Structural change and income distribution: the case of Australian telecommunications

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ABSTRACT
The Australian telecommunications sector experienced substantial structural change during the 1990s, a 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.

KEYWORDS
Computable general equilibrium; income distribution; microeconomic reform; microsimulation; telecommunications

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1. Introduction

Starting in the 1980s, governments in middle- and high-income countries began to focus on improving the efficiency of the telecommunications sector. Except for the United States, telecommunications was traditionally made up of a single, government-owned monopoly supplier. The focus on improving efficiency had two aspects: regulatory reform and privatisation. Not unexpectedly for an economically significant and politically sensitive sector, there was much opposition to such reforms. Critics of the reforms argued that their effects would be regressive across income groups (Bortolotti et al., 2002). Although the effect across income groups is an empirical issue, to our knowledge, there is only one study that analyses the distributional effects of reforming telecommunications using a framework that can capture the indirect effects of such an economically significant industry. Chisari, Estache, and Romero (1999) applied an economy-wide model to estimate the distributional effects of reforming telecommunications in Argentina. In this work, we add to this literature by analysing the distributional effects of structural change in the Australian telecommunications sector.

As in other high-income countries, telecommunications is a significant economic activity in Australia: in 2002–2003, it comprised 2.2% of total value-added for Australia.
Reflecting the importance of telecommunications as a business input. In terms of household expenditure, telecommunications has grown significantly in importance since the 1990s: from around 1.9% in the early 1990s (ABS 1994) to 3.3% in 2009/2010 (ABS 2011). 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 (Productivity Commission 2002). Coincident with the reform process, there was a 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 a major structural change in the telecommunications industry.

Infrastructure industries, such as telecommunications, are generally major service providers; so, reform 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. 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 used by all industries to some extent, but the strength of these links 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 economy-wide 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, Chisari, and Estache 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, Estache, and Romero (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 are determined at the household level and are 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, Savard, 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, Estache, and Savard 2009a, 2009b; Chisari, Estache, and Romero 1999; Verikios and Zhang 2013).

2. Changes in telecommunications during the 1990s

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 2002–2003, 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, the Australian government 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. 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;
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, Estache, and Romero (1999), we use these variables to make two calculations reflecting structural change. 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: (1) a near tripling of average output (176%); and (2) 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. The large improvements in labour productivity for telecommunications indicated by our estimates are 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 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 reflect a broad pattern of small annual reductions in the price of telecommunications ($-3\%$ on

| 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: See Verikios and Zhang (2005), Chapter 4.
average) compared with CPI growth of around 24% over the 1990s. The general pattern of relative price reductions is consistent with the large improvements in labour productivity and is likely to have been driven by the same structural changes 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, so that changes in unit-output employment will be attributed to labour-augmenting technical change. 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. Analytical framework

3.1. Overview

The linking of 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. Davies (2004) describes the 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 explicitly includes both the micro and macro dimensions (e.g., Cockburn, Corong, and Cororaton 2008; Cogneau and Robilliard 2000). 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.

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., Bourguignon and Savard 2008). Our approach follows Bourguignon and Savard (2008), 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. 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 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. There are nine government sectors (eight regional and one national). Foreigners supply imports to each region at fixed c.i.f. (cost, insurance and freight) prices, and demand commodities (exports) from each region at variable f.o.b. (free on board) 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. Theory

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

\[ Av = 0, \]

where \( A \) is an \( m \times p \) matrix of coefficients, \( v \) is a \( p \times 1 \) vector of percentage changes in model variables and \( 0 \) 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. 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. Below we present the behavioural equations that are important for the analysis undertaken here.

