Assessing linkages between regional economic indicators and CSG industry activity in NSW 2001-2011

Milestone 3

A report of the *Analysing Economic and Demographic Trajectories in NSW Regions Experiencing CSG Development* Project

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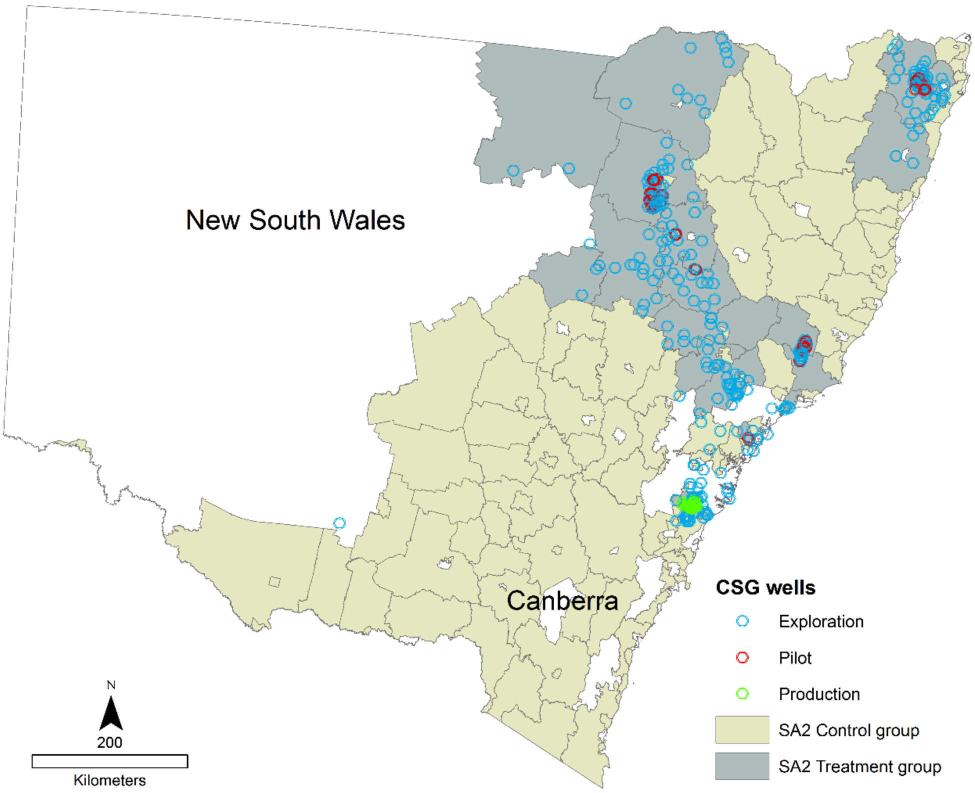

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Economic baseline for NSW CSG regions

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Glossary

Term	Explanation
CSG	Coal seam gas
Delaunay triangulation neighbours	Triangle-based approximation of spatial dependence across spatial units.
Gabriel graph neighbours	Subset of the Delaunay neighbourhood that removes spatial linkages among regions located beyond some threshold distance.
Instrumental variable	A variable *z* is an instrument for the variable x in the regression $y = Bx + u$ if *z* is uncorrelated with the error term and *z* is correlated with *x*. Instrumental variables are used to address issues of omitted variables, reverse causality, and measurement errors.
Income dynamics	Spatial and temporal changes in median family or personal income across SA2 regions.
Job multiplier effects	Spillover effects on employment across non-mining industries attributable to jobs in the CSG industry.
Multicollinearity	Two or more explanatory variables are linearly dependent, i.e. correlated.
Non-CSG well	Drillholes excavated for non-CSG mining (e.g. oil or coal exploration, profiling or production).
NSW	State of New South Wales
CSG regions	Regions in the State of New South Wales where CSG production, profiling and exploration wells were registered with the NSW Government during the period 2001–2011
SA2	Statistical Area level 2 are locations defined by the Australian Bureau of Statistics for the reporting of social and economic data. SA2 purpose is to delimit communities that interact socially and economically.
Seemingly Unrelated Regressions	A system of linear regressions with correlated error terms.
Spatial panel data	Data containing time series observations of a number of spatial units (e.g. SA2 regions).
Spatial regression model	Statistical analysis of the effect of explanatory variables (X) on a dependent variable (Y) where X, Y or both are spatially explicit.
Spatial weights matrix	A matrix representation of the spatial relationships (dependence) that exists across the units of analysis (SA2 regions).
Unobserved heterogeneity	Factors that vary across regions for which data is not readily available to include in a statistical model (e.g. farmers' experience on agricultural production).
Variance Inflation Factors	Indicator of the severity of multicollinearity in a set of explanatory variables.

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Executive summary

This report documents the assessment of the statistical associations between CSG industry activity and regional economic indicators observed in New South Wales during the periods 2001–2011. It is based on econometric analysis of income and sectoral employment dynamics in regions which experienced CSG activity (treatment group) relative to regions without CSG wells (control group). The treatment group in our analysis includes twenty-four rural regions which each had at least two wells drilled during the period 2000–2011. The control group is composed of 114 rural regions with population density distributions similar to those observed in the treatment group in 2001. Treatment and control regions have similar average socioeconomic and environmental characteristics. The report is one milestone within a larger 'baseline' project which was developed in response to stakeholder demand to establish a point of comparison in case of any potential future CSG industry activity in NSW.

Spatiotemporal income fluctuations are influenced by multiple environmental, institutional and socioeconomic parameters. To control for some of those factors we used spatially explicit information on variables that influence farm income returns (e.g. soil characteristics, topography, and climate). Time series data of parameters related to the productivity of human capital (e.g. work experience, education) and non-CSG mining revenue (coal prices and non-CSG wells) were also included in the analysis. We applied statistical methods (spatial panel regressions with random effects) to control for spatially dependent unobserved factors.

Everything else constant, CSG regions had 6.47% and 6.31% higher median personal and family income than regions in the control group, on average. These results were statistically significant at the 5% level. The estimated income effect is independent of the influence of other factors associated with changes in rural income patterns (e.g. changes in agricultural profitability, differences in human capital productivity, and changes in the prices of minerals). These findings are consistent with assessments of the income effects of the CSG construction phase in Queensland. In contrast, we did not find statistically significant linkages between CSG industry activity and indirect employment variations in NSW's CSG regions. We emphasise that the estimated models are a reduced-form representation of the complex interlinkages that drive income and employment patterns. The statistical results in this report only indicate associations between the treatment (CSG activity) and the assessed economic outcomes (median income level and indirect employment) under the modelling assumptions applied. A causal inference analysis could help to better approximate the economic effects of the CSG industry in the study region.

The statistical models generated in this report will be used to project future levels of CSG activity under alternative scenarios (Milestone 4 report). The data used in this study was obtained from open access sources (see NCRIS 2017) and the methods are well documented in the spatial econometric literature. This provides a transparent basis to replicate the analysis.

1 Introduction

Resource extractive industries are typically associated with additional economic activity and flow-on effects which can be positive and/or negative (Fleming and Measham 2015). The debate around economic and social impacts and benefits associated with such industries in regional areas can be enriched when it draws on empirical data and robust statistical evidence. Past research conducted by GISERA used empirical data and statistical methods to provide some evidence of the influence of CSG development on socioeconomic indicators in Queensland (Measham and Fleming 2014; Fleming and Measham 2015).

In New South Wales (NSW) CSG activity has not experienced the level of intensity observed in Queensland. While the CSG industry grew rapidly in the Bowen and Surat basins in Queensland (resulting in the drilling of thousands of wells), in NSW the development of the industry has been slower with only 430 (mainly exploration) wells drilled between 2000 and 2011. Differences in growth patterns of the CSG industry can be explained by differences in estimated CSG reserves (Marinoni and Navarro Garcia 2016), industry acceptance and regulations among those States (Roth 2011; Sherval and Hardiman 2014). However, given the relatively slower rate of CSG development, empirical analysis is required to test whether the smaller scale of the CSG industry in NSW has influenced regional economic trajectories.

To compare regions in NSW that have experienced CSG activity (treatment group) with non-CSG regions of similar socioeconomic characteristics (control group), we followed the matching procedure based on population density documented in the Milestone 2 report of this GISERA project (Measham and Fleming 2017). Once the treatment and control regions were identified, a comprehensive dataset of environmental, soil, topographic and socioeconomic variables associated with agricultural, mining, and human capital productivity and profitability were used to model personal and family income dynamics in CSG and non-CSG regions and local indirect employment spillover effects in regions that experienced CSG activity. The results were compared with published findings for Queensland (Fleming and Measham 2015).

In summary, we document the statistical assessment of income and indirect employment variation related to CSG activity in NSW using a baseline of environmental, economic and demographic conditions and state-of-the-art statistical methods. The results contribute to set a robust statistical baseline to compare future economic and social studies of CSG activity in NSW.

2 Methods

We followed a two-step process to investigate the relationship between CSG activity and income dynamics and indirect employment in rural New South Wales during the period 2001–2011. First, we identified regions affected by CSG activity and selected a control group composed of regions without CSG wells but with similar characteristics to the CSG regions. We then applied spatial econometric analysis to assess the linkages between changes in environmental and socioeconomic factors and spatiotemporal income fluctuations. We also applied regression analysis to investigate potential employment spillover effects associated with CSG activity. We used the Australian Bureau of Statistics (ABS) Statistical Area Level 2 (SA2) regions as the spatial unit of analysis. This spatial unit is considered the most robust to privacy concerns while representing a suitably refined degree of spatial resolution. Socioeconomic and environmental data is publicly available for these areas and the statistical methods are well documented in the literature (Elhorst 2014; Millo and Piras 2012; Fleming and Measham 2015; Moretti 2010) which provides an open and transparent way to reproduce the analysis.

2.1 Treatment and control group selection

The number and location of CSG wells drilled for exploration, appraisal or production (NSW Division of Resources and Energy 2015) were used to identify regions that experienced CSG activity during 2000–2011. Wells drilled in 2000 were included in the selection to allow for one-year lagged effects on income dynamics. Thirty SA2 regions experienced CSG activity during the period 2000–2011 with the majority of the wells (75%) drilled after 2006 (Table 1). To construct our treatment group we selected regions with at least two wells drilled during the study period (24 regions) (Fig 1).

While multiple statistical methods could be applied to select regions with similar environmental, socioeconomic and demographic characteristics to the regions influenced by CSG activity (Stuart 2010), following Fleming and Measham (2015) we identified a set of control regions using the population density distribution of CSG regions as a matching parameter. This variable was selected since its value is an indicator of the size of local labour markets, supply and demand of goods and services, and infrastructure development among other indicators of economic activity. In addition, changes in population density have been associated with agricultural land scarcity and declining farm income (Muyanga and Jayne 2014; Josephson, Ricker-Gilbert, and Florax 2014; Marcos-Martinez et al. 2017).

We identified 114 rural SA2 regions without CSG activity during the study period and with population density ranging within the 10^{th} and 90^{th} percentiles of the distribution observed in the treatment group in 2001 (i.e. between 0.4 to 80 persons per square kilometre) (Measham and Fleming 2017). This control group was used to assess changes in personal and family income levels relative to the treatment group (the approximated income effect of CSG activity).

