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Mining activity, income inequality and gender in regional Australia*

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Mining activity has been a significant driver of export growth as well as income and employment in parts of regional Australia. However, while income growth is an economic benefit, the high incomes associated with the mining sector may also lead to greater inequality. This paper describes an empirical analysis of mining activity and income inequality in regional Australia. The Gini coefficient (a measure of inequality) for personal income is found to be significantly associated with levels of mining employment. However, this relationship is not linear. Rather, income inequality initially increases with mining activity, before decreasing at medium to high levels of mining employment, following a Kuznets curve pattern. Segregating data for men and women reveals very different patterns. Among men, inequality initially increases as mining employment in a region increases, but then sharply decreases; at high levels of mining activity, income inequality among men is lower than is typically observed in non-mining areas. Among women, income inequality increases with mining activity throughout its range. This suggests that income inequality is most likely to be a problem in locales with intermediate levels of mining activity and that it affects men and women quite differently.

Key words: equity, Gini coefficient, Kuznets curve, regional development, resource curse.

1. Introduction

Mining plays a substantial role in the Australian economy, in which the export of large volumes of primary materials is a defining characteristic (McKay *et al*. 2000; Schandl *et al*. 2008). Australia is one of the largest exporters of black coal, alumina, lead, iron ore, uranium and zinc (ABARES 2010; Mudd 2010). Mining exports have grown from around a third to around a half of all Australian exports (by value) over recent decades (Figure 1). While the contribution to the national economy is evident, the impact of mining on the socio-economic well-being of Australians may not be universally positive. Direct employment in the mining sector is relatively low (< 2 per cent), although it has grown strongly in recent years (Figure 1). Policy analysts have questioned the benefits of mining to the

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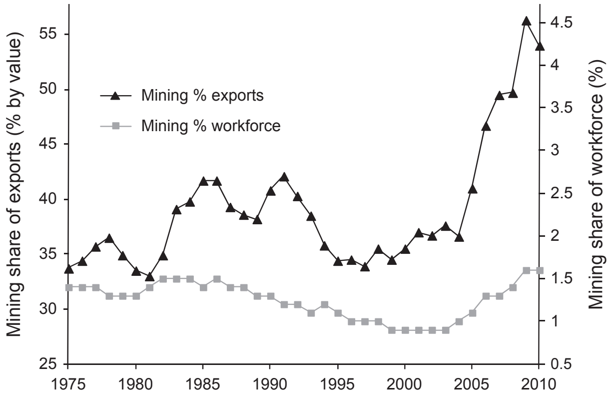

Figure 1 Mining's contribution to exports and employment in Australia (1974–2010). Source: ABARES 2010.

Australian population beyond shareholders of mining companies (Richardson 2009). These questions echo similar concerns at the global scale concerned with the distribution of costs and benefits associated with mining (MMSD 2002). In particular, the contribution of mining to socio-economic well-being within regional economies is not well understood because of limited research in this area (Solomon *et al.* 2008; Rolfe *et al.* 2010). Social impact studies have identified concerns over benefits to local communities through lower than expected business, income disparity amongst residents and the loss of labour from non-mining employers (Lockie *et al.* 2009).

These examples suggest a regional scale analogue of 'Dutch disease', which occurs when existing sectors of a national economy decline while resource extraction grows (as happened in Holland following the discovery of oil in the 1960s). The trade exposed sector is hit twice, as the exchange rate reduces international competitiveness, while it is also likely to have to pay higher wages for workers (and other inputs) to compete with growing mining and non-tradable services sectors (Corden and Neary 1982). Within a country, mining activity tends to be distributed unevenly; this is certainly the case in Australia (Hajkowicz *et al.* 2011; Taylor *et al.* 2011). This means that some of the symptoms of Dutch disease may also be manifest at the regional scale. While the exchange rate does not vary within a country, regions with high levels of mining activity may experience wage and price inflation which could adversely affect some individuals and businesses not involved with the mining industry.

