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# The economic and social benefit of coal mining: the case of regional Queensland\*

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This paper examines economic impacts of coal mining across local government areas (LGAs) in Australia. Three main distinguishing features of this research are a) the analysis through the mining boom and bust cycle, b) a focus on small regional areas within one state in Australia and c) the use of socio-economic indicators in addition to the standard income and employment indicators. An analysis of socio-economic changes in the LGAs during the business cycle provides insights as to how coal mining affects sustainable development of regions in the long run. Focus on one state reduces endogeneity in statistical analyses. The use of various socio-economic indicators helps understanding of the reported negative impacts of mining on local economies. The results show that the coal mining sector creates a spillover effect resulting in an increase in non-mining employment. The income indicators suggest that the coal mining sector creates positive impacts as indicated by the decreased share of low-income families in the area. However, some potential risks to housing are found since an increase in coal mining employment leads to increased financial stress due to increased rental costs for low-income households.

**Key words:** business cycle, coal mining, regional development, resource curse, socio-economic indicators.

## 1. Introduction

A large body of literature has analysed the resource curse hypothesis where countries with abundant resources perform mediocly compared to non-resource countries (Auty 1993, Markey *et al.* 2005, Wellstead 2007, James and Aadland 2011, Betz *et al.* 2015, Douglas and Walker 2017). The empirical analysis provided inconclusive evidence of the resource curse hypothesis. For example, Sevil (2017) stressed the potential positive role the abundant natural resources might have in helping countries to grow and develop. He showed that higher levels of resource exports were positively related to the improvements in human development index. However, Badeeb *et al.* (2017) analysed the most recent cross-country resource curse literature and concluded that resource dependence negatively affects economic growth.

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Sachs and Warner (2001) also confirmed the existence of the resource curse and showed evidence that resource-rich countries tend to grow slower than resource-poor countries.

Furthermore, the literature showed that a resource curse might have an effect beyond employment and income. For example, a negative impact on education (Gylfason 2001, Papyrakis and Gerlagh 2007, Cockx and Francken 2016), a lower rate of genuine savings and investment (Atkinson and Hamilton 2003, Gylfason and Zoega 2006, Boos and Holm-Müller 2013), a decline in agricultural sectors associated with the oil sector boom (Apergis *et al.* 2014) and reduction in public capital stock (Bhattacharyya and Collier 2014) have been reported. Sevil (2017) and Boos and Holm-Müller (2013) suggested that institutional quality might be playing the major role in whether the country had a resource curse or blessing.

While a cross-country analysis suffers from many shortcomings, including data reliability, matching of samples, time frames and methods of data collection (Jowell 1998; Gharawi *et al.* 2009), a within-country analysis of resource curse is less common (Caselli and Michaels 2013, Fleming *et al.* 2015; James 2015). Focus on a within-country analysis permits the analysis to overcome concerns regarding endogeneity (Cust and Poelhekke 2015). Despite this, results are not completely uniform. A large volume of research indicates negative impacts from mining at the local level (Lockie *et al.* 2009, Carrington and Pereira 2011, Ivanova 2014, Cardoso 2015, Li *et al.* 2017). Likewise, Douglas and Walker (2017) found a significant negative effect of resource dependence on long-run income growth and investment. Furthermore, Ivanova (2014) found that in Queensland, Australia, educational levels in some mining regions were lower, while the population in the most disadvantaged quintile was higher than average in the state. By contrast, Fleming *et al.* (2015) found no evidence of resource curse across non-metropolitan substate regions of Australia.

The reasons for a discrepancy in the results can be numerous including lack of available data at a small level at which the negative impacts prevail (Fleming *et al.* 2015). While some studies estimated the values of some negative impacts of mining on communities (e.g., Ivanova and Rolfe 2011), there is a lack of consistent data at a regional level. Furthermore, a lack of usage of broader socio-economic indicators in analysis might mask the effects of the resource curse at the regional level.

This study differs from previous studies that have discussed the impact of mining activities in regional Australia in several important ways. First, this study is focused on coal mining activities (a predominant source of exports), not the overall extractive sector, while still controlling for the effect of the non-coal mining sector in regional Queensland. Analysis of the impacts within the state controls for variations in institutions and other variables that might differ across states. Second, this study covers the growth and decline in the coal mining industry over the business cycle by employing census time-series data for about one decade, from 2006 to 2016. Coal prices have

increased dramatically from 2006 to 2011 before they plummeted in 2016 (Saunders 2015), allowing an analysis of the impacts over the full business cycle. Third, this study statistically examines some of the socio-economic indicators that typically are not included in the resource curse literature. The study uses indicators such as housing stress (weekly rent, monthly mortgage, rent and mortgage ratios, share of low-income household who experience rent and mortgage stress), access to communication and public service indicators (per cent Internet, road per capita, capital expenditure per capita, employment in health social sector per capita, total admission per capita), percentage of low-income households and percentage of children in jobless families.

