

Source: MMRF simulation.

[a] This is the input requirement per unit of output; thus, a negative sign signifies an improvement.

The national changes in relative occupational incomes (Table 8) indicate those occupations most favoured by the industry changes. Most occupations experience significant increases in relative incomes; the exceptions are *Clerks*, *Plant and machine operators, drivers*, and *Labourers and related workers*, who experience a small decreases in relative incomes. This is because around three-quarters of all wage payments in the telecommunications industries are made to these three occupational groups. Thus, when significant labour shedding occurs in these industries, it is these three occupations that are most affected, and consequently the wage rates for these occupations must fall for these workers to be reemployed in other industries.

Table 8. Microeconomic effects of structural change in telecommunications (percentage change)

Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Aust
Labour income	1.06	0.57	0.68	0.70	0.89	1.11	2.18	1.12	0.85
Managers & administrators	1.69	1.00	1.27	1.29	1.48	1.64	2.43	1.22	1.40
Professionals	1.72	1.42	1.24	1.29	1.44	1.48	2.65	1.78	1.52
Para-professionals	1.52	1.16	1.18	1.17	1.37	1.56	2.38	1.29	1.33
Tradespersons	1.59	1.33	1.31	1.45	1.37	1.74	3.26	1.58	1.47
Clerks	0.24	-0.41	-0.41	-0.30	-0.01	-0.06	1.17	0.81	-0.06
Salespersons & personal service workers	1.89	1.53	1.43	1.52	1.53	1.65	3.79	2.64	1.69
Plant & machine operators; drivers	-0.42	-1.07	-0.56	-0.86	-0.18	0.35	0.02	-1.28	-0.61
Labourers & related workers	0.01	-0.70	-0.16	-0.19	0.03	0.53	1.11	-0.21	-0.19
Non-labour income	1.71	1.47	1.60	1.67	1.70	1.96	2.65	1.73	1.64
Unemployment benefits	-1.64	-0.62	-0.98	-1.05	-1.99	-1.63	-6.60	-3.26	-1.27
Direct tax rate									-0.76

Source: Authors' simulation.

The national pattern of relative changes in occupational incomes is generally repeated at the regional level but with different absolute changes across regions. In general, the relative movements in labour income across regions reflect the relative productivity changes across regions; greater relative productivity improvements lead to greater reductions in relative labour incomes and vice versa. Non-labour income also increases nationally relative to labour income: 1.64% viz. 0.85%. This reflects a redistribution of income from labour to capital due to the improvement in labour productivity. The relative changes in non-labour income across regions reflect the pattern of movements of capital across regions, e.g., it increases the most in NT due to the large increase in the use of capital in that region. Unemployment benefits fall in all regions as employment increases in all regions. We also observe a large fall in the direct tax rate (-0.76%) as the tax base expands due to the structural change in telecommunication industries. With a fixed budget deficit, the increase in tax revenue is returned to households in the form of a lower income rate. The tax base expands as the structural change increases the use of actual resources (labour) and effective resources (productivity).

The changes in individual household real income are presented by income deciles in Table 9. At the national level all income deciles gain; higher income deciles tend to gain more than lower income deciles. In aggregate, the gain is significant (1.32%). The income changes are strongly regressive as shown by the large rise in the national Gini coefficient (0.21%). The national pattern of regressive income effects is replicated in all regions. A decomposition of the change in real household income into nominal income and price changes (not presented) indicates that nationally the differences in real household income changes across deciles are a reflection of both price and income effects but their relative importance varies by income decile. For the first four deciles, price effects are at least as important as income effects; for higher income deciles, income effects dominate the real income effects. Further, the decomposition shows that, except for the first decile, the price and income effects are reinforcing as both move such that they reduce real income.