Table 1. SA2 regions with CSG activity (wells drilled per period and cumulative numbers).

	Wells drilled during the period			Cumulative number of wells		
SA2 region ID	2000–01	2000–2006	2000–2011	2000–01	2000–2006	2000–2011
110031198	3	15	116	3	18	134
110041200	1	6	21	1	7	28
123031446	7	41	22	7	48	70
123031448	1	1		1	2	2
104011081	1		2	1	1	3
112021244	3	9	10	3	12	22
112021245	1		35	1	1	36
112021247	1	1	5	1	2	7
105031099		2	11		2	13
106011113		4	14		4	18
113011257		1			1	1*
102021049		6			6	6
107041147		4			4	4
108051167		5	24		5	29
112021249		1	5		1	6
108011151			8		0	8
127011505			1		0	1*
106011107			1		0	1*
106011109			1		0	1*
106041127			2		0	2
105011094			1		0	1*
105031104			3		0	3
106041129			9		0	9
110031196			9		0	9
110041201			7		0	7
105011096			2		0	2
106031125			2		0	2
111031232			2		0	2
112021248			1		0	1*
127011506			2		0	2
Sum	18	96	316	18	114	430

* SA2 regions with only one well were excluded from the treatment group.

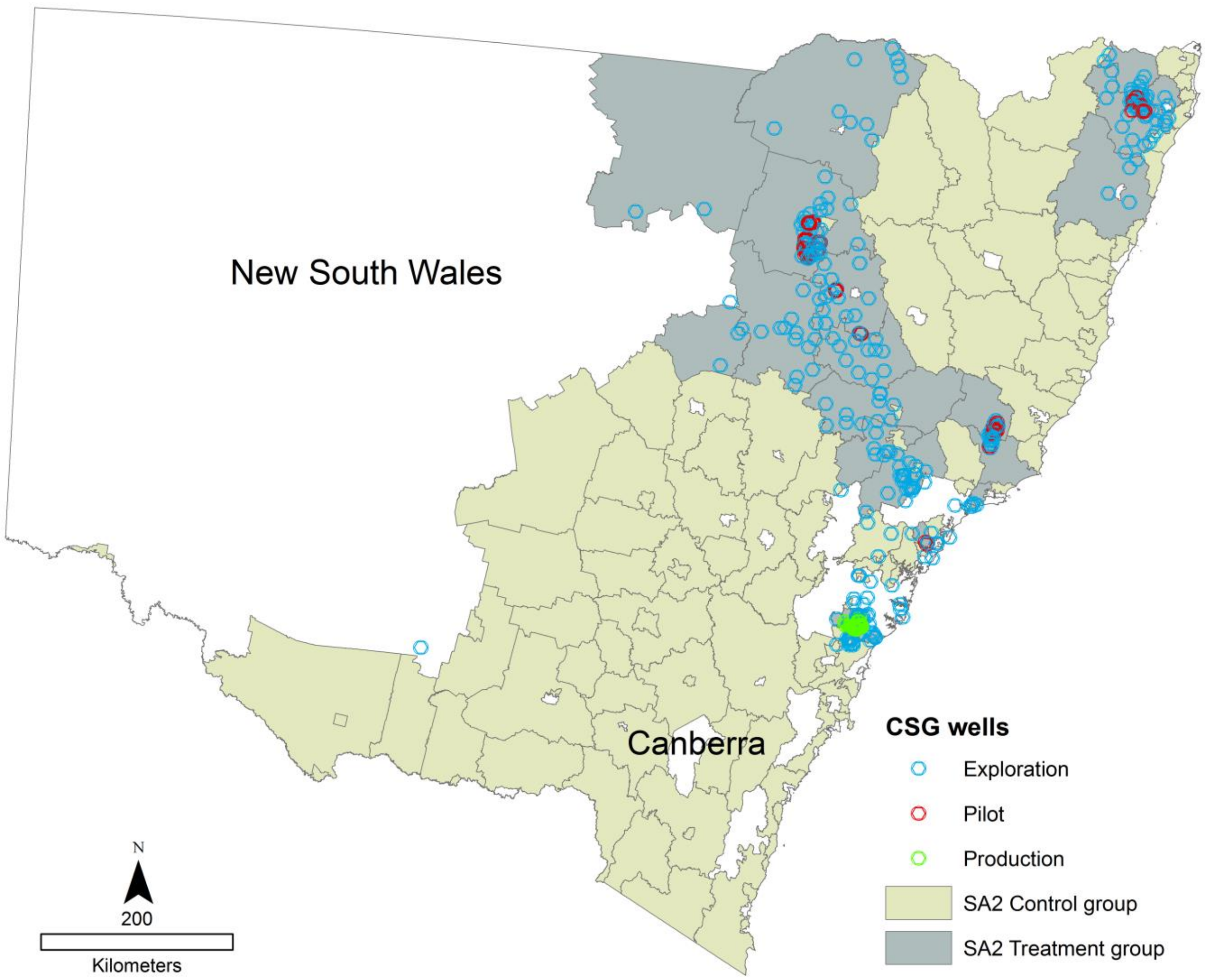


Figure 1. SA2 regions in the treatment and control groups.

2.2 Statistical analysis of income patterns

2.2.1 Spatial panel data with random effects model

In addition to population density, multiple environmental and socioeconomic factors influence spatiotemporal income dynamics in rural areas (Measham and Fleming 2014). For instance, differences in soil characteristics, topography or climatic conditions influence crop and livestock productivity and profitability (Marinoni et al. 2012). The age composition of the labour market, access to services, workers' education, etc., influence the productivity (and income returns) of the human capital. Returns to non-CSG mining (e.g. coal or oil exploration or production) are influenced by changes in exchange and interest rates, prices of minerals, etc. Information for some of those parameters is readily available (e.g. in census databases or open access geographic information systems such as the Aurin portal, https://aurin.org.au/). However multiple parameters associated with regional economic patterns are not easy to collect (e.g. work experience, heterogeneous returns to education or knowledge of farm-specific characteristics that influence profitability). Additionally, regional economic growth is spatially dependent, i.e. influenced by positive or negative externalities that cross regional borders (Fingleton and López-Bazo 2006). To estimate the income effects of CSG in rural regions more accurately, statistical methods should be used to control for unobserved regional differences and spatial dependence.

We modelled spatiotemporal median personal and family income dynamics across CSG and control regions (N = 138) during the years 2001, 2006 and 2011 (T = 3) using a spatial panel data model of the form: $\ln(\mathbf{Y}) = \boldsymbol{\beta}'\ln(\mathbf{X}) + \alpha\mathbf{z} + \mathbf{u}$, where $\mathbf{Y}$ is a vector of personal or family income values observed across the study area and time periods; $\mathbf{X}$ is a matrix of spatiotemporal covariates; $\mathbf{z}$ is a binary vector of identifiers of CSG regions; $\boldsymbol{\beta}$ is a vector of parameter estimates; α is the coefficient of the treatment variable; and $\mathbf{u}$ is an error component that accounts for the effects of spatially correlated unobserved variables ($\mathbf{u} = (\mathbf{I}_T \otimes \rho\mathbf{W})\mathbf{u} + \boldsymbol{\omega}$), unobserved SA2-specific characteristics ($\boldsymbol{\omega} = (\boldsymbol{\iota}_T \otimes \mathbf{I}_N)\boldsymbol{\mu} + \boldsymbol{\upsilon}$), and random disturbances ($\boldsymbol{\upsilon}$)(Marcos-Martinez et al. 2017). Here $\mathbf{I}_T$ and $\mathbf{I}_N$ are identity matrices of dimension T and N; $\boldsymbol{\iota}_T$ is a vector of ones of size T; $\otimes$ indicates the Kronecker product; $\mathbf{W}$ is a spatial weights matrix of size N; ρ is the spatial error correlation coefficient; $\boldsymbol{\omega}$ is a vector that captures unobserved SA2-specific heterogeneity ($\boldsymbol{\mu}$) and standard random normal disturbances ($\boldsymbol{\upsilon}$) (Millo and Piras 2012; Kapoor, Kelejian, and Prucha 2007). Since the main interest of the income effect analysis was to estimate the magnitude, significance and direction of the time-invariant identifier of CSG regions, we modelled the unobserved regional heterogeneity through random effects—i.e. we assumed that $\boldsymbol{\mu}$ is independent of $\mathbf{X}$. The model was estimated using R (R Core Team 2017) with the libraries *splm* (Millo and Piras 2012) for spatial panel regressions, and spdep (Bivand and Piras 2015) for spatial weights matrix generation and spatial autocorrelation tests.

2.2.2 Spatial dependence across SA2 regions in the study area

Spatial dependence among unobserved variables across SA2 regions was modelled through distant-based graph methods under the assumption that neighbouring regions are more likely to have similar economic and environmental characteristics than regions that are located far apart. To simulate the spatial dependence across regions we first generated triangle-based links across regions to approximate regional connectivity (this is technically known as Delaunay triangulation) (Fig 2a). Then we removed links between distant regions that are unlikely to be spatially related. This resulted in a spatial weights matrix based on Gabriel graph neighbours (Fig 2b) (Bivand and

Piras 2015). Symmetry conditions among neighbourhood effects (i.e. if $SA2_i$ is a neighbour of $SA2_k$ then $SA2_k$ is a neighbour of $SA2_i$) and normalised weights among regions were enforced.

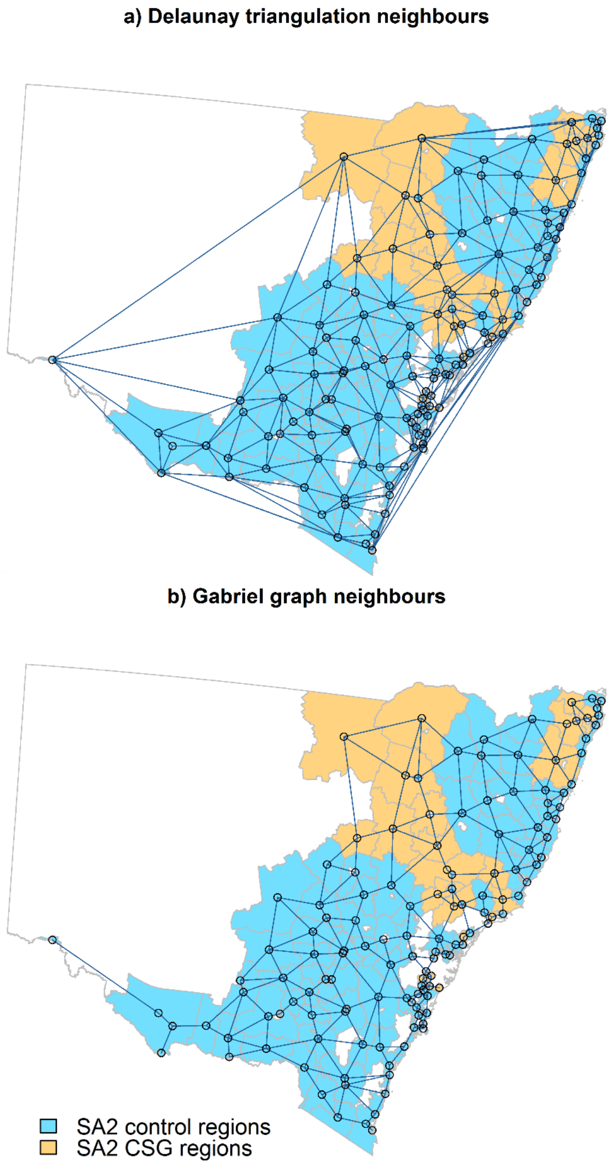


Figure 2. Graph-based generation of the spatial weight matrix. To approximate the spatial dependence among neighbouring regions we first generated triangle-based links across regions in the study area (Delaunay triangulation), and then removed the links between distant regions that are unlikely to be spatially dependent (Gabriel graph neighbours).