Therefore, while mining may be beneficial at the macroeconomic scale, the impacts on local communities are more complex. When a mine establishes in a regional town, it is likely that many of the jobs created will go to incomers rather than existing residents because specialist skills are often required. Similarly, much of the income may leave – workers often base their families elsewhere, staying around the mine site only between shifts, which means the local community bears many of the costs but gains few of the benefits of their employment at the mine (Rolfe *et al.* 2007). Other industries, notably agriculture, may find it harder to attract labour.

For some time, economic geographers have tested for patterns of relative advantage and disadvantage across regional Australia. Frequently, these differences have been described in terms of 'haves' and 'have-nots' (Stimson 2001). Outside of metropolitan Australia, mining regions have tended to be relatively advantaged compared with agricultural regions (Baum 2006). These advantages tend to include relatively strong employment and relatively higher average income across time (Stimson 2001; Baum *et al.* 2005; Taylor *et al.* 2011). While this holds strong for clear-cut cases (mining-dominated regions compared with agriculture-dominated regions), there remain questions over regions which experience a degree of mining in mixed economies. It should be noted that, while in the past many mines were supported by purpose-built 'company towns', this is no longer the favoured model in Australia, so existing regional towns must generally support mine workers (Rolfe *et al.* 2007). It should also be noted that different sectors are characterised by male- and female-dominated workforces (Stimson 2001), and this raises the question of how relative income advantage relates to gender.

Questions over equity in the mining sector focus on the distribution of benefits and costs (MMSD 2002). For example, a detailed study of six mining towns in Central Queensland identifies housing shortages and staff shortages as adverse impacts of mining growth for individuals and businesses in these towns (Petkova-Timmer *et al.* 2009). By contrast, Hajkowicz *et al.* (2011) examine the relationship between mining activity and well-being indicators across 71 local government areas across regional Australia, finding that the presence of mining has a positive effect on household incomes. They also consider quality of life indicators (housing affordability, communication) and find them to be positively correlated with mining activity. This study shows a positive correlation between mining activity and socio-economic well-being, although as the authors point out the scale of the analysis may not account for more localised impacts.

On this basis, this paper examines the relationship between income inequality and employment in the mining sector in regional Australia, drilling down to the finest feasible scale. In so doing, it builds on the earlier work of Maxwell *et al.* (1991), who used data from three Australian censuses (1976, 1981 and 1986) to compute degrees of income inequality for states, statistical divisions and local government areas. In that study, the measures of income distribution varied widely, and the authors noted that much of the variation could be explained by factors such as industry structure and family composition in particular geographical areas. Of particular interest to our current study is the observation (page 25) that '[t]he contribution of differences between male and female incomes was greatest in several major mining regions'. The Gini coefficient provides a numeric measure of inequality. The coefficient takes values between zero and one, with zero representing complete equality and one representing complete inequality. Our focus is on the impact of mining on socio-economic well-being, and particularly the distribution of income, at the local scale.

2. Methods

The income and employment data used were obtained from the Australian Bureau of Statistics 2006 Census of Population and Housing (ABS 2010). The census took place across Australia in August 2006. The CDATA Online product allows users to download customised census data sets based on particular selection criteria. For the purposes of this work, we gathered data for weekly gross individual income by gender and industry of employment, based on a person's place of usual residence. By focussing on a person's place of normal residence, rather than their actual location at the time of the census, we are examining the impact of mining in the places where people live, rather than on sites where mine workers may be based during their shifts (many 'fly in-fly out' workers spend 7–10 days at a time on a mine site, usually in temporary accommodation).

The Australian Bureau of Statistics (ABS) uses a hierarchical geographical classification system to collect and publish census data. Statistical Local Areas (SLAs), in aggregate, cover the whole of Australia without gaps or overlaps (ABS 2005). The focus of our study was on the impact of mining on regional Australia, so we excluded SLAs classified by the ABS in the 'major city' category. This removed Adelaide, Brisbane, Canberra, Hobart, Melbourne, Perth and Sydney – Australia's largest cities – from our analysis. Retaining just the 'regional' (both 'inner' and 'outer') and remote SLAs gave us a sample size of 781 regions. Australia's population is concentrated in the major cities, so our 781 regional SLAs covered around 6 million people, of the population of 20 million at the time of the 2006 census.