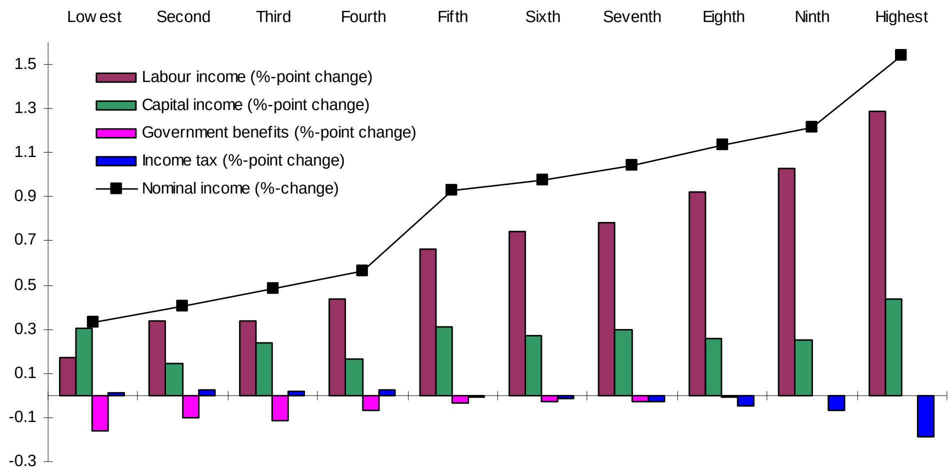
Table 9. Effects on household real income and inequality (percentage change)

Income decile	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Aust
Lowest	0.72	0.54	0.78	0.37	1.08	0.48	1.39	0.43	0.69
Second	0.80	0.60	0.84	0.60	0.76	0.69	1.54	0.74	0.74
Third	0.84	0.71	0.82	0.66	1.07	0.93	2.77	1.44	0.87
Fourth	0.84	0.97	0.90	0.76	1.11	0.90	1.59	1.17	0.93
Fifth	1.31	1.14	1.27	1.10	1.01	1.45	3.09	1.68	1.25
Sixth	1.37	1.05	1.23	1.16	1.36	1.54	2.44	1.63	1.28
Seventh	1.40	1.21	1.11	1.39	1.43	1.38	2.15	1.69	1.32
Eighth	1.55	1.11	1.18	1.44	1.58	1.43	2.61	1.76	1.38
Ninth	1.63	1.26	1.27	1.43	1.57	1.66	3.19	1.72	1.47
Highest	1.93	1.51	1.81	1.68	1.72	1.80	3.22	2.12	1.78
All deciles	1.42	1.15	1.24	1.26	1.39	1.40	2.53	1.64	1.32
Gini coefficient	0.25	0.17	0.19	0.24	0.18	0.22	0.28	0.22	0.21

Source: Authors' simulation.

Figure 1 decomposes the percentage change in nominal income into the contributions by its four components. It shows that, nationally, the main drivers of the nominal effects are the changes primary factor income. All deciles experience higher labour and capital income reflecting the fact that the regressive income effects are driven by labour income and not capital income. The increases in labour income are largest for higher income deciles due the large relative increases in labour income for *Managers and administrators*, *Professionals*, and *Para-professionals*, all of whom are heavily represented in the higher income deciles. Government benefits and direct taxes make only small contributions to the changes in nominal income.

Figure 1. Decomposition of national household income effects



Note: Nominal income is presented as a percentage change, whereas all other variables are percentage-point changes. The results for labour and capital income, government benefits and income tax sum to the percentage change in nominal income.

5. 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 the parameters. Table 10 reports the estimated means and standard deviations for real household income and inequality with respect to 50% symmetric, triangular variations in parameters. 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 10. Results of systematic sensitivity analysis: household real income and inequality (percentage change)

Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUST
					1. Mean				
All deciles	1.42	1.15	1.24	1.26	1.39	1.40	2.53	1.64	1.32
Gini coefficient	0.25	0.17	0.19	0.24	0.18	0.22	0.28	0.22	0.21
					2. Elasticity of substitution across occupations				
All deciles	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00
Gini coefficient	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
					3. Elasticity of primary factor substitution				
All deciles	0.05	0.05	0.05	0.05	0.05	0.04	0.06	0.04	0.05
Gini coefficient	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01
					4. Elasticity of import-domestic substitution				
All deciles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gini coefficient	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					5. Elasticity of intra-domestic substitution				
All deciles	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.00	0.00
Gini coefficient	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					6. Elasticity of export demand				
All deciles	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.00	0.00
Gini coefficient	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
					7. Elasticity of employment with respect to the real wage				
All deciles	0.04	0.01	0.03	0.03	0.03	0.04	0.12	0.03	0.03
Gini coefficient	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
					8. Elasticity of household expenditure				
All deciles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gini coefficient	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					9. Elasticity of labour supply				
All deciles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gini coefficient	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors' calculations.