The rest of the paper is structured as follows. Section 2 discusses the resource curse literature. Section 3 explains the empirical strategy. Section 4 describes the data and variables used. Section 5 presents results, and Section 6 concludes.

## 2. Resource curse within a country

The economic and social impact of a commodity boom is part of the broader resource curse literature. Most of the earlier studies on this topic used a cross-country data and estimated the impact of resources on national economy (Auty 1993, Sachs and Warner 2001, Van der Ploeg 2011). For example, Sachs and Warner (2001) argued that resource-abundant countries tend to grow more slowly and have higher price levels than resource-poor countries, and therefore, resource-abundant countries did not show strong export-led growth. However, this cross-country evidence suffered from numerous confounding factors that are correlated with each other and harder to differentiate, such as institution, financial development and political environment variables (Van Der Ploeg and Poelhekke 2016).

A growing attention is given in the literature to within-country differences (e.g., Domenech (2008), Hajkowicz *et al.* (2011), Weber (2014), Betz *et al.* (2015), Fleming *et al.* (2015), Douglas and Walker (2017)). The empirical analysis provided cases both for and against a potential resource curse. For instance, Paldam (2013) suggested that natural resources were likely to provide a gain to the economy in the first 50 years; then, the new growth path would merge with a lower growth resulting in a loss relative to the expectations and resulted in larger fluctuations around the long-run growth trend. Papyrakis and Gerlagh (2007) and James and Aadland (2011) found that in the United States, the states/counties with greater dependence on resources had lower growth than other states. Papyrakis and Gerlagh (2007) argued that resource abundance led to decrease in investment, educational attainments and R&D expenditure.

Some studies have attempted to provide the short- and long-run perspectives specifically for the coal mining sector, mainly taking the US cases. Matheis (2016) examined the short- and long-run effects of coal mining activities in the United States for over a century using population and

manufacturing activity. The study found that the short-run potential net benefits were overturned by the long-run negative impacts in local areas. He showed that coal mining activity stimulated population growth for two decades but had negative effects on population growth after three decades. While coal mining activity had a small and positive short-run impact on manufacturing industry, per capita employment in manufacturing decreased in both the short run and the long run. Douglas and Walker (2017) examined 409 Appalachian coal mining counties, selected for homogeneity, between 1970 and 2010. They found that an increase in resource dependence was associated with short- and long-run decline in the annual growth rate of per capita personal income. These short- and long-run growth declines were resulted from the disincentives to education.

While some research did not find strong evidence of resource curse at the within a country level (Domenech 2008; Weber 2014; Betz *et al.* 2015), both positive and negative impacts were noted. For example, Domenech (2008) explored the effects of mineral resources extraction in Spain from 1860 to 1920. He found a positive effect of mineral resources on industrialisation with no reduction of real wage growth or slowing down in the accumulation of human capital measured in literacy rate. However, Domenech (2008) mentioned that the impacts of resource abundance were subdued by the lack of the backward or forward linkages within the regions. Betz *et al.* (2015) examined the effect of coal mining on the Appalachian region, USA, using a range of economic indicators. They did not find strong evidence of a resources curse but noted that coal mining is negatively associated with the population growth and entrepreneurship, therefore possibly having a negative effect on future economic growth.

Most of the socio-economic impacts of the resource sector rely on its spillover effect, rather than direct effect. The resource sector can directly generate higher household income level in the mining regions as salary or wages should increase given the increase in labour demand (Williams and Nikijuluw 2020). This income effect is likely to affect the distributional pattern of income in local areas, since the region where miners reside and/or work will have higher investment and demand for non-tradable sectors. Several studies had looked at the socio-economic impacts of the mining activities. Perdue and Pavela (2012) found that non-mining counties had lower poverty and unemployment rates than mining counties in West Virginia, USA. Oxley (2014) analysed the socio-economic impact of coal in the Appalachian region of Kentucky. She found an inverse relationship between the median household income and coal mining employment as well as a direct impact between coal mining employment and poverty rates and age-adjusted mortality. Caselli and Michaels (2013) investigated the effect of oil production among Brazilian municipalities on local economies. They found that social transfers, household income, investment in infrastructure and public good provision did not increase as much as the reported revenues from oil.