We began by exploring the relationship between mining employment and broader measures of socio-economic advantage and disadvantage. The ABS Socio-Economic Indexes for Areas (SEIFA) rank areas in terms of their socio-economic characteristics as measured in the census (ABS 2008). These are standardised indexes designed to compare relative socio-economic disadvantage between regions based on individual and household characteristics recorded in the census. The indexes incorporate economic resources such as wealth as well as social resources such as housing and education. There are four versions of SEIFA: disadvantage, which measures relative socio-economic disadvantage among individuals and households within a region; advantage–disadvantage, which measures relative advantage as well as disadvantage; economic resources, which considers people's access to economic resources; and education-occupation, which considers training and employment-related skills (ABS 2008). For each of these indexes, a low score indicates that an SLA has relatively poor socio-economic characteristics.

For the regression analysis, remoteness was included following the ABS remoteness categories of inner regional, outer regional, remote and very remote. Some SLAs cover more than one remoteness category; for these, we took the category which covered the majority of the population in the SLA. Mining activity was estimated by taking the percentage of employed people working in the mining industry in each SLA from the census data. Gini coefficients were calculated from individual gross weekly incomes, considering only employed persons, for men, women and all persons. The population of each SLA was also included in the regression models as a continuous variable.

Our principal hypothesis was that mining activity had no effect on income inequality in regional Australia. The data were analysed using linear regression in R for Windows (version 2.12.0; http://www.r-project.org) using bootstrapped standard errors with 10,000 bootstrap samples. Exploratory data analysis using scatter plots and locally weighted scatter plot smoothing (loess curves with a smoothing parameter of 2/3) suggested that the relationship between income inequality and mining employment was non-linear. Therefore, we chose to categorise mining employment for inclusion in the model, effectively converting it into a series of dummy variables. Given the extreme skewness of this variable (see Figure 2), we chose the following seven categories: 0–0.1, 0.1–0.5, 0.5–1, 1–2, 2–5, 5–10 and 10 per cent +. These categories were chosen to represent a reasonable spread from negligible mining activity through low, medium and higher levels of mining employment, while ensuring each band had a reasonable number of observations (217, 262, 121, 87, 50, 22 and 22, respectively).

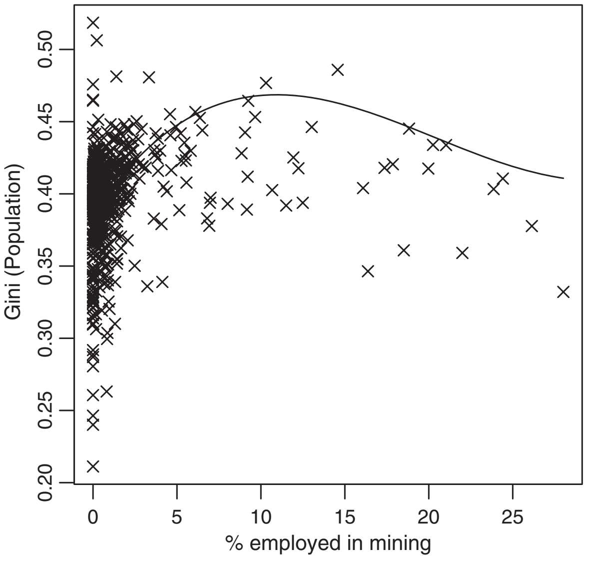

Figure 2 Gini coefficient for gross weekly income for all employed persons, against the proportion of the workforce employed in mining, with a loess curve (scatter plot smoother). Each circle represents an Statistical Local Area.