2.3 Employment multiplier effects of CSG activity.

Local employment spillovers during the CSG exploration and construction phase have been documented in Queensland for the period 2001–2011 (Fleming and Measham 2015; Fleming et al. 2016). Although the CSG industry in NSW did not reach a comparable level of activity during that period we assessed whether the observed CSG activity was related to changes in indirect employment. Based on Moretti (2010) and Fleming et al. (2016), we first investigated whether changes in mining employment during the period 2001–2011 were associated with changes in employment across other industries. The job multiplier regressions are represented as:

$$\ln\left(employment_{i,2011}\right)-\ln\left(employment_{i,2001}\right)=\beta_0+\beta_1\left[\ln\left(employment_{\text{mining},2011}\right)-\ln\left(employment_{\text{mining},2001}\right)\right]+\varepsilon_i$$

Where *ln* indicates the natural logarithm, $employment_{i,t}$ indicates the proportion of workers employed in industry *i* at time *t*, with *i* different to mining and *t* equal to the years 2001 and 2011, β_0 is the regression intercept, β_1 is the marginal effect on employment in industry *i* of a one percent change in mining employment, and ε_i is a standard random normal error term. Job multiplier analysis for 18 industries were run simultaneously using Seemingly Unrelated Regressions (SUR) to account for the fact that changes in employment in one industry directly or indirectly influence employment in other sectors. The industries considered in the indirect employment analysis were:

1. Agriculture
2. Manufacturing
3. Electricity, gas, water and waste services
4. Construction
5. Wholesale trade
6. Retail trade
7. Accommodation and food services
8. Transport, postal and warehousing
9. Information media and telecommunications
10. Financial and insurance services
11. Rental, hiring and real estate services
12. Professional, scientific and technical services
13. Administrative and support services
14. Public administration and safety
15. Education and training
16. Health care and social assistance
17. Arts and recreation services
18. Other services

Additionally, to control for changes in employment in the mining sector unrelated to the CSG industry (e.g. increasing employment in coal production), we also estimated a system of seemingly unrelated regressions using the number of CSG wells within each SA2 region as an instrumental variable (IV) (Fleming and Measham 2015). The corresponding SUR–IV model for industry *i* is:

$$\ln\left(employment_{i,2011}\right)-\ln\left(employment_{i,2001}\right)=\beta_0+\beta_1\left[\ln\left(CSG\text{ wells}_{2011}\right)-\ln\left(CSG\text{ wells}_{2001}\right)\right]+\varepsilon_i .$$

The SUR and SUR–IV systems of equations were estimated in R (R Core Team 2017) using two- and three-stage least squares with the package *systemfit* (Henningsen and Hamann 2007).

3 Data

Based on boundaries of the control and treatment regions (Fig 1) and spatial data of climatic, soil and topographic characteristics, we estimated average values for parameters associated with crop and livestock productivity (Table 2). Socioeconomic time series were also collected to account for human capital parameters (e.g. percentage of the labour force with at least a bachelor degree) and for variables that influence returns to mining activity (e.g. exchange rates, prices of relevant minerals). Variance inflation factors were estimated to identify correlation issues among the collected variables and to inform model selection.

Table 2. Average region specific characteristics related to land and human capital productivity.

Variable	Description and source	Unit	Resolution	Included in regression
Dependent variables				
Personal income	Median total personal income (weekly) (ABS 2011a).	2011/12 AUD	SA2	Yes
Family income	Median total family income (weekly) (ABS 2011a).	2011/12 AUD	SA2	Yes
Average soil and topographic characteristics				
Bulk density	Upper 30 cm soil layer bulk density (ACLEP 2014).	Mg/m^3		Yes
Clay content	Upper 30 cm soil layer % clay content (ACLEP 2014).	%	250 m	Yes
pH	Upper 30 cm soil layer pH (ACLEP 2014).	-	250 m	
Slope	Topographic gradient.	degree	95 m	Yes
Elevation	Metres above sea level (Gallant et al. 2011).	metres	95 m	Yes

Table 2. Average region specific characteristics related to land and human capital productivity (continued).

Variable	Description (source)	Unit	Resolution	Included in regression
Average climatic conditions				
Maximum temperature (long term mean)	Average maximum temperature observed during the period 1978–2015.	°C	0.05°	No
Rainfall (long term mean)	Average annual rainfall observed during the period 1978–2015.	mm	0.05°	No
Rainfall	Five-year moving averages of annual rainfall (Australian Bureau of Meteorology 2015).	mm	0.05°	Yes
Rainfall variability	Five-year moving standard deviations of annual rainfall.	mm	0.05°	Yes
Maximum temperature	Five-year moving averages of annual average maximum temperature (Australian Bureau of Meteorology 2015).	°C	0.05°	Yes
Maximum temperature variability	Five-year moving standard deviations of annual average maximum temperature.	°C	0.05°	Yes
Socioeconomic factors				
Population density	Number of people per square kilometre.	people/km^2	SA2	No
Age (and age squared)	Median age of persons (ABS 2011a).	year	SA2	Yes
Household size	Average household size (ABS 2011a).	person	SA2	No
Education level	Number of persons with bachelor, graduate or postgraduate degree (ABS 2011b).	person	SA2	No
Labour force	Persons aged 15 years and over (ABS 2011b).	person	SA2	No
Higher education	Percent of population aged 15 years and over with at least a bachelor degree.	%	SA2	Yes
Total employment	Total number of persons employed across industries (ABS 2011c).	person	SA2	No
Percent employed in agriculture	Percent employed in agriculture with respect to total employment.	%	SA2	Yes
Percent employed in mining	Percent employed in mining (including gas extraction) with respect to total employment.	%	SA2	Yes
Percent employed in manufacturing	Percent employed in manufacturing with respect to total employment.	%	SA2	Yes

Table 2. Average region specific characteristics related to land and human capital productivity (continued).

Variable	Description (source)	Unit	Resolution	Included in regression
Socioeconomic factors				
Percent employed in other industries	Percent employed in other industries with respect to total employment (ABS 2011c).	%	SA2	Yes
Mortgage repayment	Median mortgage repayment (monthly) (ABS 2011a).	2011/12 AUD	SA2	No
Household income	Median total household income (weekly) (ABS 2011a).	2011/12 AUD	SA2	No
Remoteness accessibility index	The Accessibility and Remoteness Index of Australia (ARIA) is based on the road distance from populated localities to urban centres offering public and private services (GISCA 2001).	score	1 km	Yes
CSG region	Categorical variable to indicate regions with coal seam gas activity (NSW Division of Resources and Energy 2015).	binary	SA2	Yes
CSG well density	Number of CSG wells per 100 square kilometres.	Wells per 100 km^2	SA2	Yes
Non-CSG well density	Number of drillholes for non-CSG mining (e.g. oil or minerals exploration) per 100 square kilometres.	Wells per 100 km^2	SA2	Yes
Iron ore prices	Average export unit value $/ton of iron ore (Office of the Chief Economist 2014).	2011/12 AUD		No
Thermal coal price	Average export unit value $/ton of thermal coal (Office of the Chief Economist 2014).	2011/12 AUD		Yes
Trade weighted index	Weighted geometric average of the currencies used in at least 90% of Australia's two-way merchandise and services trade (Reserve Bank of Australia, 2014a).	2011=1		No
Interest rates	Annual interbank interest rate (Reserve Bank of Australia 2014).	%		No
Farmers' terms of trade	Ratio of prices received (outputs) to prices paid (inputs) by Australian farmers (Australian National Greenhouse Accounts 2013).	2011/12 AUD		No

Note: SA2 averages of spatial data were computed using zonal statistics in ArcMap 10.4.

Summary statistics indicate that the distribution of the explanatory variables in the control group closely matched the distribution observed in the treatment group (Table 3). This provides empirical support to the use of population density as a matching variable. Maps of the spatially explicit variables used in the analysis are shown in Appendix A.

Table 3. Summary statistics for continuous variables used in the statistical analysis.

Variable	Mean		Standard deviation		Unit
	CSG regions	Non-CSG regions	CSG regions	Non-CSG regions	
Dependent variables					
Personal income	474.00	460.00	96.84	95.63	2011/12 AUD
Family income	1198.00	1132.00	319.28	280.38	2011/12 AUD
Average soil and topographic characteristics					
Bulk density	1.35	1.38	0.09	0.13	Mg/m^3
Clay content	28.76	25.12	12.11	9.34	%
Slope	5.15	4.88	3.71	3.33	degree
Elevation	246.00	339.7	147.92	297.39	metres
Average climatic conditions					
Rainfall	908.00	875.00	273.00	378.00	mm
Rainfall variability	172.00	175.00	72.00	103.00	mm
Maximum temperature	24.10	22.60	1.73	2.12	^oC
Maximum temperature variability	0.49	0.46	0.18	0.17	^oC
Socioeconomic factors					
Age	39.20	40.40	4.17	5.67	years
Higher education	8.48	9.81	3.24	4.30	%
Percent employed in agriculture	18.72	14.05	14.05	11.71	%
Percent employed in mining	2.60	1.48	5.12	3.33	%
Percent employed in manufacturing	8.44	8.42	3.75	3.72	%
Remoteness accessibility index	3.6	3.00	2.77	1.74	Score
CSG well density	1.32	0.00	4.00	0.00	Wells per 100 km^2
Non-CSG well density	0.53	0.88	1.36	2.91	Non-CSG wells per 100 km^2
Thermal coal prices (export price)	81.48	81.48	14.55	14.55	2011/12 AUD

4 Results

4.1 Income effects analysis

Marginal income effects of CSG activity. Estimates for the CSG region variable indicate that, holding everything else constant, regions in the treatment group had 6.47% and 6.31% higher personal and family income than regions in the control group, on average (Tables 4 and 5). These results were statistically significant at the 5% level.

Variables associated with agricultural and non-CSG mining income. Spatiotemporal variations in climate and soil characteristics partially explain regional differences in agricultural returns and land use allocations (Marcos-Martinez et al. 2017). Although farm income is generally low in Australia (Vanclay 2003) changes in the profitability of agricultural activities are likely associated with personal and family income patterns observed during the study period. The results indicate that on average regions with higher bulk density had larger personal and family income. Elevation also had a positive but small association with regional family income levels. Increases in annual average rainfall were negatively associated with changes in both personal and family income levels. A one percent increase in maximum temperature was negatively related to personal income. Increasing maximum temperature variability was associated with lower median income across the study area. Increases in thermal coal prices (a variable correlated with other mineral commodities prices) were related to higher income levels.