Australia, as one of the resource-rich countries, which experienced boom and bust cycles in its mining sector over the last decades, has been discussed in several case studies. Goodman and Worth (2008) claimed to find evidence of a resource curse in Australia, particularly in social displacement, geographical inequalities and damaging boom–bust cycles. On the other hand, Hajkowicz *et al.* (2011) found no evidence of negative impact from the resource sector when analysing the relationship between the gross values of mineral production on some quality-of-life indicators at local government area (LGA) level. Hajkowicz *et al.* (2011) used household income, rent and loan payments, Internet access, high school completion, life expectancy and unemployment rate to measure the region aggregate quality-of-life indicators. Their results indicated the positive impacts of mining on income, housing affordability, communication access, education and employment in regional and remote Australia. Looking at the case of NSW, Marcos-Martinez *et al.* (2019) analysed the effect of coal seam gas mining during 2001–2011 and found a positive effect on family income but a lack of indirect employment effects. These findings from both studies contradict the empirical evidence which shows negative impacts of mining, especially on specific socio-demographic groups of population (Mancini and Sala 2018). However, Hajkowicz *et al.* (2011) also found that the income inequality was higher in the largest mining regions, which suggested that regional benefits plausibly mask strong but localised negative impacts of mining including inequalities and disadvantages.

Another indirect effect from mining activities can be through the housing sector. The mining sector requires skilled labour, which is unlikely to be satisfied fully from the residential workforce in the regional area (Fleming *et al.* 2015) and therefore induces migration. Although most of the mineworkers usually reside in a subsidised housing area developed by the mining companies, independent contractors and non-mineworkers may still face high rent cost or high mortgages (Kotey and Rolfe 2014). Since a large percentage of mining workers is transient, the demand for rented dwellings will increase higher than purchased or owned ones. As land and property ownership is highly concentrated, the benefit of this higher housing cost might only benefit a certain group of households, while it could create a housing risk for the low-income group, as well as barriers to economic development (Williams and Nikijuluw 2020).

Regarding public service sectors, mining activity may create a fiscal effect, which comes from higher collection of income tax and royalties. For instance, James (2015) indicated the increase in government savings and a tax decrease to residents with the increased revenue from extractive industries in the United States using fifty-one years of state-level data. Studies also have shown that political stability, improved legislation including fiscal management and quality of regulation can determine whether resource curse can be avoided (Gelb *et al.*, 2002, Iimi 2007; Cavnar 2008; McPhail 2008). In Australia, income taxation from coal, oil and gas companies and special taxes

on offshore oil and gas are collected by the national government and then distributed to the state and local governments through transfer arrangements (Blackwell and Dollery 2013). While state governments are responsible for providing education, health, housing and other services, local governments have an authority to manage and spend the resource revenues on developing productive infrastructure and better management of basic public services including funding a diverse range of learning programs and educational experiences. Some councils run libraries, museums and theatres and provide public halls and swimming pools (Parliament 2019). Some states including Queensland have reinvested a portion of the state royalties in resource regions to fund infrastructure projects supporting local needs (Seeney 2012, Blackwell and Dollery 2013). These re-investments in public services can indirectly improve welfare and reduce poverty. In a long-term perspective, this positive spillover of the resource sector to the economy can only be sustained if the local and state governments have a good policy in human capital formation and manufacturing sectors.

The closest predecessor to this study is Fleming *et al.* (2015) which looked at within-country effect of resource boom and bust in non-metropolitan Australian LGAs using some economic indicators. The indicators included mining employment change, share of agricultural/mining/manufacturing employment, family income, population density, unemployment rate and a percentage of population with university degree. They found that while the resources have been a blessing for local economies, some negative effects were experienced in some LGAs. The results showed that the relationship between mining and non-mining employment changes ranges from negative 2 per cent to a positive of 8 per cent in the rate of non-mining employment creation when the number of miners doubled. However, their study also found a possible labour crowding out from other sectors to meet the demands of the mining industry. That means that in some regions of Australia, mining growth has been associated with lower economic growth in terms of non-mining employment.

This study employs within-country (state) analysis to show how a specific commodity, coal, may impact economic and social sector in regional Queensland. By focusing only on regional Queensland, this study has an advantage of fewer confounding factors, which can affect the coal mining impacts since the institutional set-up and governance in one state are less varied. Some literature suggested that different governance and institutional capabilities might contribute to economic development or lack of such due to mining (Andersen and Aslaksen 2008). For example, Fleming *et al.* (2015) findings were based on all non-metropolitan LGAs of the country, with different state governance over regional development and investment of mining royalties.

This study uses the labour demand generated in coal and non-coal mining sectors as the mining variables. Mining activities are more capital-intensive industries rather than labour-intensive ones (Topp *et al.* 2008). Hence, the

labour demand shock is arguably exogenous at the LGA level since this shock does not depend on any local policy but rather an investment decision at national level. Therefore, the effects of coal activity on employment growth in non-mining sectors are mainly affected by the labour movement and the growth in non-tradable sectors.