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 \( j = 1, \ldots, 54 \) firms in the \( r = 1, \ldots, 8 \) 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:

\[ q_{jr}^F = q_{jr} + a_{jr}^A, \]

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, $q^F_{ijr}$. All industries face CES (constant elasticity of substitution) production functions:

$$q^F_{ijr} = q^*_{ijr} + a^F_{ijr} - \sigma(p^F_{ijr} + a^F_{ijr} - p^*_{ijr});$$  \hspace{1cm} (3)

where $\sigma(=0.5)$ is the elasticity of factor substitution, $a^F_{ijr}$ is factor $i$-augmenting technical change, and $p^F_{ijr}$ is the price of the $i$-th primary factor. $p^*_{ijr}$ is the price of primary factor composite, i.e., $\sum_{i=1}^{3} S^F_{ijr} \cdot p^F_{ijr}$, where $S^F_{ijr}$ represents the factor shares in valued-added. For $i = \text{capital}$, (3) represents the stocks of capital used by each industry made up of past investment net of depreciation. Equation (3) consists of a scale term ($q^*_{ijr} + a^F_{ijr}$) and a substitution term ($p^F_{ijr} + a^F_{ijr} - p^*_{ijr}$). 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 demands; this effect will be larger the greater the value of $\sigma$. Any change in $a^F_{ijr}$ 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.\(^5\)

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

$$q^L_{mjr} = q^*_{mjr} - \tau(p^L_{mjr} - p^L_{jr}), \hspace{1cm} i = \text{labour}$$  \hspace{1cm} (4)

where $\tau(=0.35)$ is the CES between any pair of labour types, and $p^L_{mjr}$ is the unit cost to the firm of the $m$-th labour type inclusive of payroll tax. $p^L_{jr}$ is the average cost of labour to the firm, i.e., $\sum_{m=1}^{8} S^L_{mjr} \cdot p^L_{mjr}$, where $S^L_{mjr}$ represents the 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 specify labour income by occupation. To exploit the richness of these data, we modify the model for an occupation-specific price of labour in each region. Thus, we add a supply function for the $(m,r)$-th labour type supplied by household $c$ in region $r, l^c_{mr}$,

$$l^c_{mr} = \beta^c v^c_{mr};$$  \hspace{1cm} (5)

whereby

$$v^c_{mr} = w_{mr} - p^c_r,$$  \hspace{1cm} (6)

where $w_{mr}$ is the average (over all industries) post-tax wage rate received by the $(m,r)$-th labour type, and $p^c_r$ 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, $v_{mr}$, and $\beta^e$, the household labour supply elasticity. $\beta^e$ is set at 0.15 reflecting the econometric evidence on labour supply in Australia (Kalb 1997).

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 in 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—15 years to return to steady-state levels after a negative shock to employment growth (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 $r_{wmr}$ and employment $q_{lmr}$ of the form,

$$r_{wmr} = \gamma^e q_{lmr},$$  \hfill (7)

whereby

$$r_{wmr} = w_{mr} - p_r.$$  \hfill (8)

Equation (8) defines $r_{wmr}$ as the pre-income-tax wage rate deflated by the regional consumer price index. $\gamma$ represents the employment elasticity of the real wage (i.e., the responsiveness of the real wage to changes in employment), and $q_{lmr} = \sum_{j=1}^{54} e_{mjr} * q_{mjr}$ (i.e., employment of occupation $m$ across all industries). In any perturbation of the model, $\gamma$ 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, $\gamma$ 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 $\gamma$ by making it depend on whether the real wage is rising or falling. For $r_{wmr} \geq 0$, $\gamma$ is set at 2 based on casual empiricism of the Australian labour market, whereby the real wage rate grows faster than employment. For $r_{wmr} < 0$, $\gamma$ 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 $k = 1, \ldots, 54$ 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 $q_{jr}$ using Leontief production technology;

$$q_{kjr} = q_{jr} + a_{jr}.$$  \hfill (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 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 \( q_{jr} \). Output prices are then determined by a market-clearing condition for each commodity.

### 3.2.2. 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. 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 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 the rate of return. The national CPI is the numeraire.

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 as a result of 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. Without this assumption, additional tax revenue raised as a result of structural changes will be retained by the government as an improvement in their budget balance or a reduction of government debt; this would have an unfavourable effect on household income.