Factors that influence returns to human capital. A one percent increase in the proportion of the labour force with at least a bachelor degree (higher education) was statistically associated with 0.17% higher family and personal income on average. The coefficients of median age and median age squared reflect the non-linear association of this variable with income generation (i.e. increases in median age improve income levels at a decreasing rate). Regions located in remote areas were associated with lower income levels. Increases in the proportion of people employed in agricultural or manufacturing industries were associated with lower personal and family income.

Other parameters were not statistically different to zero, i.e. the data suggest the corresponding covariates have not been associated with observed changes in income indicators.

Table 4. Percent change in personal income associated with a 1% change in each continuous variable or relative to non-CSG regions.

Parameters	Estimate	Std. Error	t-value	Pr(>|t|)	
CSG region	6.4672	2.7301	2.3689	0.0183	**
Well density	0.0003	0.0013	0.1985	0.8426	
Average soil and topographic characteristics					
Bulk density	0.3765	0.1431	2.6318	0.0085	***
Clay content	0.0036	0.0343	0.1064	0.9153	
Elevation	0.0082	0.0143	0.5728	0.5668	
Slope	–0.0050	0.0157	–0.3201	0.7489	
Average climatic conditions					
Rainfall	–0.0630	0.0222	–2.8387	0.0045	***
Rainfall variability	0.0008	0.0058	0.1378	0.8904	
Maximum temperature	–0.4015	0.1187	–3.3838	0.0007	***
Maximum temperature variability	–0.0188	0.0081	–2.3327	0.0197	**
Socioeconomic factors					
Higher education	0.1652	0.0153	10.7811	0.0000	***
Median age	4.3016	0.1127	38.1694	0.0000	***
Median age squared	–2.4541	0.0888	–27.6281	0.0000	***
Remoteness/accessibility index	–0.0384	0.0182	–2.1028	0.0355	**
Agricultural employment	–0.0266	0.0109	–2.4421	0.0146	**
Mining employment	0.0001	0.0022	0.0368	0.9706	
Manufacturing employment	–0.0417	0.0123	–3.3757	0.0007	***
Thermal coal price	0.2770	0.0327	8.4593	0.0000	***
Non-CSG well density	0.0009	0.0009	0.9639	0.3351	
Intercept	8.8998	0.4910	18.1277	0.0000	***
Error variance parameters					
Var. of unobserved heterogeneity / Var. of random disturbances	10.5583	1.6456	6.4160	0.0000	***
Spatial error correlation	0.0955	0.0660	1.4477	0.1477	
R-squared	0.9782				

Significance codes: '***' 0.01 '**' 0.05 '*' 0.1. All continuous variables were log transformed.
Balanced dataset: 414 observations (114 control regions, 24 treatment regions, and 3 periods).

Table 5. Percent change in family income associated with a 1% change in each continuous variable or relative to non-CSG regions.

Parameters	Estimate	Std. Error	t-value	Pr(>|t|)	
CSG region	6.3085	2.8308	2.2285	0.0264	**
Well density	0.0026	0.0017	1.5318	0.1256	
Average soil and topographic characteristics					
Bulk density	0.3278	0.1528	2.1460	0.0319	**
Clay content	–0.0307	0.0358	–0.8577	0.3911	
Elevation	0.0381	0.0153	2.4954	0.0126	**
Slope	0.0033	0.0167	0.2001	0.8414	
Average climatic conditions					
Rainfall	–0.1253	0.0282	-4.4494	0.0000	***
Rainfall variability	0.0003	0.0079	0.0403	0.9679	
Maximum temperature	–0.0366	0.1343	–0.2725	0.7852	
Maximum temperature variability	–0.0576	0.0111	-5.1878	0.0000	***
Socioeconomic factors					
Higher education	0.1772	0.0171	10.3756	0.0000	***
Median age	4.4563	0.1330	33.5113	0.0000	***
Median age squared	–2.5146	0.1048	–24.0046	0.0000	***
Remoteness/accessibility index	–0.1006	0.0197	–5.1178	0.0000	***
Agricultural employment	–0.0256	0.0125	–2.0563	0.0398	**
Mining employment	–0.0022	0.0028	–0.7895	0.4298	
Manufacturing employment	–0.0513	0.0146	–3.5077	0.0005	***
Thermal coal price	0.2931	0.0404	7.2616	0.0000	***
Non-CSG density	–0.0007	0.0011	–0.6260	0.5313	
Intercept	8.8663	0.5549	15.9794	0.0000	***
Error variance parameters					
Var. of unobserved heterogeneity / Var. of random disturbances	6.4219	1.1052	5.8106	0.0000	***
Spatial error correlation	0.2880	0.0640	4.5007	0.0000	***
R-squared	0.9760				

Significance codes: '***' 0.01 '**' 0.05 '*' 0.1. All continuous variables were log transformed.
Balanced dataset: 414 observations (114 control regions, 24 treatment regions, and 3 periods).

Unobserved regional characteristics and spatial dependence. The estimated model is a reduced-form representation of the complex interlinkages that drive income patterns. The statistical procedure implemented to control for unobserved, spatially dependent factors helped the model explain a significant proportion of the family and personal income variability observed across regions (Fig 3) and periods (Fig 4) (R-squared values of 0.98 for both income indicators). The estimates closely approximated the average spatial income patterns observed during the period 2001–2011 (Fig 3). As a comparison, using only the observed data (Xs) a regression analysis would be only able to explain around 63% and 69% of the spatiotemporal personal and family income variability. The high explanatory power is common for spatial econometric models (e.g. Wheeler et al. 2013). The estimated spatial error correlation parameters indicate low (0.10) and moderate (0.29) spatial dependence among unobserved factors in neighbouring regions influencing personal and family income, respectively. However, this parameter was only statistically significant for family income.

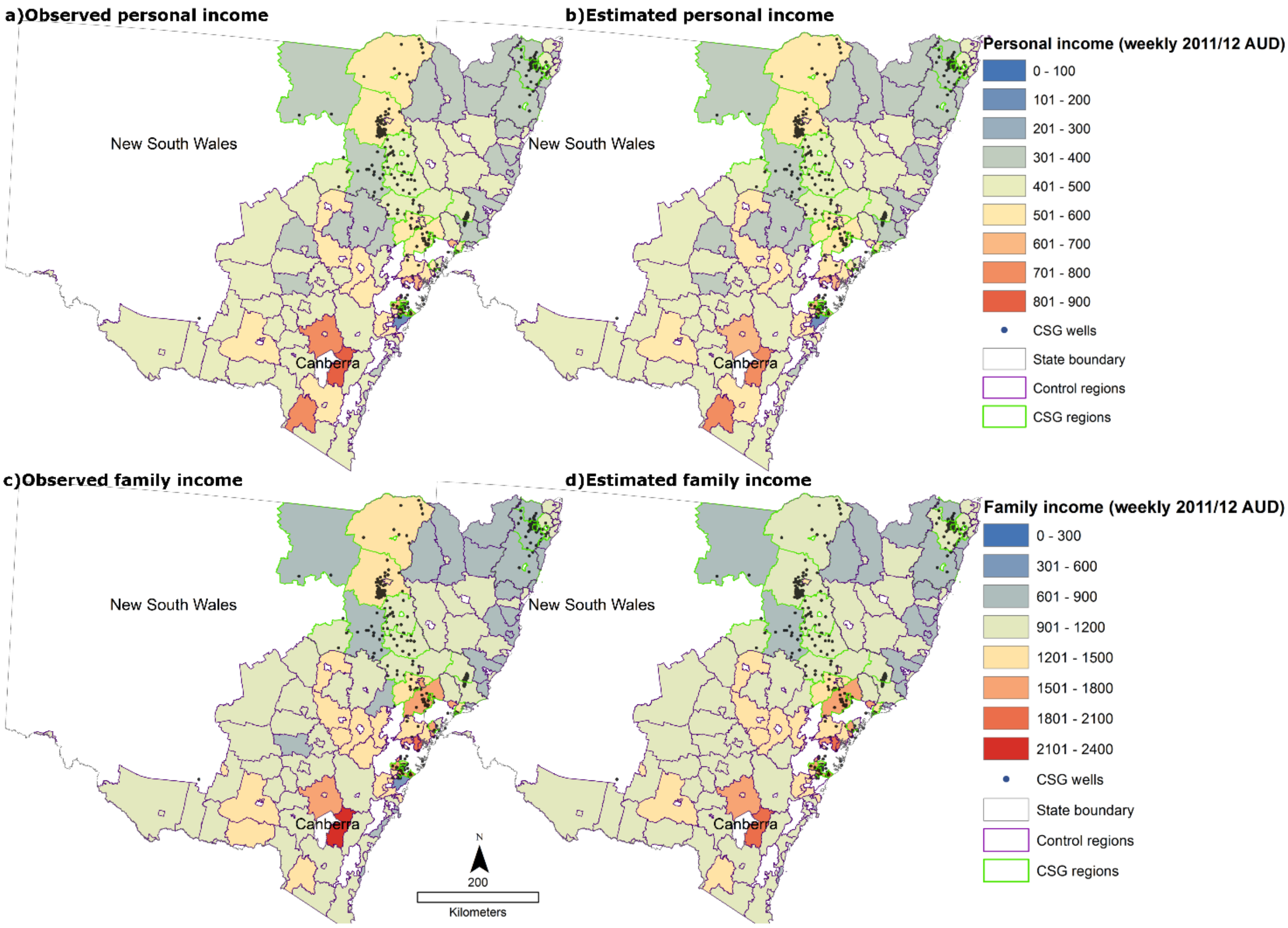


Figure 3. Observed and estimated personal and family income (2001–2011 mean). Average personal income: observed (a) and estimated (b). Average family income: observed (c) and estimated (d).