### 3. Empirical strategy

To answer the question of whether there are economic and social benefits of coal mining activities in the regional Queensland, this study employs a panel econometric model to assess the effect of mining on employment, income and housing indicators. The estimation model is adopted from Fleming *et al.* (2015), with some differences and extensions.

The methodology of this study differs from Fleming *et al.* (2015) in several ways. First, this study decomposes mining into two variables – coal mining employment and non-coal mining employment. The coal mining employment then serves as the main variable of interest, while non-coal mining employment becomes one of the major covariates. The second difference is the time period. While Fleming *et al.* (2015) only use two points of census time, 2001 and 2011, this study uses three points of census years, 2006, 2011 and 2016. By doing this, the results can capture the stories during the first and second resource boom periods in Australia. Also, due to several time points, this study is able to employ a panel fixed-effect specification when measuring the effects of coal mining employment, instead of the cross-sectional difference-growth model as adopted by Fleming's study. The third difference is the spatial focus of the study. While Fleming *et al.* (2015) examined all Australian states, this study is focused solely on one of the major coal mining states, Queensland. Thus, the issue of endogeneity is minimised.

This study extends what Fleming *et al.* (2015) found by expanding the examination of coal mining impact to other economic and social sectors. The outcome of this study covers three groups of outcomes, which are employment and income, housing and public service indicators. The housing and public service indicators are two categories of outcomes which have not been much discussed in many previous studies. In addition to the usual employment numbers in other sectors and personal income levels, this study also examines the impact of coal mining employment on some poverty indicators, such as percentage of low-income families and percentage of children under 15 years old in jobless families.

The model specification of this study is formulated as follows:

$$y_{it} = \rho \text{coal}_{it} + \gamma \text{noncoal}_{it} + \mathbf{X}_{it}\boldsymbol{\beta} + \alpha_i + \varphi_t + \varepsilon_{it} \quad (1)$$

where  $i = 1, \dots, n$  denotes a LGA,  $t = 1, \dots, T$  denotes a census year,  $\mathbf{X}_{it}$  are LGA's and neighbouring LGAs' characteristics,  $\alpha_i$  is the LGA-specific fixed

effect,  $\varphi_t$  is the census year, and  $\varepsilon_{it}$  is the random error.  $y_{it}$  is outcome indicators in LGA  $i$  in time  $t$ , which is a function of coal mining employment (*coal*), non-coal mining employment (*non-coal*) and a set of LGA-specific controls. In line with the earlier literature (Fleming *et al.* 2015), the model also controls for several LGA-specific characteristics that possibly confound the effect of mining employment on outcomes, such as share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density and share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs. Neighbouring LGAs are other LGAs in the state of Queensland, which are measured based on straight contiguity criteria of whether the two LGAs share common borders or not, and then, the average is weighted by population. The *coal* and *non-coal* variables will take value in logarithmic form, while for the outcomes, it will be on log value if the value is in absolute number and or the distribution of the variables is highly skewed, such as non-mining employment number, capital expenditure per capita and road per capita. By estimating equation (1), this study overall will get the elasticity of the coal mining employment on the outcome, or in other words, the percentage changes in outcome as a result of one per cent increase in the coal mining employment.

One potential econometric challenge from the above model is the exogeneity of coal employment as the variable of interest. As summarised by Fleming *et al.* (2015), the labour demand shocks produced from mining boom and busts can be considered as exogenous given the extraction is provided by nature, the mining industry is driven by profit that derived from international market and prices, also most mining investments are made by non-local, national or multinational companies.

Endogeneity, can also come from the correlation between the LGA characteristics ( $\mathbf{X}_i$ ) and the error term through natural grouping of one type of industry or household across LGA. For instance, high educated households who have a specific high demand for one type of housing facilities will reside in an LGA that has commitment and ability to deliver such goods. This results in a correlation between the education level of the LGA (as an element of  $X_{it}$ ) and the error term, leading to an inconsistent estimate of the education coefficient and potentially distorting the estimates of the remaining coefficients. This problem is usually addressed through finding a suitable instrument for the offending variables. An alternative approach, however, is to use the panel data in which all time-invariant LGA characteristics can be captured by the LGA-specific intercepts. This study therefore uses the fixed-effect panel approach to capture the unobserved time-invariant LGA characteristics.

#### 4. Data and variables

This study maintains a consistently defined number of 78 LGAs in Queensland throughout the available time period (2006, 2011, 2016). The time period is chosen based on the most recent census years. It uses the 2016 ASGS (Australian Statistical Geography Standard) edition of LGA boundaries from the ABS. Therefore, if the available data are using other types of boundaries, the data are adjusted to the 2016 ASGS LGA boundaries using correspondence techniques. When the option is available, the LGA classification used in this paper is based on the 'Place of usual residence' rather than 'Place of work'.