3. Results

SLAs with higher levels of mining employment tended to have higher SEIFA scores for three of the four indexes: disadvantage, advantage–disadvantage and economic resources (Table 1); for these indexes, the SEIFA score increased consistently with mining employment. Differences between the very low categories are likely to reflect differences between SLAs in characteristics other than purely percentage employed in mining. For SLAs with mining employment in the above 5 per cent, SEIFA scores were around 100 points higher on average, which equates to an increase of 1–2 deciles compared to SLAs with minimal mining employment. This is likely to reflect the higher incomes associated with mining employment and is consistent with the findings of Hajkowicz *et al*. (2011) that mining activity is positively correlated

Table 1 Regression coefficients (and standard errors) for Socio-Economic Indexes for Areas index scores

	Disadvantage	Advantage-disadvantage	Education-occupation	Economic resources
Intercept	963.0*** (9.2)	935.3*** (7.0)	967.6*** (6.0)	968.6*** (7.8)
Mining employment: 0–0.1%	Reference level			
Mining employment: 0.1–0.5%	44.2** (10.8)	23.2** (7.0)	6.0 (5.5)	38.9*** (9.0)
Mining employment: 0.5–1%	82.8*** (14.4)	48.8*** (9.3)	17.8* (6.9)	69.5*** (12.3)
Mining employment: 1–2%	72.2*** (15.5)	47.6*** (10.3)	11.8 (7.6)	64.7*** (13.3)
Mining employment: 2–5%	85.0*** (19.1)	49.1*** (13.0)	−7.4 (8.4)	81.6*** (15.9)
Mining employment: 5–10%	122.0*** (21.7)	76.9*** (13.9)	−7.1 (10.0)	112.6*** (19.0)
Mining employment: 10% +	150.5*** (26.3)	110.1*** (16.9)	−0.1 (11.4)	128.5*** (20.0)
State: Victoria	Reference level			
State: New South Wales	−13.6 (7.3)	−8.0 (6.2)	−12.8* (5.6)	−1.4 (6.6)
State: Northern Territory	−97.4*** (19.1)	−7.7 (13.3)	−9.4 (10.0)	−73.7*** (16.1)
State: Queensland	−46.6*** (10.7)	−18.3* (7.9)	−23.2**** (6.1)	−25.0** (9.5)
State: South Australia	−19.0 (12.1)	−21.7* (8.80)	−23.7*** (7.1)	−7.8 (10.6)
State: Tasmania	−17.5 (12.4)	−16.6 (10.6)	−28.7* (11.8)	−8.9 (10.5)
State: Western Australia	−20.3 (11.4)	−7.2 (8.0)	6.0 (6.9)	−2.1 (9.9)
Remoteness: Inner regional	Reference level			
Remoteness: Outer regional	−11.1 (6.4)	−10.6* (5.4)	3.5 (4.8)	−16.7** (5.6)
Remoteness: Remote	−65.3*** (16.6)	−45.5*** (10.8)	−3.4 (7.7)	−65.7*** (14.3)
Remoteness: Very remote	−219.5*** (19.6)	−128.9*** (12.3)	−57.6*** (8.5)	−194.8*** (16.4)
SLA population ('000s)	0.00 (0.23)	0.49* (0.21)	−0.47* (0.21)	−0.41*** (0.21)
Adjusted R^2	0.49	0.36	0.19	0.48

SLA, Statistical Local Area.
*Significant at $P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

with socio-economic well-being. However, the fourth SEIFA index, education-occupation (which is the only one of the four not to include income measures), showed no overall relationship with mining employment (Table 1). All four indexes also showed a significant negative relationship with remoteness (Table 1).

Focussing on income inequality, Figure 2 illustrates the relationship between the proportion of the working population employed in the mining industry and the Gini coefficient for all non-capital city SLAs in Australia. Regression analysis indicated that mining employment was significantly related to the Gini coefficient for all employed persons ($F_{6,764} = 14.34$; $P < 0.0001$). State proved significant overall in the model ($F_{6,764} = 15.88$; $P < 0.0001$), indicating that the Gini coefficient varies between states over and above any impact of mining employment. Remoteness category was also significant at the 5 per cent level ($F_{3,764} = 13.34$; $P < 0.0001$), while the population of an SLA was not ($F_{1,764} = 3.37$; $P = 0.067$). Table 2 presents the regression coefficients for the model. For each of the categories of mining employment in Table 2, the Gini coefficient was significantly higher than in the reference category (mining employment < 0.1 per cent). It rises up to the 5–10 per cent category before falling back somewhat in the 10 per cent + category, reflecting the pattern observed in the scatter plot (Figure 2). The decline in the Gini between the 5–10 and 10 per cent + mining employment categories was not significant at the 5 per cent level.