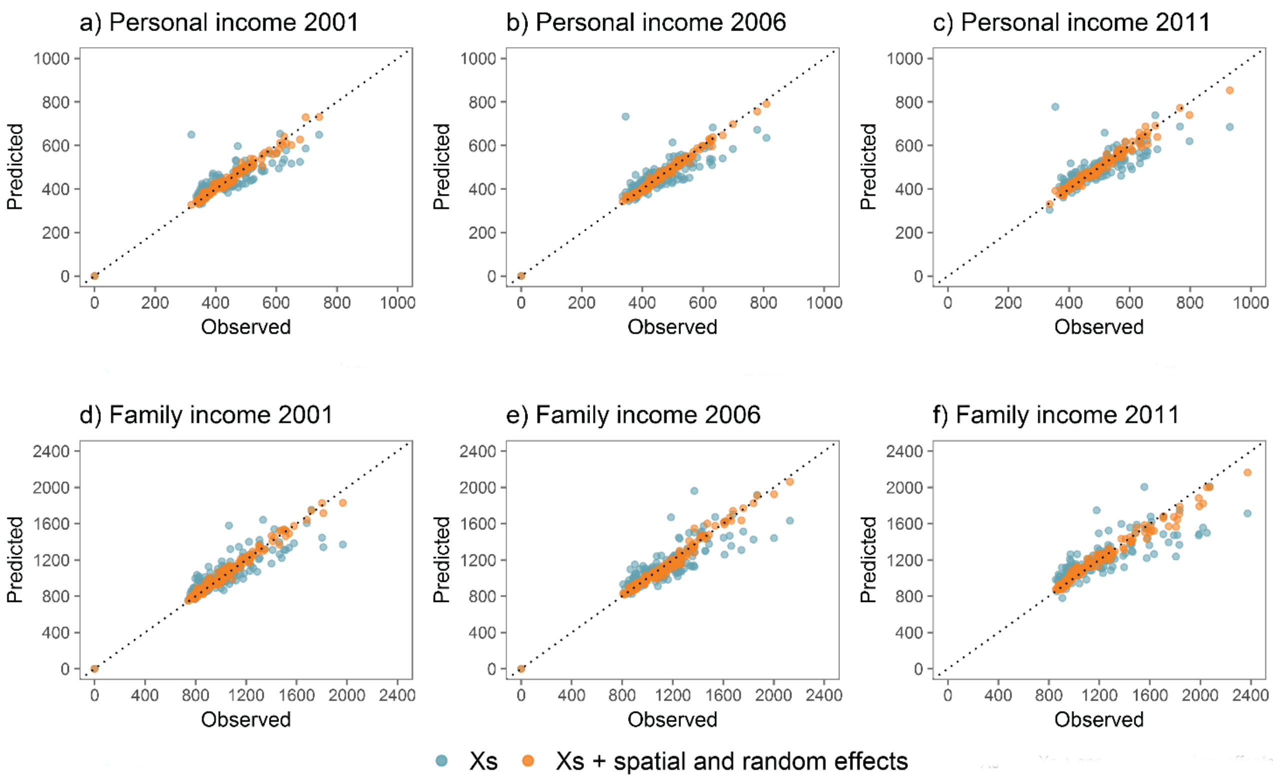


Figure 4. Contribution of spatial effects and unobserved heterogeneity in the modelling of median personal and family income dynamics. Dashed diagonal lines indicate perfect fit between observed and estimated data. Estimates based only on included explanatory variables (Xs) are shown in blue. Estimates based on the Xs and the unobserved heterogeneity and spatial effects (Xs + spatial and random effects) are shown in orange.

4.2 Employment multiplier effects of CSG activity

The results of the indirect employment analysis indicate that employment in the *Rental, hiring and real estate services* and the *Professional, scientific and technical services* industries were positively associated with changes in employment in the mining sector (including non-CSG mining) (Table 2). However, when we assessed whether such effect was related to CSG activity (using the SUR-instrumental variable model) we did not find statistical evidence of job multiplier effects related to the CSG industry during the study period (Table 6).

Table 6. Results of statistical analysis of CSG employment multiplier effects during the period 2001–2011.

Industry of employment	Seemingly unrelated regressions (SUR) coefficients	SUR – instrumental variable regressions coefficients
Agriculture	0.0047	0.0030
Manufacturing	–0.0020	–0.0072
Electricity, gas, water and waste services	0.0219	0.0147
Construction	0.0002	–0.0027
Wholesale trade	0.0017	–0.0128
Retail trade	–0.0488	–0.0768
Accommodation and food services	–0.0031	–0.0001
Transport, postal and warehousing	0.0009	–0.0072
Information media and telecommunications	0.0012	–0.0171
Financial and insurance services	0.0098	0.0039
Rental, hiring and real estate services	**0.0401**	0.0195
Professional, scientific and technical services	**0.0195**	0.0098
Administrative and support services	–0.0052	–0.0129
Public administration and safety	–0.0087	–0.0176
Education and training	–0.0048	–0.0004
Health care and social assistance	0.0050	–0.0040
Arts and recreation services	0.0151	0.0024
Other services	–0.0017	–0.0009
McElroy-R2	0.0634	0.0446
Explanatory variable	Log of the 2001–11 change in mining employment	log of 2001–11 change in well numbers

Number of observations: 24. Bold numbers indicate statistical significance at the 10% level.

5 Discussion

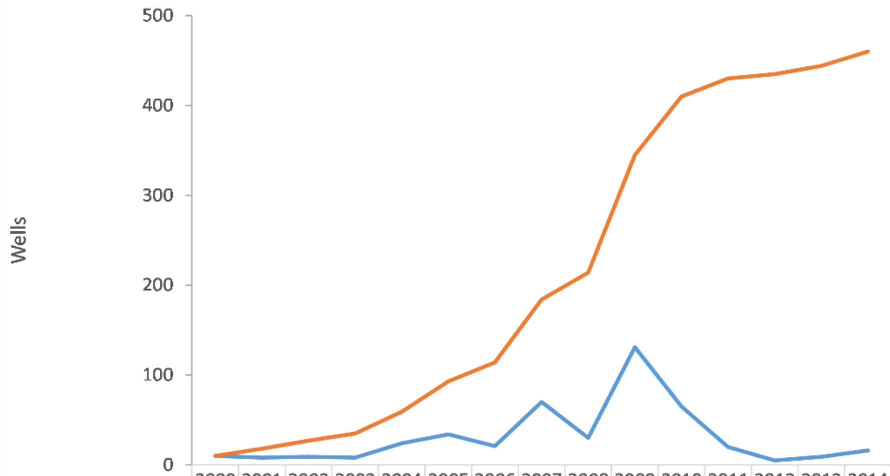
5.1 CSG development and regional income dynamics

Spatial econometric analysis allowed the estimation of the marginal effect of CSG activity observed during the period 2001–2011 while controlling for the influence of other spatiotemporal factors such as topographic and climatic characteristics and non-modelled regional differences that influence income dynamics in rural NSW. For instance, the unobserved regional heterogeneity may include short-term economic impacts of the National Broadband Network rollout across the study area, differences in access to irrigation across regions (Appendix A), and significant non-CSG mining activity in some regions (e.g. coal production). Statistically significant differences in median personal and family income were detected between treatment CSG and control regions. These findings are consistent with the income effects of the CSG construction phase in Queensland (Fleming and Measham 2015).

The matching procedure based on population density generated covariates with similar distribution among the treatment and control groups. The endogenous selection of treatment and control groups sharing similar characteristics may explain the low marginal effects of most of the modelled variables. We expected that increases in precipitation would be associated with higher income from improved agricultural yields. The counterintuitive negative association detected between rainfall and income may reflect the decreasing rainfall patterns observed during the Millennium drought (1997–2012) (Heberger 2011) in a context of increasing household disposable income which occurred mostly outside the farm sector (OECD 2017). The coefficients for the modelled human capital indicators are consistent with past research showing positive returns of education on income and the patterns of life cycle earnings (income increasing at decreasing rates as experience grows) (Willis 1986; Blundell, Graber, and Mogstad 2015). Increases in minerals demand generating long-lived price increases could result in new mining developments, expansion of existing projects, increased exploration and expansion of related infrastructure (Rolfe et al. 2007). The marginal effect of increases in mineral prices appears to be approximated by the positive and statistically significant coefficients of thermal prices (a variable highly correlated with the prices of other mining commodities).

The number of CSG wells drilled per year during the study period reached a maximum in 2009 (131 new wells drilled that year). Multiple factors motivated a decrease in CSG extraction that resulted in low levels of drilling activity after 2012 (Fig 5). The activity of the industry during the study period was not statistically associated with changes in employment in other sectors. This result is consistent with the economic baseline assessment of official employment statistics documented in the Milestone 2 report of this project (Measham and Fleming 2017). We expect similar conclusions for other secondary and tertiary socioeconomic impacts documented for other regions with comparatively large CSG activity (Rolfe et al. 2007; Measham and Fleming 2014; Marinoni and Navarro Garcia 2016). However further research is needed to document such hypotheses.

While we tested for a potential linkage between CSG well density and income effects, the low spatial and temporal variability of drilling activity could explain the lack of statistical significance of the CSG well density parameter. Most of the CSG wells drilled during the study period were concentrated in a few SA2 regions—25% of the regions in the treatment group accounted for 74% of the total number of wells—and the majority of the wells were drilled after 2006.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Wells per year	10	8	9	8	24	34	21	70	30	131	65	20	5	9	16
Cumulative	10	18	27	35	59	93	114	184	214	345	410	430	435	444	460

Figure 5. CSG wells drilled per year and cumulative values.

The results show that statistical procedures to control for spatially dependent unobserved variables associated with regional income dynamics help to generate more accurate marginal effect estimates. The high explanatory power of the model can be used to estimate deviations from 2001–2011 trends in income indicators that could be attributable to future levels of CSG activity once more data is available.

5.2 Limitations

We emphasise that the estimated models are a reduced-form representation of the complex interlinkages that drive income and employment patterns. The statistical results in this report only indicate associations between the treatment (CSG activity) and the assessed economic outcomes (median income level and indirect employment) under the applied modelling assumptions. A causal inference analysis could help to better approximate the economic effect of the CSG industry in the study region (Law et al. 2017). Spatial dependence across regions in the study area was approximated through a distance-based spatial weight matrix. This approach could be improved by using data on the flow of trade between regions (Qu and Lee 2015) or estimates of available CSG resources at the basin level.

6 Conclusion

Rural economic development is influenced by complex political, institutional, economic and environmental processes (Scoones 2009). While structural modelling of all those processes could allow a robust assessment of the net effects of CSG development on rural economies, such an exercise would be extremely data and resource intensive. As an alternative we show that a spatial econometric approach could help account for some of the main factors influencing rural income dynamics and provide policy makers with more robust estimates of the socioeconomic effects associated with the CSG industry. The statistical income analysis indicates that the CSG industry in NSW was associated with higher median personal and family income relative to regions without CSG presence during the period 2001–2011. The estimated income effect is net of the influence of other factors that are related to changes in rural income patterns (e.g. changes in climate impacting agricultural profitability), human capital productivity (e.g. age and education) and returns to non-CSG mining activity (e.g. changes in mineral prices). In contrast, no statistical evidence of job multiplier effects related to CSG activity was found.

Further research is needed to assess the impacts and benefits that the CSG industry has during different stages of development on regional economies (i.e. exploration, production, and retirement of CSG wells). This could improve the robustness of projections of potential economic and demographic changes associated with future CSG development.

7 References

ABS. 2011a. "T02 Selected Medians and Averages." Canberra: Australian Bureau of Statistics. http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_CENSUS2011_T02.

———. 2011b. "T28 Selected Labour Force, Education and Migration Characteristics."

———. 2011c. "T33 Industry of Employment by Sex." Canberra: Australian Bureau of Statistics. http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_CENSUS2011_T33.

ACLEP. 2014. "National Soil Data Provided by the Australian Collaborative Land Evaluation Program." National Committee on Soil and Terrain. http://www.asris.csiro.au/themes/NationalGrids.html.

Australian Bureau of Meteorology. 2015. "Climate Data Online." http://www.bom.gov.au/climate/data/.

Australian National Greenhouse Accounts. 2013. "Australian Land Use, Land Use Change and Forestry Emissions Projections to 2030." Canberra.