The two rows labelled "Mean" in Table 10 are the calculated means across the different solutions of the model. As expected they are the same as for the original simulation as reported in Table 9. The other sets of results in Table 10 report the values of the standard deviations as each group of parameters is varied by 50%. The results indicate that our estimates of household real income effects are remarkably robust with respect to variations in nearly all model parameters because the estimated standard deviations are much smaller than the simulation results. The results also show our estimates of inequality are insensitive 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 structural change in telecommunications.

6. Discussion and concluding remarks

We analyse the distributional impact of structural change in Australian telecommunications during the 1990s, as captured by unit-output employment and relative prices. The structural change occurred during a period of regulatory reform and rapid change in telecommunications products and technologies. To assess the distributional impact of the structural change we apply a top-down/bottom-up macro-micro approach: we incorporate detailed household income and expenditure accounts within a multi-region CGE model of Australian regions, whereby feedback effects between the two models is two-way. Our study is motivated by the desire to assess the distributional impact of the structural change, especially due to the seemingly strong direct links (via direct purchases by households) and indirect links (via inter-industry usage) between telecommunications and income distribution.

Our results indicate that structural change in telecommunications over the 1990s had a significant effect on household real income but only a small effect on income distribution. Overall, household real income rose by 1.32%. This reflects the even distribution of the effects across regions; the only exception being the NT where real household income is estimated to have grown by 2.53%. We also estimate the direct effects of the structural change (i.e., purely from the change in prices paid by households) and find that these make up about one-quarter of the overall (total) effect on household income. For all regions, income inequality, as measured by the Gini coefficient, rises; nationally, inequality is estimated to have increased slightly with a 0.21% increase in the coefficient. Sensitivity analysis via systematic variation of model parameters indicates that our results are robust with respect to all model parameters.

Structural change in telecommunication is estimated to have significantly improved labour productivity. The improvements in labour productivity release labour and capital from telecommunications industries that then move to other industries. These productive factors are reemployed by other industries mostly at higher wage and rental rates, that is, the overall demand for labour rises due to the improvement in telecommunications labour productivity. Thus, the overall employment of labour rises because cheaper telecommunications reduce production costs for most industries as most industries are users of telecommunications, and thus most industries expand production in response. Thus, we find strong positive indirect effects from the reforms. Our finding of strong positive indirect effects from structural change in telecommunications is consistent with the work of Boccanfuso et al. (2009a, b), Chisari et al. (1999) and Verikios and Zhang (2013). Taken together, our work and that of Boccanfuso et al. (2009a, b), Chisari et al.

(1999) and Verikios and Zhang (2013) suggests that structural change in an industry with strong interindustry links (e.g., electricity and telecommunications) will lead to indirect effects that are likely to be large. We also find that the pattern of generally higher wage rates favourably affects higher income deciles more than lower income deciles, leading to progressive nominal income effects.

Our work makes two contributions to the macro-micro literature. One, we include micro feedback effects in our analytical framework, whereas few studies include such effects. Of the handful of studies analysing the distributional effect of structural change in infrastructure industries using a macro-micro approach (i.e., Boccanfuso et al., 2009a, b; Chisari et al. 1999; Verikios and Zhang, 2013), none include a micro-feedback effect at the household level. Thus, our work represents an advance on studies that analyse the distributional effects of structural change in infrastructure industries using a macro-micro approach. Another contribution of our work is that we estimate the distributional effects from significant structural change in a previously state-owned monopoly; for the case of telecommunications in Australia we find that the structural change can generate large positive effects on household income and little effect on income distribution: this is an important research finding. This finding supports the work of Chisari et al. (1999) who estimate similarly large positive effects on household income and little effect on income distribution from reform and privatisation of telecommunications in Argentina. A possibly more important finding is that in this case workers displaced from the telecommunications industry bear little burden through either lower real wages or higher unemployment; this finding also supports the work of Chisari et al. (1999).

References

Adams, P.D., Horridge, J.M. and Parmenter, B.R. (2000), *MMRF-GREEN: A Dynamic, Multi-Sectoral, Multi-Regional Model of Australia*, Centre of Policy Studies/IMPACT Centre, Working Paper OP-94, Monash University, October.

Andersen, L.E. and Faris, R. (2002), *Natural Gas and Income Distribution in Bolivia*, Andean Competitiveness Project Working Paper, Instituto de Investigaciones Socio-Económicas, Catholic University of Bolivia, La Paz, and Center for International Development, Harvard University, February.