Table 2 Regression coefficients (and standard errors) for Gini coefficient

	Gini (population)	Gini (females)	Gini (males)
Intercept	0.399*** (0.003)	0.386*** (0.004)	0.384*** (0.003)
Mining employment: 0–0.1%		Reference level	
Mining employment: 0.1–0.5%	0.009*** (0.003)	0.012*** (0.003)	0.008* (0.004)
Mining employment: 0.5–1%	0.013*** (0.004)	0.015*** (0.004)	0.008 (0.005)
Mining employment: 1–2%	0.023*** (0.004)	0.017*** (0.005)	0.019*** (0.005)
Mining employment: 2–5%	0.035*** (0.005)	0.026*** (0.005)	0.026*** (0.008)
Mining employment: 5–10%	0.037*** (0.006)	0.031*** (0.007)	0.006 (0.008)
Mining employment: 10% +	0.031** (0.010)	0.052*** (0.012)	−0.039** (0.014)
State: Victoria		Reference level	
State: New South Wales	0.007** (0.002)	0.011*** (0.003)	0.009*** (0.002)
State: Northern Territory	−0.032*** (0.006)	−0.030*** (0.006)	−0.027*** (0.004)
State: Queensland	−0.013*** (0.003)	−0.010** (0.004)	−0.014*** (0.006)
State: South Australia	−0.004 (0.003)	−0.004 (0.004)	−0.003 (0.004)
State: Tasmania	0.001 (0.003)	−0.002 (0.004)	−0.003 (0.004)
State: Western Australia	−0.001 (0.003)	0.008 (0.005)	−0.010** (0.004)
Remoteness: Inner regional		Reference level	
Remoteness: Outer regional	−0.009*** (0.002)	−0.006** (0.002)	−0.006** (0.002)
Remoteness: Remote	−0.011** (0.004)	−0.001 (0.005)	−0.007 (0.005)
Remoteness: Very remote	−0.016*** (0.004)	−0.024*** (0.005)	0.003 (0.0066)
SLA population ('000s)	0.0001 (0.0000)	−0.0001 (0.0000)	0.0001 (0.0000)
Adjusted R^2	0.29	0.27	0.13

SLA, Statistical Local Area.
*Significant at $P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Separating the data for women and men reveals quite different patterns. Among men, income inequality rises initially with levels of mining employment (Figure 3, right) before decreasing at higher levels. However, among women, income inequality continues to rise with the proportion of the population employed in mining (Figure 3, left). The regression models for women and men are shown in Table 2. For women, mining employment is positively associated with the Gini coefficient ($F_{6,764}$ = 7.21; P < 0.0001), as is state ($F_{6,764}$ = 18.60; P < 0.0001) and remoteness ($F_{3,764}$ = 8.19; P < 0.0001). Income inequality rises consistently across the categories of mining employment in the model; unlike in the model for the population as a whole, there is no evidence of any decline in inequality at higher levels of mining employment (Table 2).

For men, mining employment is significant in the regression model ($F_{6,764}$ = 5.76; P < 0.0001), along with state ($F_{6,764}$ = 10.53; P < 0.0001) and remoteness ($F_{3,764}$ = 3.10; P = 0.026). Income inequality increases over the first five categories of mining employment. However, in the 5–10 per cent mining employment category, the average Gini coefficient drops back close to its level in SLAs with minimal mining employment (from which it is not significantly different). For the highest category of mining employment, male income inequality is significantly lower than the reference category (minimal mining employment) (Table 2).