Bivand, Roger, and Gianfranco Piras. 2015. "Comparing Implementations of Estimation Methods for Spatial Econometrics." *Journal of Statistical Software* 63 (18): 1–36. http://www.jstatsoft.org/v63/i18/.

Blundell, Richard, Michael Graber, and Magne Mogstad. 2015. "Labor Income Dynamics and the Insurance from Taxes, Transfers, and the Family." *Journal of Public Economics* 127 (July): 58–73. doi:10.1016/j.jpubeco.2014.04.011.

Elhorst, Paul J. 2014. *Spatial Econometrics From Cross-Sectional Data to Spatial Panels*. Edited by Henk Folmer, Mark Partridge, Gilles Duranton, Daniel P. McMillan, Andrés Rodríguez-Pose, and Henry W. C. Yeung. Springer. http://www.springer.com/economics/regional+science/book/978-3-642-40339-2.

Fingleton, Bernard, and Enrique López-Bazo. 2006. "Empirical Growth Models with Spatial Effects." *Papers in Regional Science* 85 (2). Blackwell Publishing Ltd: 177–98. doi:10.1111/j.1435-5957.2006.00074.x.

Fleming, David A., and Thomas G. Measham. 2015. "Local Economic Impacts of an Unconventional Energy Boom: The Coal Seam Gas Industry in Australia." *Australian Journal of Agricultural and Resource Economics* 59 (1): 78–94. doi:10.1111/1467-8489.12043.

Fleming, David A., Thomas G. Measham, Paul Graham, and Y. Cai. 2016. "Employment Scenarios in Queensland CSG Regions 2014-2034: A Report to the Gas Industry Social and Environmental Research Alliance (GISERA)." Canberra.

Gallant, J., N. Wilson, T. Dowling, A. Read, and C. Inskeep. 2011. "STRM-Derived 3 Second Digital Elevation Model Version 1.0." Canberra: Commonwealth of Australia (Geoscience Australia). http://www.ga.gov.au/metadata-gateway/metadata/record/72760/.

GISCA. 2001. “Accessibility/Remoteness Index of Australia (ARIA).” Canberra: Australian Bureau of Statistics. http://data.daff.gov.au/anrdl/metadata_files/pa_aria_r9s___00312a00.xml.

Heberger, Matthew. 2011. “Australia’s Millennium Drought: Impacts and Responses.” In *The World’s Water*, 97–125. doi:10.5822/978-1-59726-228-6_5.

Henningsen, Arne, and Jeff D. Hamann. 2007. “Systemfit: A Package for Estimating Systems of Simultaneous Equations in R.” *Journal of Statistical Software* 23 (4): 40. doi:10.1007/BF02589035.

Josephson, Anna Leigh, Jacob Ricker-Gilbert, and Raymond J.G.M. Florax. 2014. “How Does Population Density Influence Agricultural Intensification and Productivity? Evidence from Ethiopia.” *Food Policy* 48 (October): 142–52. doi:10.1016/j.foodpol.2014.03.004.

Kapoor, Mudit, Harry H. Kelejian, and Ingmar R. Prucha. 2007. “Panel Data Models with Spatially Correlated Error Components.” *Journal of Econometrics* 140 (1): 97–130.

Law, Elizabeth A, Paul J Ferraro, Peter Arcese, Brett A Bryan, Katrina Davis, Ascelin Gordon, Matthew H Holden, et al. 2017. “Projecting the Performance of Conservation Interventions.” *Biological Conservation* 215 (November): 142–51. doi:10.1016/j.biocon.2017.08.029.

Marcos-Martinez, Raymundo, Brett A. Bryan, Jeffery D. Connor, and Darran King. 2017. “Agricultural Land-Use Dynamics: Assessing the Relative Importance of Socioeconomic and Biophysical Drivers for More Targeted Policy.” *Land Use Policy* 63 (April): 53–66. doi:10.1016/j.landusepol.2017.01.011.

Marinoni, O., and J. Navarro Garcia. 2016. “A Novel Model to Estimate the Impact of Coal Seam Gas Extraction on Agro-Economic Returns.” *Land Use Policy* 59 (December). Elsevier Ltd: 351–65. doi:10.1016/j.landusepol.2016.08.027.

Marinoni, O., J. Navarro Garcia, S. Marvanek, D. Prestwidge, D. Clifford, and L.A. a. Laredo. 2012. “Development of a System to Produce Maps of Agricultural Profit on a Continental Scale: An Example for Australia.” *Agricultural Systems* 105 (December): 33–45. doi:10.1016/j.agsy.2011.09.002.

Measham, Thomas G., and David A. Fleming. 2014. “Impacts of Unconventional Gas Development on Rural Community Decline.” *Journal of Rural Studies* 36 (October): 376–85. doi:10.1016/j.jrurstud.2014.04.003.

———. 2017. “Economic Baseline for NSW CSG Regions: Report to the Gas Industry Social and Environmental Research Alliance (GISERA).” Canberra.

Millo, Giovanni, and Gianfranco Piras. 2012. “Splm: Spatial Panel Data Models in R.” *Journal of Statistical Software* 47 (1): 1–38. http://www.jstatsoft.org/v47/i01/paper.

Moretti, Enrico. 2010. “Local Multipliers.” *American Economic Review* 100 (2): 373–77. doi:10.1257/aer.100.2.373.

Muyanga, Milu, and T.S. Jayne. 2014. “Effects of Rising Rural Population Density on Smallholder Agriculture in Kenya.” *Food Policy* 48 (October): 98–113. doi:10.1016/j.foodpol.2014.03.001.

NCRIS. 2017. "Australian Urban Research Infrastructure Network Portal." https://portal.aurin.org.au/.

NSW Division of Resources and Energy. 2015. "Drillholes and Wells Location." http://dwh.minerals.nsw.gov.au/CI/warehouse.

OECD. 2017. "Household Disposable Income (Indicator)." doi:10.1787/dd50eddd-en.

Office of the Chief Economist. 2014. "Resources and Energy Statistics 2014." Canberra.

Qu, Xi, and Lung Fei Lee. 2015. "Estimating a Spatial Autoregressive Model with an Endogenous Spatial Weight Matrix." *Journal of Econometrics* 184 (2): 209–32. doi:10.1016/j.jeconom.2014.08.008.

R Core Team. 2017. "R: A Language and Environment for Statistical Computing." Vienna, Austria: R Foundation for Statistical Computing. https://www.r-project.org/.

Reserve Bank of Australia. 2014. "Interest Rates and Yields - Money Market." www.rba.gov.au/statistics/tables/xls/f01hist.xls.

Rolfe, John, Bob Miles, Stewart Lockie, and Galina Ivanova. 2007. "Lessons from the Social and Economic Impacts of the Mining Boom in the Bowen Basin 2004-2006." *Australasian Journal of Regional Studies* 13 (2): 134–53.

Roth, Lenny. 2011. *Regulation of the Coal Seam Gas Industry in NSW*. https://pdfs.semanticscholar.org/f7cc/4907f2524c721dcd7a8dffa7e15933911107.pdf.

Scoones, Ian. 2009. "Livelihoods Perspectives and Rural Development." *Journal of Peasant Studies* 36 (1): 171–96. doi:10.1080/03066150902820503.

Sherval, M, and K Hardiman. 2014. "Competing Perceptions of the Rural Idyll: Responses to Threats from Coal Seam Gas Development in Gloucester, NSW, Australia." *Australian Geographer*. http://www.tandfonline.com/doi/abs/10.1080/00049182.2014.899028.

Stuart, Elizabeth A. 2010. "Matching Methods for Causal Inference: A Review and a Look Forward." *Statistical Science : A Review Journal of the Institute of Mathematical Statistics* 25 (1). NIH Public Access: 1–21. doi:10.1214/09-STS313.

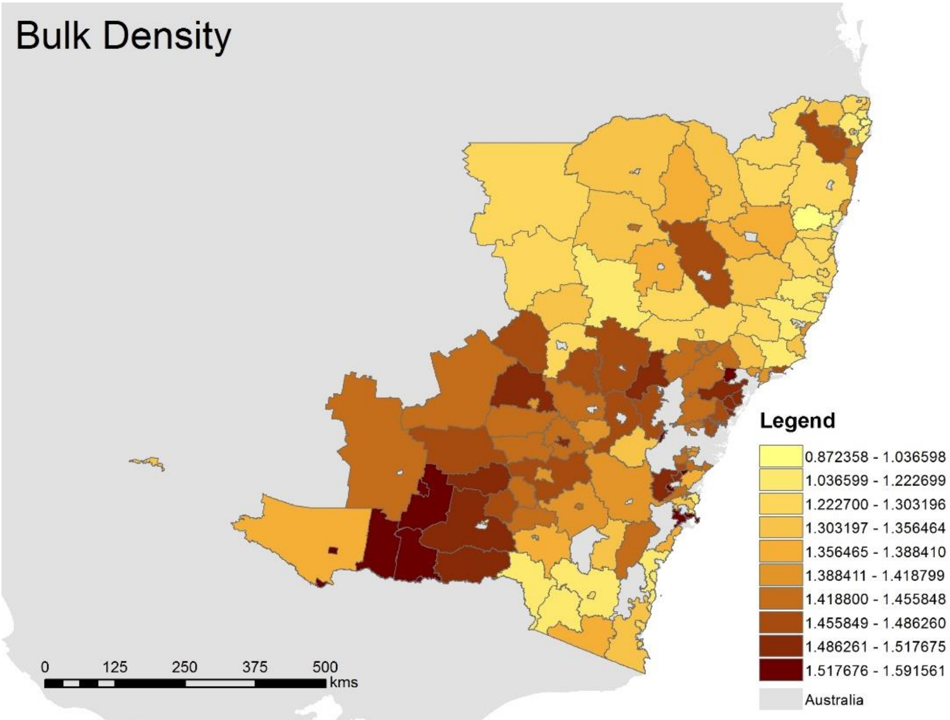
Vanclay, F. 2003. "The Impacts of Deregulation and Agricultural Restructuring for Rural Australia." *Australian Journal of Social Issues*. http://onlinelibrary.wiley.com/doi/10.1002/j.1839-4655.2003.tb01137.x/full.