Employment, income and poverty indicators are compiled from the pre-populated census data in *Census DataPacks*. The coal mining employment number is accessed through another data set version of the census data which is the *Census TableBuilder*. The housing indicator data come from the *Social Health Atlas (SHA)*, a data set compiled by the Public Health Information Development Unit (PHIDU) at the Torrens University Australia. The data for the access to communication and public service indicators are sourced both from the SHA and from Queensland Local Government Comparative Information. According to the number of coal employment, coal mining production and a share of coal employment out of the total employment, the coal mining LGAs were selected. Coal mining LGAs considered in this study are Whitsunday, Isaac, Central Highlands, Banana, Livingstone, Rockhampton and Mackay LGAs.

The dependent variables consist of three groups: 1) employment and income, 2) housing and 3) access to communication and public service indicators. The employment and income outcomes are non-mining employment, household income, percentage of low-income families out of total families and a percentage of children under 15 years old in jobless families out of total children. Housing indicators include weekly rent, monthly mortgage, ratio of median rent cost out of median household income, ratio of median mortgage payment out of median household income and a percentage of low-income households under financial stress, each from rent and mortgage. Access to communication and public service outcomes covers percentage of households with Internet connection, total linear kilometres of council-managed road per capita, total capital expenditure on roads per capita, number of persons who work in health and social sectors, total hospital admission and total hospital admission with cancer diagnosis. The complete statistic descriptive of each variable is presented in Appendix S2 and Appendix S3.

Compiling data at the LGA level is a non-trivial process. Although the census and SHA include some of the best available data sources, these sources still suffer from inconsistencies and misreporting issues. For instance, the census data record that for some LGAs, their median rent and mortgage are zero. To address these data issues, we apply several adjustments before our

data are ready to use for analysis. First, we record the value of the variable as missing values, if the data show value of zero of weekly rent, monthly mortgage and percentage of households with Internet connection. Second, we change the value of rent stress and mortgage stress into missing for any LGA that has missing weekly rent and/or monthly mortgage.

In the analysis, this study estimates two types of sample. The first one is using all the LGAs in Queensland based on 2016 boundaries, with a total of 75 LGAs (Appendix S1), excluding migratory offshore and no usual address sample, and three island LGAs: Torres Island, Mornington and Palm Island. The statistical software automatically excludes these three island LGAs when running the estimation because those LGAs do not have any common border sharing neighbouring LGAs, which are parts of the control variables. The second set of samples excludes the major cities in Queensland to address the urbanised outliers, which are Gold Coast, Redland, Brisbane, Moreton Bay, Logan and Ipswich, with a total of 69 LGAs. For housing and public service estimation, the number of observations might be less than the total available LGAs due to the data availability which vary across indicators.

## 5. Results

### 5.1 Coal mining on employment and income indicators

The panel regression model in this study adopts a similar framework to that presented in Fleming *et al.* (2015) with a log of coal employment as the main variable of interest. Column (1) and column (2) both in Table 1 and in Table 2 use a similar outcome variable as Fleming *et al.* (2015) used; except in this study, we use household income rather than family income. When running the household income outcome, we exclude the family income as control variable to avoid the high multicollinearity between the dependent and independent variable. In addition to those outcome variables, this study is also interested to look further at the impact of coal activities on other income indicators which capture poverty, such as percentage of low-income families and percentage of children living in jobless families. Furthermore, this LGA level panel model also controls for log of non-coal mining employment to account for any impact on those outcomes that are generated by other mining activities.

Table 1 and Table 2 indicate that coal mining activities positively impact the non-mining employment growth. Column (1) shows that one percentage increase in coal employment is associated with a 0.1% increase in number of non-mining employment, holding other factors constant. The result on non-mining employment is robust, even when excluding the major cities' LGAs in Queensland. This coefficient is three times higher than the elasticities of non-coal mining employment on non-mining employment, possibly since there are only few non-coal mining activities located in the regional Queensland. This result on non-mining employment is also higher than what Fleming *et al.*

**Table 1** Panel regression results of coal employment on employment and income indicators

Variables	(1) Log of non-mining employment	(2) Household income	(3) % low income	(4) % child in jobless family
Log of coal employment	0.096*** [0.023]	24.246 [22.240]	-6.546*** [2.399]	-2.692 [1.755]
Log of non-coal mining employment	0.027*** [0.009]	-5.862 [9.099]	-0.664 [0.747]	0.284 [0.875]
Observations	225	225	221	223
R-squared	0.749	0.794	0.281	0.446
Number of LGAs	75	75	75	75

Note: Robust standard errors in brackets, \*\*\* $P < 0.01$ , \*\* $P < 0.05$ , \* $P < 0.1$ . All regressions cover three time periods: 2006, 2011 and 2016, and control for LGA fixed effect, time (year) fixed effect and LGA-specific controls. LGA-specific controls include share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density, share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs, except in column (2), in which we exclude family income as control variable.