ABS (Australian Bureau of Statistics) (1990, 1991, 1992, 1993), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (1994a), *1993-94 Household Expenditure Survey, Australia: Unit Record File*, Cat. No. 6535.0, ABS, Canberra.

—— (1994b), *Australian National Accounts, Input-Output Tables, Commodity Details, 1989-90*, Cat no. 5215.0, ABS, Canberra.

—— (1994c), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (1995, 1996), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (1997a), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (1997b), *Information Technology, Australia, 1995-96*, Cat no. 8126.0, ABS, Canberra

—— (1998a), *Australian National Accounts, State Accounts, 1996-97*, Cat. no. 5220.0, ABS, Canberra.

—— (1998b), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (1999), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (2000a), *Australian National Accounts, State Accounts, 1998-99*, Cat. no. 5220.0, ABS, Canberra.

—— (2000b), *Labour Force, Australia*, Cat. no. 6203.0, ABS, Canberra.

—— (2001a), *Australian National Accounts, Input-Output Tables, 1996-97*, Cat. no. 5209.0, ABS, Canberra.

—— (2001b), *Australian National Accounts, State Accounts, 1999-00*, Cat. no. 5220.0, ABS, Canberra.

—— (2001c), *Consumer Price Index, Australia*, Cat. no. 6401.0, ABS, Canberra, April.

—— (2006), *ICT Satellite Account, ASNA Experimental Estimates, 2002-03*, Cat. No. 5259.0, ABS, Canberra.

Benitez, D., Chisari, O. and Estache, A. (2003), 'Can the gains from Argentina's utilities reform offset credit shocks?', in Ugaz, C. and Price, C.W. (eds), *Utility Privatization and Regulation: A Fair Deal for Consumers?*, Edward Elgar, Northampton, MA, pp. 175–202.

Boccanfuso, D., Estache, A. and Savard, L. (2009a), 'A macro–micro analysis of the effects of electricity reform in Senegal on poverty and distribution', *Journal of Development Studies*, vol. 45, no. 3, pp. 351–68.

—— (2009b), 'Electricity reforms in Mali: a macro–micro analysis of the effects on poverty and distribution', *South African Journal of Economics*, vol. 77, no. 1, pp. 127–47.

Bortolotti, B., D'Souza, J.D., Fantini, M. and Megginson, W.L. (2002), 'Privatization and the sources of performance improvement in the global telecommunications industry', *Telecommunications Policy*, vol. 26, pp. 243–68.

Bourguignon, F. and Savard, L. (2008) "Distributional effects of trade reform: an integrated macro-micro model applied to the Philippines" in Bourguignon, F., Pereira Da Silva, L.A. and Bussolo, M. (eds.), *The Impact of Macroeconomic Policies on Poverty and Income Distribution: Macro-Micro Evaluation Techniques and Tools*, Palgrave-Macmillan Publishers Limited, Houndmills, Angleterre, pp. 177–211.

—— and Spadaro, A. (2006), 'Microsimulation as a tool for evaluating redistribution policies', *Journal of Economic Inequality*, vol. 4, no. 1, pp. 77–106.

Chen, S. and Ravallion, M. (2004), ‘Welfare impacts of China’s accession to the World Trade Organization’, *The World Bank Economic Review*, vol. 18, no. 1, pp. 29–57.

Chisari, O., Estache, A. and Romero, C. (1999), ‘Winners and losers from the privatization and regulation of utilities: lessons from a general equilibrium model of Argentina’, *The World Bank Economic Review*, vol. 13, no. 2, pp. 357–78.

——, Maquieyra, J. and —— (2009), ‘Liberalization of trade in services: A CGE analysis for Argentina, Brazil and Uruguay’, *Munich Personal RePEc Archive Paper No. 15336*, May.

Cockburn, J., Corong, E. and Cororaton, C.B. (2008), ‘Poverty effects of the Philippines’ tariff reduction program: insights from a computable general equilibrium framework’, *Asian Economic Journal*, vol. 22, issue 3, pp. 289–319.

Cogneau, D. and Robilliard, A-S. (2000), *Growth, Distribution and Poverty in Madagascar: Learning From a Microsimulation Model in a General Equilibrium Framework*, TMD Discussion Paper 61, International Food Policy Research Institute, Washington DC.