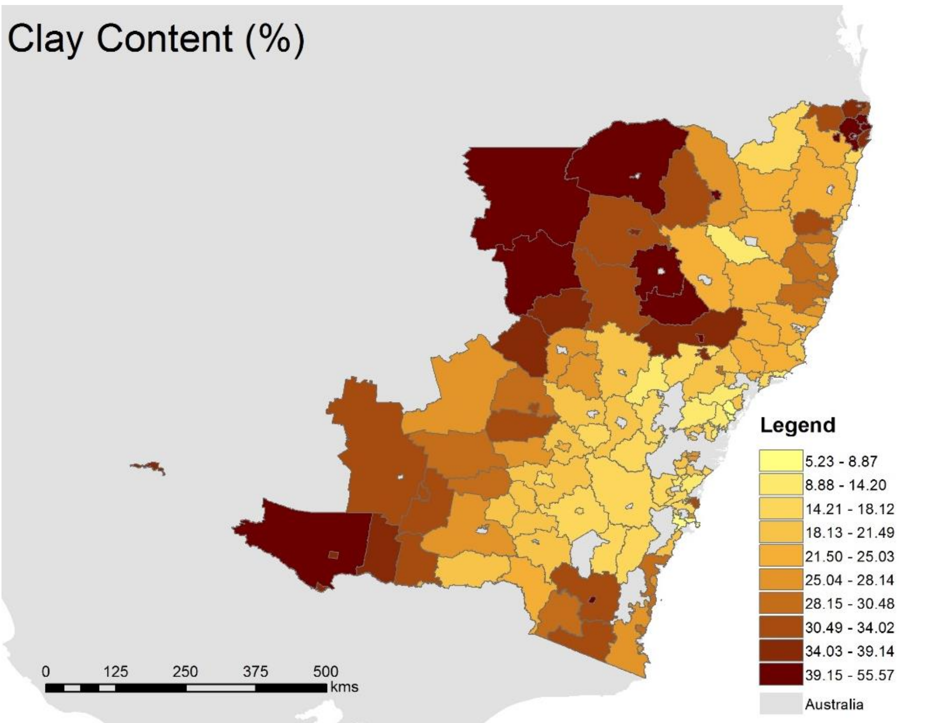
Wheeler, David, Dan Hammer, Robin Kraft, Susmita Dasgupta, and Brian Blankespoor. 2013. "Economic Dynamics and Forest Clearing: A Spatial Econometric Analysis for Indonesia." *Ecological Economics* 85. Elsevier B.V.: 85–96. doi:10.1016/j.ecolecon.2012.11.005.

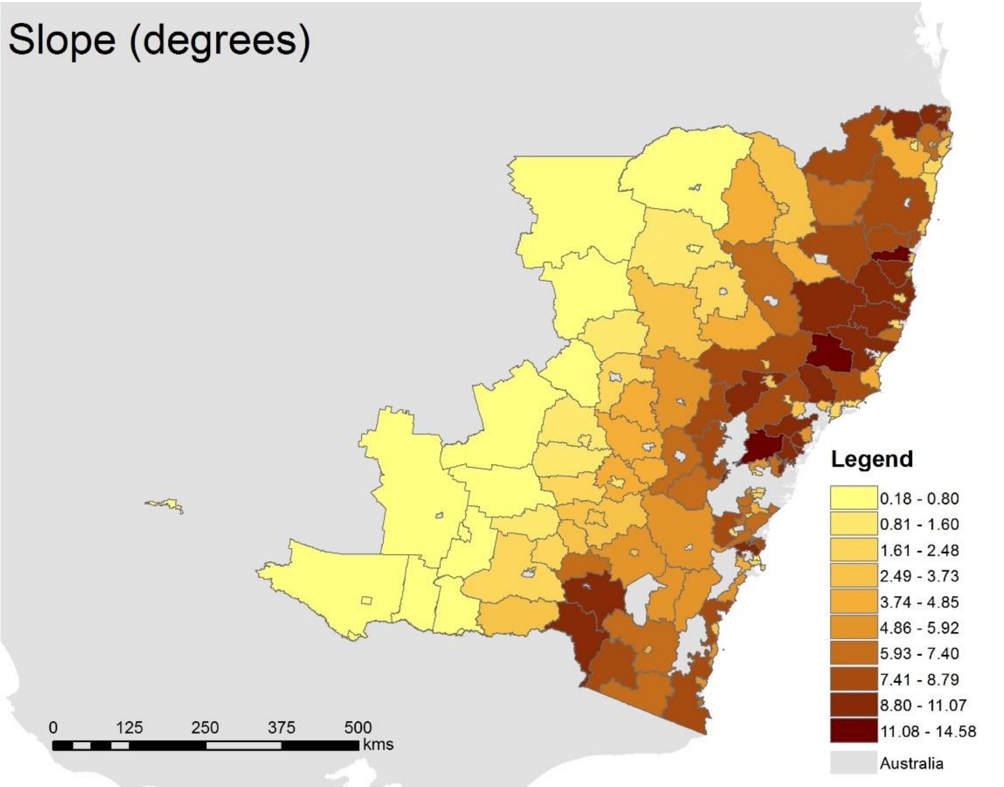
Willis, Robert J. 1986. "Wage Determinants: A Survey and Reinterpretation of Human Capital Earnings Functions." *Handbook of Labor Economics*. doi:10.1016/S1573-4463(86)01013-1.

8 Appendix. Maps of explanatory variables.

8.1 Soil and topographic factors



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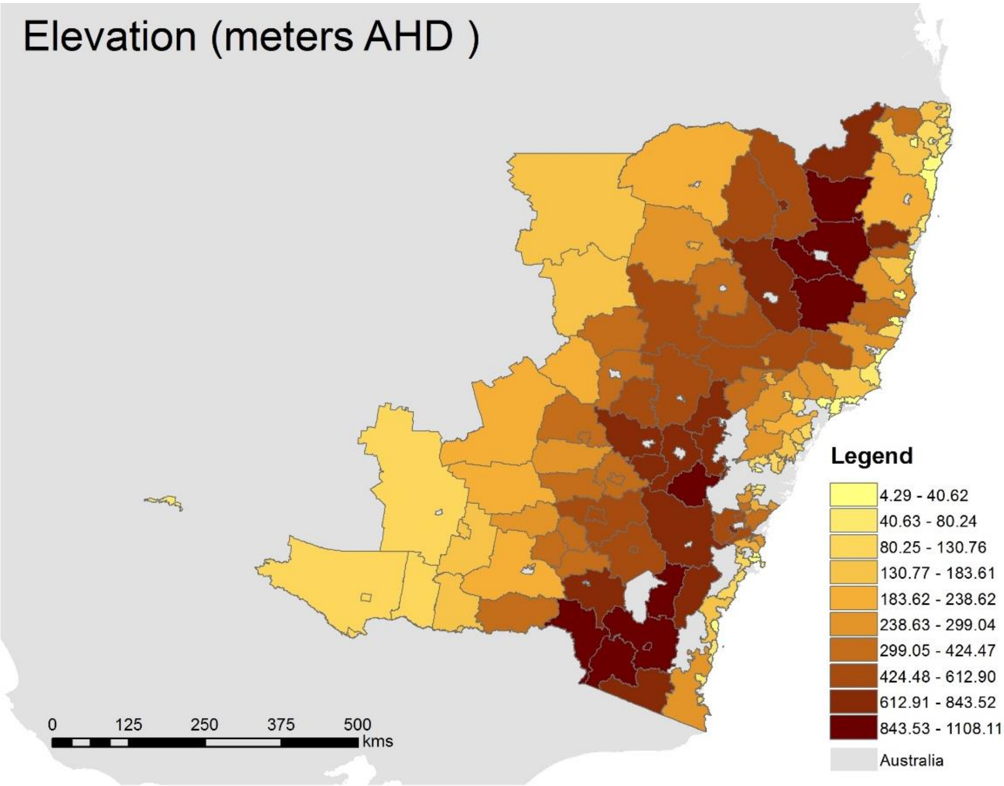
0.81 - 1.60
1.61 - 2.48
2.49 - 3.73
3.74 - 4.85
4.86 - 5.92
5.93 - 7.40
7.41 - 8.79
8.80 - 11.07
11.08 - 14.58
Australia
0
125
250
375
500
kms


Elevation (meters AHD)
Legend
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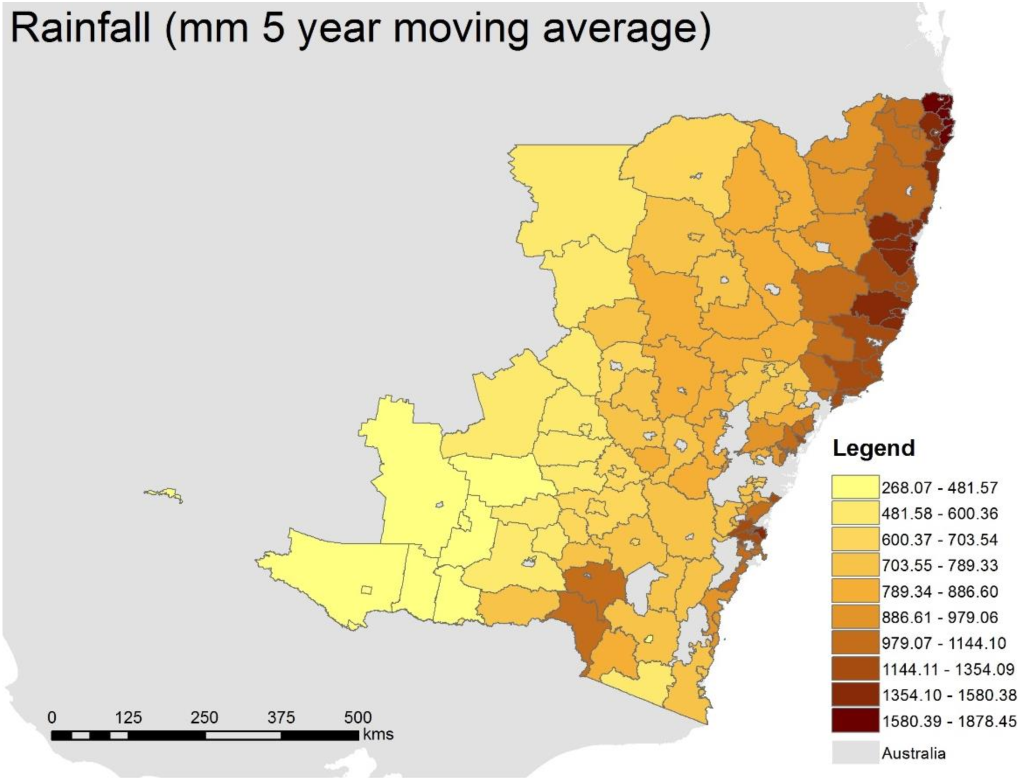
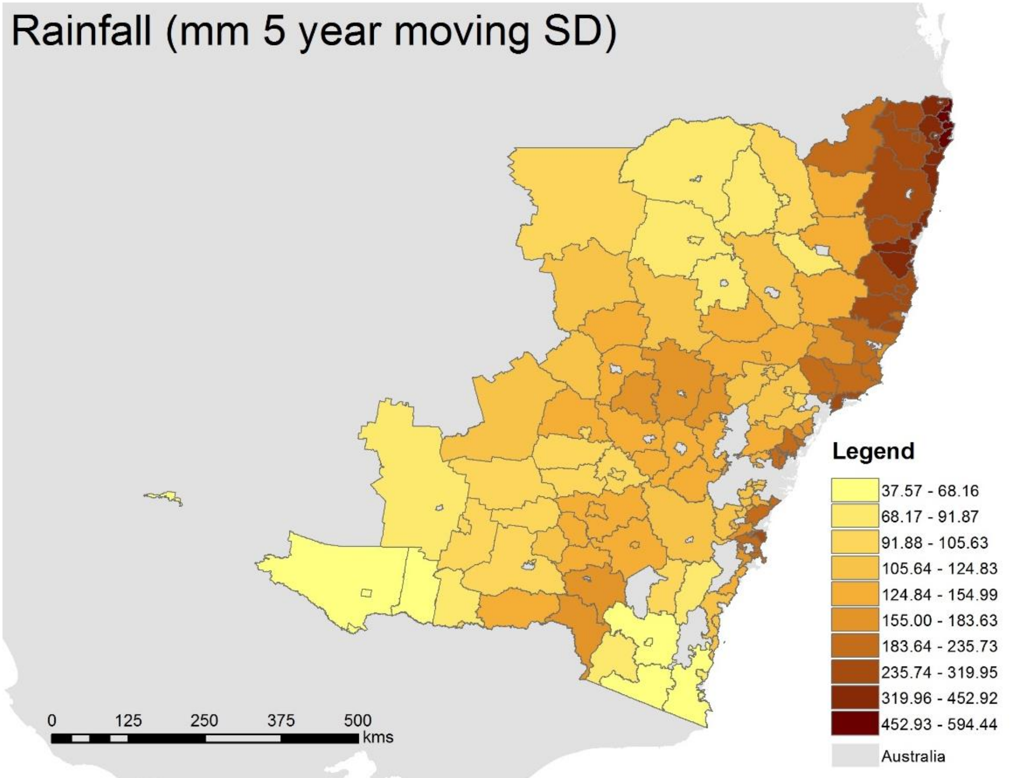
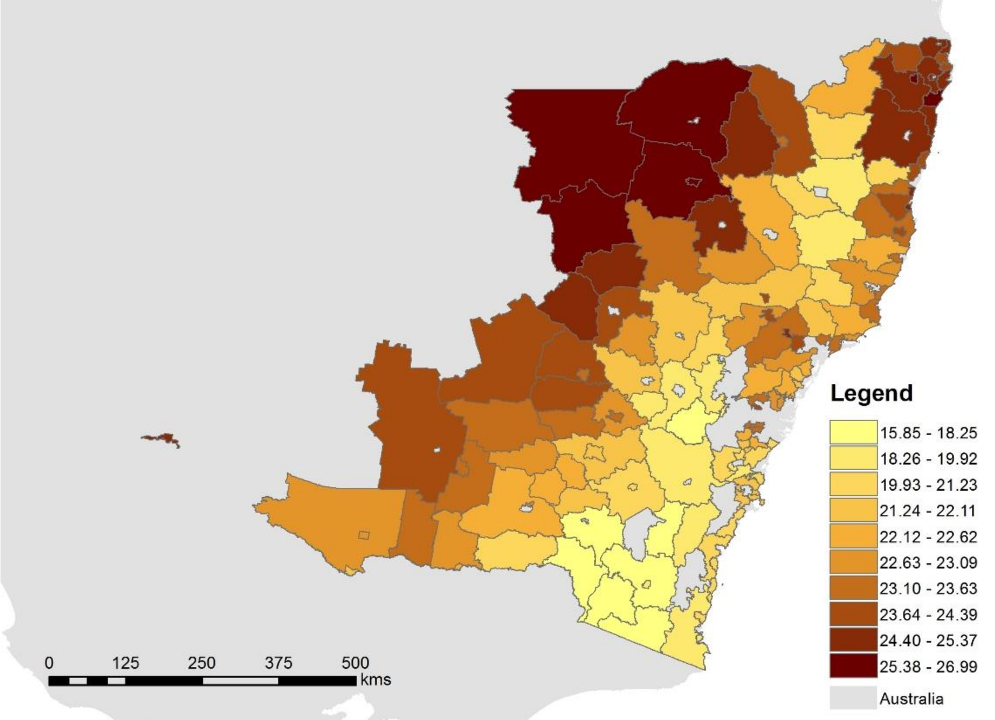
40.63 - 80.24
80.25 - 130.76
130.77 - 183.61
183.62 - 238.62
238.63 - 299.04
299.05 - 424.47
424.48 - 612.90
612.91 - 843.52
843.53 - 1108.11
Australia
0
125
250
375
500
kms