**Table 2** Panel regression results of coal employment on employment and income indicators, excluding major cities

Variables	(1) Log of non-mining employment	(2) Household income	(3) % low income	(4) % child in jobless family
Log of coal employment	0.092*** [0.024]	27.146 [22.898]	-6.659** [2.529]	-3.234* [1.773]
Log of non-coal mining employment	0.027*** [0.009]	-6.881 [9.354]	-0.658 [0.786]	0.213 [0.887]
Observations	207	207	205	207
R-squared	0.747	0.773	0.282	0.441
Number of LGAs	69	69	69	69

Note: Robust standard errors in brackets, \*\*\* $P < 0.01$ , \*\* $P < 0.05$ , \* $P < 0.1$ . All regressions cover three time periods: 2006, 2011 and 2016, and control for LGA fixed effect, time (year) fixed effect and LGA-specific controls. LGA-specific controls include share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density, share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs, except in column (2), in which we exclude family income as control variable.

(2015) found. One possible explanation is because this study uses a more specific case, while Fleming *et al.*'s (2015) is more general by only looking at overall mining sector and taking all LGAs across Australia as its sample.

For other income indicators, the results show a significant negative association between coal mining and poverty measurements, while the impact on median household income remains insignificant. Although the result on household income is different from what Fleming *et al.* (2015) found, the result on this study is more aligned with the common perceptions regarding mining income. With the increase in fly-in/fly-out and drive-in/drive-out mining operations, mining employees have a choice where to locate their

families (Petkova-Timmer *et al.* 2009; Hajkowicz *et al.* 2011, Ivanova and Rolfe 2011). As a result, some of the mining income is spent outside the mining regions; thus, the impact on personal welfare in mining LGAs is diminished. On poverty, as shown in column (3), a one per cent increase in the coal employment will reduce 0.06 percentage point of share of low-income families out of total family in the region. Also, when excluding the major cities LGA, one per cent increase in coal employment will reduce the share of children below 15 years old in jobless families by 0.03 percentage point. This negative coefficient indicates that an increase in coal mining activities potentially creates new working opportunities for low-income households, thus reducing an overall unemployment that eventually move them out of poverty.

## 5.2 Coal mining on housing indicators

The estimation of coal mining impacts on housing indicators is one of the extensions that this study covers compared to Fleming *et al.* (2015). The rationale to include housing indicators in assessing the economic and social benefits of coal mining activities is because people who live in mining areas may face higher rent costs or higher mortgages due to the migration influx from other regions. While accommodation for mineworkers usually being subsidised by the mining companies, large percentage of the population in mining areas are transient, and therefore, dwellings tend to be rented rather than purchased or owned. This phenomenon can lead to a higher demand for rented dwellings but does not necessarily create enough incentives for new residential developments.

For housing indicators, this study found a positive association between the coal mining activities and the share of low-income households who experience financial stress from rent cost, while there is no significant impact on financial stress from mortgage payment. Weekly median rent grows by \$0.14 for one per cent increase in coal mining employment (Table 3, Column 1). Monthly median mortgage is increasing by \$0.91 for one per cent increase in coal mining employment (Table 3, Column 2). When major cities are excluded, the results are robust for monthly mortgage but less for the weekly rent. Table 3, Column (5) finds that a one per cent increase in coal employment will increase share of low-income households that experience financial stress from rent cost for about 0.02 per cent. This result is robust even after excluding potential outliers of the major cities in Queensland (Table 4). This result confirms the notion that there is a demand spike of rent dwellings because the large percentage of population in mining areas are transient which potentially hurts the low-income households. However, columns (3) and (4) suggest that the impact of coal mining activities on share of median rent and median mortgage out of median household income is not significant. This clarifies that the higher rent cost is not burdening the overall population but is more impacting the low-income families.

**Table 3** Panel regression results of coal employment on housing indicators

Variables	(1) Weekly rent	(2) Monthly mortgage	(3) Rent ratio	(4) Mortgage ratio	(5) % rent stress	(6) % mortgage stress
Log of coal employment	13.981*** [4.618]	90.597* [50.783]	0.001 [0.004]	0.003 [0.010]	2.456** [1.136]	-1.025 [1.827]
Log of non-coal mining employment	5.441*** [1.627]	48.347* [28.120]	0.001 [0.001]	0.009 [0.007]	1.076** [0.447]	-0.271 [0.490]
Observations	223	186	223	186	221	184
R-squared	0.856	0.668	0.614	0.361	0.522	0.178
Number of LGAs	75	65	75	65	75	65

Note: Robust standard errors in brackets, \*\*\* $P < 0.01$ , \*\* $P < 0.05$ , \* $P < 0.1$ . All regressions cover three time periods: 2006, 2011 and 2016, and control for LGA fixed effect, time (year) fixed effect and LGA-specific controls. LGA-specific controls include share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density, share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs.