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

Davies, J. (2004), ‘Microsimulation, CGE and macro modelling for transition and developing economics’, Paper prepared for the United Nations University / World Institute for Development Economics Research (UNU/WIDER), Helsinki.

Dixon, P.B. and Rimmer, M.T. (2002), *Dynamic General Equilibrium Modelling for Forecasting and Policy: A Practical Guide and Documentation of MONASH*, Contributions to Economic Analysis 256, North-Holland Publishing, Amsterdam.

——, —— and Wittwer, G. (2011), ‘Saving the Southern Murray-Darling Basin: the economic effects of a buyback of irrigation water’, *Economic Record*, vol. 87, no. 276, pp. 153–68.

Dwyer, L., Forsyth, P., Spurr, R. and Vanho, T. (2003), ‘Tourism's contribution to a state economy: a multi-regional general equilibrium analysis’, *Tourism Economics*, vol. 9, no. 4, pp. 431–48.

Giesecke, J. (2006), ‘The national and regional consequences of rapid growth in Australia’s telecommunications sector’, *Economic Analysis and Policy*, vol. 36, no. 1-2, pp. 61–97.

Harrison, W.J. and Pearson, K.R. (1996), ‘Computing solutions for large general equilibrium models using GEMPACK’, *Computational Economics*, vol. 9, no. 2, pp. 83–127.

Hertel, T.W. and Reimer, J.J. (2005), ‘Predicting poverty impacts of trade reform’, *Journal of International Trade and Economic Development*, vo. 14, no. 4, pp. 377–405.

Horridge, M., Madden, J. and Wittwer, G. (2005), ‘The impact of the 2002-2003 drought on Australia’, *Journal of Policy Modeling*, vol. 27, no. 3, pp. 285–308.

Johansen, L. (1960), *A Multisectoral Study of Economic Growth*, North-Holland, Amsterdam.

Kalb, G. (1997), *An Australian Model for Labour Supply and Welfare Participation in Two-Adult Households*, PhD thesis, Monash University, October.

Kennedy, S and Borland, J. (2000), ‘A wage curve for Australia?’, *Oxford Economic Papers*, vol. 52, pp. 774–803.

Konan, D.E. and Maskus, K.E. (2006), ‘Quantifying the impact of services liberalization in a developing country’, *Journal of Development Economics*, vol. 81, pp. 142–62.

Löfgren, H., Doukkali, R., Serghini, H. and Robinson, S. (1997), *Rural Development in Morocco: Alternative Scenarios to the Year 2000*, TMD Discussion Paper 17, International Food Policy Research Institute, Washington DC.

Naqvi, F. and Peter, M.W. (1996), ‘A multiregional, multisectoral model of the Australian economy with an illustrative application’, *Australian Economic Papers*, vol. 35, issue 66, pp. 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.

PC (Productivity Commission) (2001), *Telecommunications Competition Regulation*, Draft report, Canberra, March.

—— (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’, *The Australian Economic Review*, vol. 30, no. 3, pp. 256–72.

Savard, L. (2010), ‘Scaling up infrastructure spending in the Philippines: a CGE top-down bottom up microsimulation approach’, *International Journal of Microsimulation*, vol. 3, no. 1, pp. 43–59.

SCNPMGTE (Steering Committee on National Performance Monitoring of Government Trading Enterprises) (1995), *Government Trading Enterprises Performance Indicators: 1989-90 to 1993-94, Volume 2*, SCNPMGTE.

Verikios, G. and Zhang, X-G. (2003), ‘The economic effects of removing barriers to trade in telecommunications’, *The World Economy*, vol. 27, no. 3, pp. 435–58.

—— (2005), *Modelling Changes in Infrastructure Industries and Their Effects on Income Distribution*, Research Memorandum MM-44, Productivity Commission, September.

—— (2013), ‘Structural change in the Australian electricity industry during the 1990s and the effect on household income distribution: a macro-micro approach.’, *Economic Modelling*, vol. 32, pp. 564–75.

Wittwer, G., McKirdy, S. and Wilson, R. (2005), ‘Regional economic impacts of a plant disease incursion using a general equilibrium approach’, *Australian Journal of Agricultural and Resource Economics*, vol. 49, no. 1, pp. 75–89.

Ye, Q. (2008), ‘Commodity booms and their impacts on the Western Australian economy: the iron ore case’, *Resources Policy*, vol. 33, no. 2, pp. 83–101.