### 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 \( q^H_{ir} \) is then

\[
q^H_{ir} = [1 - \alpha_{ir}] \cdot hou_r + \alpha_{ir} \cdot [qlux^H_{ir} - p^H_{ir}] + f_{ir}^H;
\] (10)

where \( hou_r \) is the (exogenous) number of households in region \( r \), \( qlux^H_{ir} \) is the total luxury expenditure of the \( r \)-th household, \( p^H_{ir} \) is the consumer price for the \((i, r)\)-th good, and \( f_{ir}^H \) is an exogenous shift term. \( \alpha_{ir} \) 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 \( qlux^H_{ir} \) and a negative function of \( p^H_{ir} \). The sum of these two effects on household demand is controlled by \( \alpha_{ir} \), which is defined as \( \alpha_{ir} = \alpha \cdot \varepsilon_{ir} \), where \( \alpha \) is the ‘Frisch parameter’ and \( \varepsilon_{ir} \) 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):

\[
q_{icr} = [1 - \alpha_{icr}] \cdot hou_r + \alpha_{icr} \cdot [qlux^H_{icr} - p^H_{icr}];
\] (11)

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

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

\[
q^H_{ir} = \sum_c S_{icr}^* \cdot q_{icr};
\] (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.

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

$$cv_c = -(i_c - p_c),$$

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

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

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).

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

$$i_c = \sum_x S_{cx}(i_x + q_x),$$

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 $p_{cnr} = \sum_k^{54} CM_{kn} * p_{kr}$, where a regional ($r$) subscript has been added and $CM_{kr}$ 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 $(c, r)$-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 $i_{cr} = \sum_{s=1}^{2} S_{sr} (p_{sr}^F + q_{sr}^F)$, where $p_{sr}^F$ and $q_{sr}^F$ are the rental rate and quantity of the $(s,r)$-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, $i_{cur} = p_{r}^H + e + n_r$, where $p_{r}^H$ 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 $i_{chr} = p_{r}^H + e + s_r$, where $s_r$ is the population in region $r$. Note that $p_{r}^H$ 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 $\sum_{x=1}^{33} i_{cxr} = 1 S_{cxr} * i_{cxr}$, where $S_{cxr}$ is the share of income source $x$ in total income for the $(c,r)$-th household. Real household disposable income, $y_{cr}$, is then $y_{cr} = S_{cr} * i_{cr} - ST_{cr} (i_{cr} + r) - p_{cr}$, where $r$ is the income tax rate, and $S_{cr}$ 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—1994 Household Expenditure Survey (HES93) (ABS 1994). The survey contains detailed information on household consumption patterns and income sources of 8389 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. As the focus here is the effect of structural change in telecommunications, Table 3 presents the national share of household expenditure allocated to telecommunications.

### Table 3. Selected expenditure and income shares, national.

| Income decile | Share of telecommunications expenditure in total expenditure | Non-labour incomea | Labour income | Government benefits | Direct tax rate (%) |
|---------------|----------------------------------------------------------|--------------------|---------------|---------------------|-------------------|
| 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.

aNon-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.
across income deciles. We notice that the share falls slightly as household income increases, with the average share being 1.9%. Compared to other infrastructure services, the telecommunications share of household expenditure is rather high: e.g., electricity (2%), gas (0.006%), urban transport (0.08%) and water and sewerage (1%). 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, 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.

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 Victoria (VIC) and the Australian Capital Territory (ACT), the lowest income decile gains around twice as much as the highest decile. Again, this reflects the greater importance of telecommunications in the consumption basket for lower income

| 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.
deciles. The progressivity of the income effects is reflected in the fall in the national and regional Gini coefficients.