**Table 4** Panel regression results of coal employment on housing indicators, excluding major cities

Variables	(1) Weekly rent	(2) Monthly mortgage	(3) Rent ratio	(4) Mortgage ratio	(5) % rent stress	(6) % mortgage stress
Log of coal employment	9.536* [4.804]	93.665* [50.022]	-0.000 [0.004]	0.005 [0.010]	2.248** [1.113]	-1.070 [1.916]
Log of non-coal mining employment	6.485*** [1.724]	51.779* [29.355]	0.002 [0.001]	0.011 [0.008]	0.999** [0.435]	-0.214 [0.512]
Observations	205	168	205	168	205	168
R-squared	0.882	0.638	0.644	0.352	0.535	0.179
Number of LGAs	69	59	69	59	69	59

Note: Robust standard errors in brackets, \*\*\* $P < 0.01$ , \*\* $P < 0.05$ , \* $P < 0.1$ . All regressions cover three time periods: 2006, 2011 and 2016, and control for LGA fixed effect, time (year) fixed effect and LGA-specific controls. LGA-specific controls include share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density, share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs.

### 5.3 Coal mining on access to communication and public service indicators

Another extension of this paper compared to other recent studies is in examining the impact of coal mining activities on public service and facilities. Mining activities may attract state and local governments to expand its services especially in improving the public facilities that can increase investment or business opportunity, such as road facilities. This study looks at three kinds of access to communication and public service indicators: Internet connection to represent the business supporting facilities (column 1), road and capital expenditure to represent the infrastructure facilities

(columns 2 and 3) and number of people working in health or social sectors and total hospital admission to represent the health service facilities (column 4 to column 6). The internet provides significant cost savings to various businesses, resulting in lower prices to consumers and faster economic growth (Choi and Yi 2009, Minges 2015). Adequate infrastructure and better transport connectivity tend to improve productivity, economic growth and sustainability (Deng 2013; Ng *et al.* 2019). Through higher participation and productivity, good health contributes to economic performance and is positive for individual well-being (Hsiao and Heller 2007, Soucat 2013).

Table 5 and Table 6 shows that coal mining activities reduce the length of road per capita which is managed by the local councils. A one per cent increase in coal mining employment leads to a 0.6 per cent decrease in the length of road, excluding the major cities. This may result from the crowding out effect of infrastructure investment, previously under the domain of local council, but due to the coal mining discovery, the mining companies are the one who built roads. For the access to Internet, the results show no significant result, albeit the positive coefficient.

On the other hand, for health-related indicators, Table 5 and Table 6 finds that coal mining activities positively impact the number of people who work in health and social services. However, this positive result on the number of health practitioners has not been translated into changes in admission number, which sometimes used as a proxy for morbidity level. The results show no significant result, both for total hospital admission per capita and for total hospital admission due to cancer.

## 6. Conclusion

The broader impacts of commodity boom to the society remain a stimulating empirical case in the resource curse literature. This study contributes to the discussion by using a within-country analysis of coal mining impacts on regional Queensland from 2006 to 2016. The results show that coal mining activities could create negative impacts on regional socio-economic indicators. Careful assessment of the impacts can assist in developing appropriate policies to reduce the negative and to increase the positive impacts at regional and state levels.

The findings confirm that coal mining sector creates spillover effect from an increase in non-mining employment. The coal mining sector is not associated with increased household income levels but does contribute to a decreased share of low-income families in the area. An additional benefit from coal mining is the reduction in the percentage of children under 15 years in jobless families, while non-coal mining does not have the same effect.