4. Discussion

Our analysis finds evidence that across the 781 SLAs in regional Australia, there is a significant relationship between mining employment and income

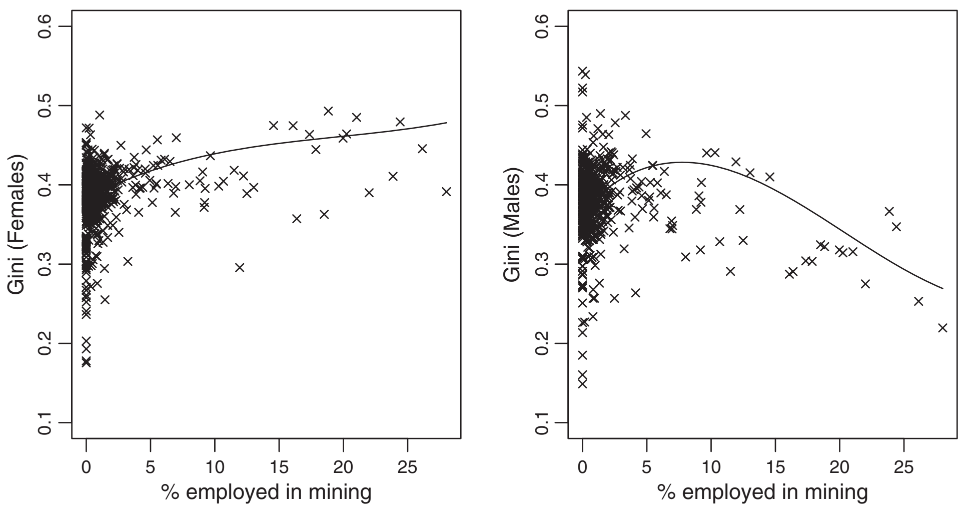

Figure 3 Gini coefficient for females (left) and males (right), against the proportion of the workforce employed in mining, with a loess curve.

inequality. Thus, we can reject the hypothesis that income inequality is not related to mining activity in regional Australia. Such statistical associations do not demonstrate causality (in either direction), but our results are suggestive that changes in income inequality may be linked to changes in mining employment. We also find evidence that the relationship between income inequality and mining employment is non-linear (although the models that were used do not allow for a formal test of non-linearity). At low levels of mining employment, income inequality increases with increased mining employment, but this relationship becomes inverted; once mining employment passes 10 per cent, inequality actually decreases with mining activity. Among men, this pattern is more pronounced. Again, income inequality initially increases with the proportion of the total population employed in mining, but in regions with 10 per cent or more of the population employed in the mining industry, male income inequality was significantly lower than in regions without any significant mining employment.

Mining towns have the distinction amongst surrounding settlements that even traditional blue collar occupations are associated with high incomes (Stoeckl and Stanley 2007). Indeed, high incomes in the mining industry are recognised as being necessary to sustain viable workforces in remote locations, with low job satisfaction related to environmental conditions such as dust and working conditions such as long shifts (Iverson and Maguire 2000). While this presents a difficulty for competing businesses in remote locations (Evans and Sawyer 2009), the high incomes within the mining sector may to some extent break down the income disparities seen between professionals, tradesmen and unskilled workers elsewhere. Among women, the pattern is quite different, with income inequality continuing to increase throughout the range of mining employment levels. This suggests that mining affects the welfare of men and women quite differently. This finding is consistent with Stimson (2001), who observed that throughout Australia, gender is a factor in relative economic advantage and disadvantage where men or women represent a higher proportion of spatially distinct workforces. At its simplest, the tendency towards male-dominated workforces in the mining sector is the most likely reason for the difference in income equality.

The observed relationship between income inequality and mining employment resembles the Kuznets curve from development economics, which shows an inverted U-shaped relationship between income inequality and per capita income. The Kuznets curve suggests that in the early stages of economic development, as individuals begin to shift from the agricultural to the industrial or service sectors, income inequality increases; it peaks and then declines as more people shift to the more productive sectors (Kuznets 1955). Most of the evidence for the Kuznets curve comes from cross-sectional data, considering a single moment in time across a range of countries with differing income profiles; there is also some evidence from time series studies, although this is more equivocal (e.g. Bahmani-Oskooee and Gelan 2008). An unresolved question is whether changes in income equality are associated with changes in mining employment through time in regional Australia. Another open question is the extent to which any changes in income inequality reflect individuals in regional towns changing roles (i.e. moving into the mining industry) versus changes in the population as mining develops. Lower inequality at high levels of mining employment could result both from many individuals increasing their income and from people on the lowest incomes relocating elsewhere.