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 computed in the previous section; 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 indicate that value-added for telecommunications comprises around 2% of national value-added. This varies from 1.5% in TAS to 2.2% in 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% in New South Wales (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% because of structural changes in the telecommunications industry. As productivity improves in the telecommunications sector, resources are released to other industries but more labour is released than capital as a result of the increase in the efficiency with which labour is used; this drives down the

| 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| 0.41| 0.41| 0.46| 0.61| 0.61| 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| 0.28| 0.34| 0.34| 0.31| 0.32| 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.

| 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.
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.

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 average productivity change is a share-weighted average of the change in labour productivity and the change in non-labour productivity. 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 telecommunications imposed on the model (see Table 1).

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 small decreases in relative

Table 7. Effects on telecommunications sector as a result of changes in unit-output employment and relative output prices (percentage change).

| Variable                | NSW | VIC | QLD | SA  | WA  | TAS | NT  | ACT |
|-------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Labour productivity     | -40.8 | -45.3 | -51.2 | -46.4 | -49.6 | -41.1 | -43.0 | -42.7 |
| Average productivity    | -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.

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

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.
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.

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% vs. 0.85%. This reflects a redistribution of income from labour to capital due to the improvement in labour productivity. The relative change in non-labour income across regions reflects 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 because of structural changes in the telecommunications sector.

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 regressive as shown by the 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 changes 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. Furthermore, 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.

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

| 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| 0.24| 0.22| 0.28| 0.22| 0.21 |

Source: Authors’ simulation.
are the changes in primary factor income. All deciles experience higher labour and capital income, but the regressive income effects are driven by much larger increases in labour income compared to capital income. The increases in labour income are largest for higher income deciles because of 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.

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 (DeVuyyst 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.

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 that 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 changes 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 macro and micro 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 changes 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 is a significant improvement in

| Variable | NSW | VIC | QLD | SA | WA | TAS | NT | ACT | AUST |
|----------|-----|-----|-----|----|----|-----|----|-----|------|
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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.
household welfare relative to similar policy reforms during this period (e.g., Verikios and Zhang 2013). 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 the price of telecommunications paid by households) and find that these make up about three-tenths 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.

The structural change in telecommunications 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, Estache, and Savard (2009a, 2009b), Chisari, Estache, and Romero (1999) and Verikios and Zhang (2013). Taken together, our work and that of Boccanfuso, Estache, and Savard (2009a, 2009b), Chisari, Estache, and Romero (1999) and Verikios and Zhang (2013) suggest that structural changes in an industry with strong inter-industry 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 three contributions to the macro–micro literature. First, we compare the income and distributional results of structural change in an important infrastructure industry; we find that compared to a top-down/bottom-up macro–micro approach, a pure microsimulation approach underestimates the welfare gains to households (0.42% vs. 1.32%) and the effects on the Gini coefficient (−0.04% vs. 0.21%). For an industry with important inter-industry links, a macro–micro approach is strongly preferred over a pure microsimulation approach. Second, our work includes micro-feedback effects in the 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, Estache, and Savard 2009a, 2009b; Chisari, Estache, and Romero 1999; Verikios and Zhang 2013), none includes 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. Third, we estimate the distributional effects from significant structural changes in a previously state-owned monopoly; in 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, Estache, and Romero (1999) who estimated 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, Estache, and Romero (1999).

Notes

1. Section 2.1 draws on PC (2002).
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 to ensure that we do not overestimate the effects on the wider economy of changes in telecommunications unit-output employment.
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.
4. The model is implemented and solved using the multistep algorithms available in the GEMPACK economic modelling software (Harrison and Pearson 1996).
5. See, for example, Adams et al. (2000), Dixon and Rimmer (2002), Dixon, Rimmer, and Wittwer (2011), Dwyer et al. (2003), Horridge, Madden, and Wittwer (2005), Wittwer et al. (2005), and Ye (2008).
6. That is, minus the ratio of total expenditure to luxury expenditure.
7. An alternative would be to assume that $\varepsilon_{i,cr}$ is constant across households (e.g., Bourguignon and Savard 2008).

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Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

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