An interesting result was regarding the mortgage and rent stress. Possibly due to offset by higher wages, property owners did not feel much mortgage stress. However, resulting higher renting prices put a significant stress on non-homeowners. The result was similar even if the major cities were included in

**Table 5** Panel regression results of coal employment on access to communication and public service indicators

Variables	(1) Pet Internet	(2) Log of road per capita	(3) Log of capital expenditure per capita	(4) Employment in health social sector per capita	(5) Total admission per capita	(6) Total admission due to cancer per capita
Log of coal employment	0.521 [1.642]	-0.517 [0.351]	-0.262 [0.368]	0.005** [0.002]	-0.354 [0.271]	-4.167 [2.870]
Log of non-coal mining employment	-0.185 [0.704]	-0.373*** [0.129]	-0.495** [0.214]	0.002** [0.001]	-0.236 [0.214]	-4.328 [3.041]
Observations	223	190	181	225	133	147
R-squared	0.790	0.544	0.305	0.432	0.130	0.381
Number of LGAs	75	74	68	75	75	75

Note: Robust standard errors in brackets, \*\*\* $P < 0.01$ , \*\* $P < 0.05$ , \* $P < 0.1$ . Column (1) to (4) covers 2006, 2011 and 2016. Column (5) and (6) cover only 2011 and 2016 due to data availability. All regressions control for LGA fixed effect, time (year) fixed effect and LGA-specific controls. LGA-specific controls include share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density, share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs.

**Table 6** Panel regression results of coal employment on public service indicators, excluding major cities

Variables	(1) Pct Internet	(2) Log of Road per capita	(3) Log of capital expenditure per capita	(4) Employment in health social sector per capita	(5) Total admission per capita	(6) Total admission due to cancer per capita
Log of coal employment	0.263 [1.720]	-0.619** [0.283]	-0.235 [0.374]	0.004** [0.002]	-0.342 [0.296]	-4.611 [3.074]
Log of non-coal mining employment	-0.151 [0.731]	-0.396*** [0.128]	-0.490** [0.221]	0.002** [0.001]	-0.219 [0.228]	-4.585 [3.133]
Observations	207	172	163	207	121	135
R-squared	0.786	0.580	0.309	0.417	0.138	0.403
Number of LGAs	69	68	62	69	69	69

Note: Robust standard errors in brackets, \*\*\* $P < 0.01$ , \*\* $P < 0.05$ , \* $P < 0.1$ . Column (1) to (4) covers 2006, 2011 and 2016. Column (5) and (6) cover only 2011 and 2016 due to data availability. All regressions control for LGA fixed effect, time (year) fixed effect and LGA-specific controls. LGA-specific controls include share of employment in agriculture, share of employment in mining, share of employment in manufacture, family income, population density, share of people who have university degree, weighted average of total population in neighbouring LGAs, weighted average of unemployment rate in neighbouring LGAs and weighted average of family income in neighbouring LGAs.

the sample. This means that coal mining activity increases rental stress to low-income families in mining LGAs.

Mining activities are usually promoted as benefits to the regions. Results have shown that potential benefits might not always be capitalised. For example, there is a negative association between coal employment and local council roads per capita, excluding major cities. Surprisingly, capital expenditure was not influenced by coal mining activity but was negatively associated with non-coal mining activity. Although the number of people employed in health and social services is significantly higher in coal mining LGAs, there are some interesting results regarding total hospital admissions which seem to be not associated with higher coal employment. We also did not find a statistically significant association between coal mining employment and admissions due to cancer. It is perhaps because the cases of coal mining pneumoconiosis are rare and do not change dramatically the rates of the disease in the population.

This study, however, also has some caveats that may inform future research topics. First, this study uses coal mining employment as an indicator for coal mining sector. While many studies have used the same variable, a better approach may include using coal reserve or coal production in an LGA to measure the magnitude and value coal mining sector precisely. Secondly, this paper treats the coal mining employment as exogenous. One alternative to address this issue is finding a strong external instrument. Conversely, if finding suitable instrument is problematic, another alternative specification can be introduced by using lagged value of the coal mining employment and employing a dynamic panel model.

Overall, this paper highlights that coal mining activities can induce benefit in one aspect, such as declining poverty indicators and more employment, while at the same time also creating risks in other aspects such as housing stress. These patterns are robust to specification, whether including major cities or not. Therefore, for policy matters, these results imply that discussion on the benefit of coal mining should extend further into which sector or area that needs to be improved, rather than a question of whether resource curse occurs or not. For instance, in this study, while mining activities create more jobs in the region, some improvements to public provision of health and infrastructure result from additional revenue that state and local government get from mining taxes, royalties, rates and charges. Also, housing affordability programs need to be sustained to address the risk of financial stress from housing for low-income families.

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### Supporting Information

Additional Supporting Information may be found in the online version of this article:

- Appendix S1** Map of LGAs in Queensland, 2016.
- Appendix S2** Summary statistics of dependent variables.
- Appendix S3** Summary statistics of independent variables.
- Appendix S4** Panel regression results of coal employment on employment and income indicators, all variables.
- Appendix S5** Panel regression results of coal employment on selected housing indicators, all variables.
- Appendix S6** Panel regression results of coal employment on selected access to communication public service indicators, all variables.
- Appendix S7** Coal employment changes in mining LGAs between 2006 and 2016, persons.