The expansion of mining in a region will always cause some problems for other industries because of competition for labour and other resources. In itself this is not necessarily a problem as the overall economic benefits are likely to be positive, although if it occurs rapidly, there is greater potential for adverse impacts (Rolfe *et al.* 2007). Given mining exploits a finite resource, mines have a limited lifespan. Individual mines may last for a few decades, and there is always the possibility of a sudden closure, as occurred at a number of sites in Australia following the sharp falls in commodity prices in 2008. While some locations (e.g. Mt Isa, Kalgoorlie) have maintained a constant mining presence for many generations, a key question for emerging mining areas is how readily they could transition back to a non-mining centred economy. Tracking changes in regional communities, and the distribution of income and other resources within those communities, through the life cycles of mines are, therefore, required for a complete picture of the impacts of mining in regional areas.

This study has extended the work of Hajkowicz *et al.* (2011), finding that even at a finer scale, there is no evidence that mining activity has a negative socio-economic impact and that most relative measures of socio-economic advantage are positively associated with mining employment in regional Australia. Our analysis focussed on the SLAs where mining employees reside (the places they identified as their 'place of usual residence' in the census), enabling us to examine the impact of mining employment on regional communities, even if those communities are some distance from an actual mine site. However, it does mean that any impacts of non-resident workers at their place of employment will not be detected. Another potential confounding factor is that high-earning mine workers may choose to live in areas of high amenity (e.g. on the coast) which also have higher wages in the broader population. However, there is no clear evidence of this in our data; the SLAs with the highest levels of mining employment were inland areas in close physical proximity to mines (note that Australia's seven largest cities were not included in the analysis).

We have also extended the findings of economic geographers who have long seen a pattern between mining and economic advantage in terms of income and employment (Stimson 2001; Baum *et al.* 2005; Baum 2006). For income inequality, the results are more nuanced. There is evidence that mining is associated with increased income inequality, particularly at intermediate levels of activity. However, in regions where mining makes up a greater share of the economy, it is associated with a marked decrease in inequality among men but an increase among women. Overall the evidence suggests that mining is mostly associated with positive socio-economic outcomes, but there are some adverse impacts which may require the attention of policy makers.

High mining incomes create flow-on benefits in regional towns (Petkova-Timmer *et al.* 2009), although many of the benefits may accrue to major cities – an input–output analysis for the Australian state of Queensland found that the economic multipliers associated with mining activity are far higher in the state capital (Brisbane) than in the regions where mining actually occurs (Rolfe *et al.* 2010). Our results suggest that it is regions with intermediate levels of mining employment in which adverse distributional consequences will be greatest. Housing affordability is clearly a key issue (Rolfe *et al.* 2007), which could be addressed by ensuring that the planning process does not prevent housing supply from increasing in response to increased demand. Measures should also be considered to ensure equality of opportunity for women in regions with high levels of mining activity. Our study has focussed solely on Australia, which has a relatively unusual combination of high per capita incomes and a proportionally large mining sector. In countries with lower incomes, there are likely to be fewer opportunities outside the mining sector, so the impact of mining on income inequality may be more pronounced.

A key qualification is that our study focussed on personal, rather than household, income. Women in mining towns are more likely to have a partner on a high income and so may be more likely to accept a lower personal income (e.g. working fewer hours) in favour of a higher household income than may be available in metropolitan regions (Maxwell *et al.* 1991; Lovell and Critchley 2010). However, it may also be because mining towns offer relatively fewer employment opportunities for women, resulting in greater income inequality. Some authors have inquired whether the longer working hours of male partners may tend to isolate women to domestic roles (Collis 1999; Sharma and Rees 2007). Further research to better understand the reasons for the gender difference presented in this paper will be crucial to inform the policy implications of the stark differences between male and female income equality presented here.

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