8.2 Climatic parameters

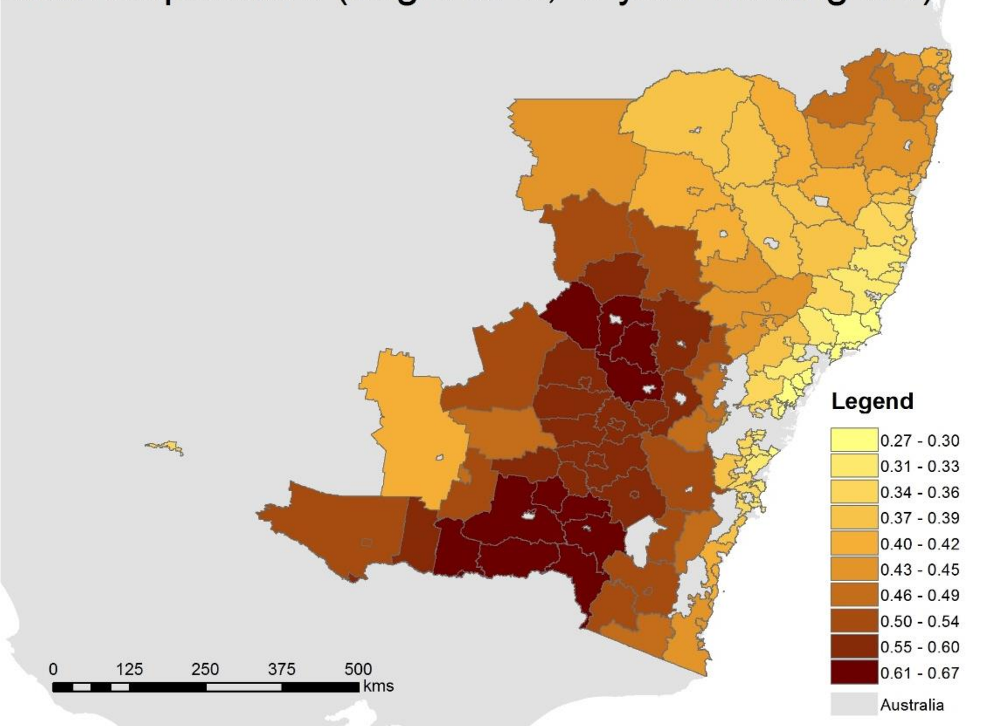




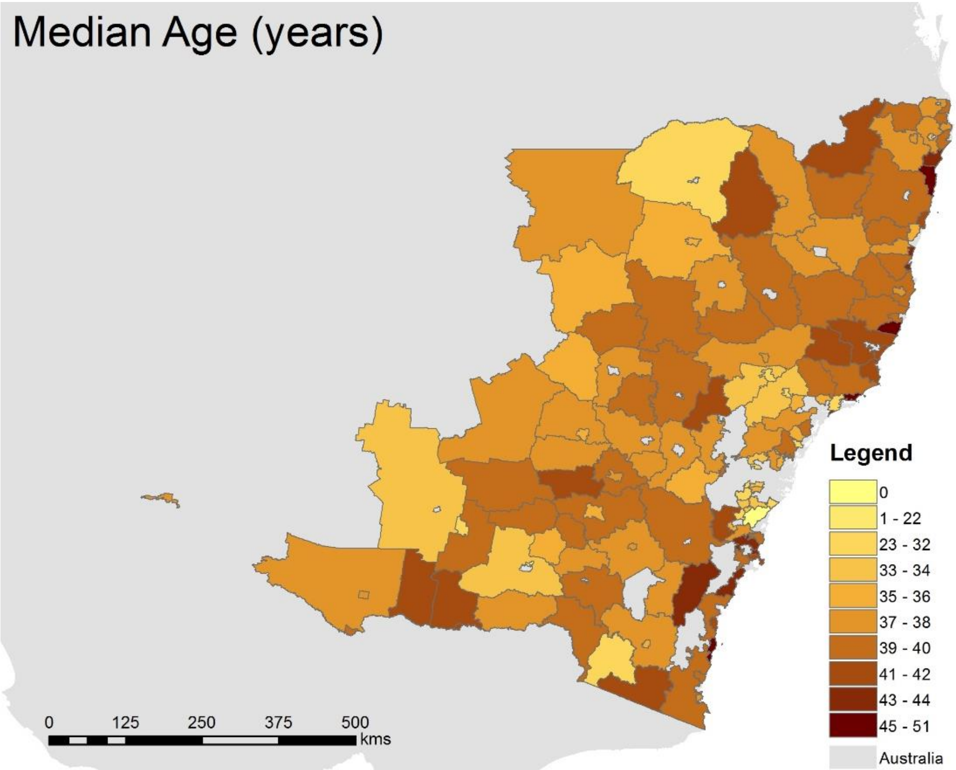
MaxTemperature (degrees C, 5 year moving average)

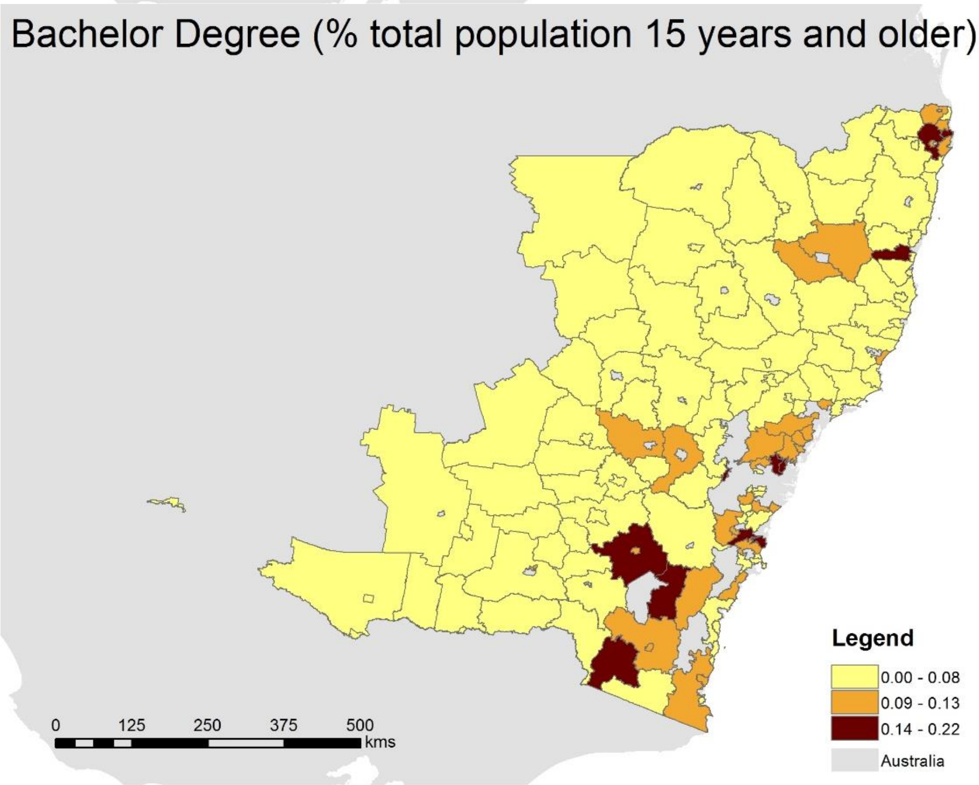


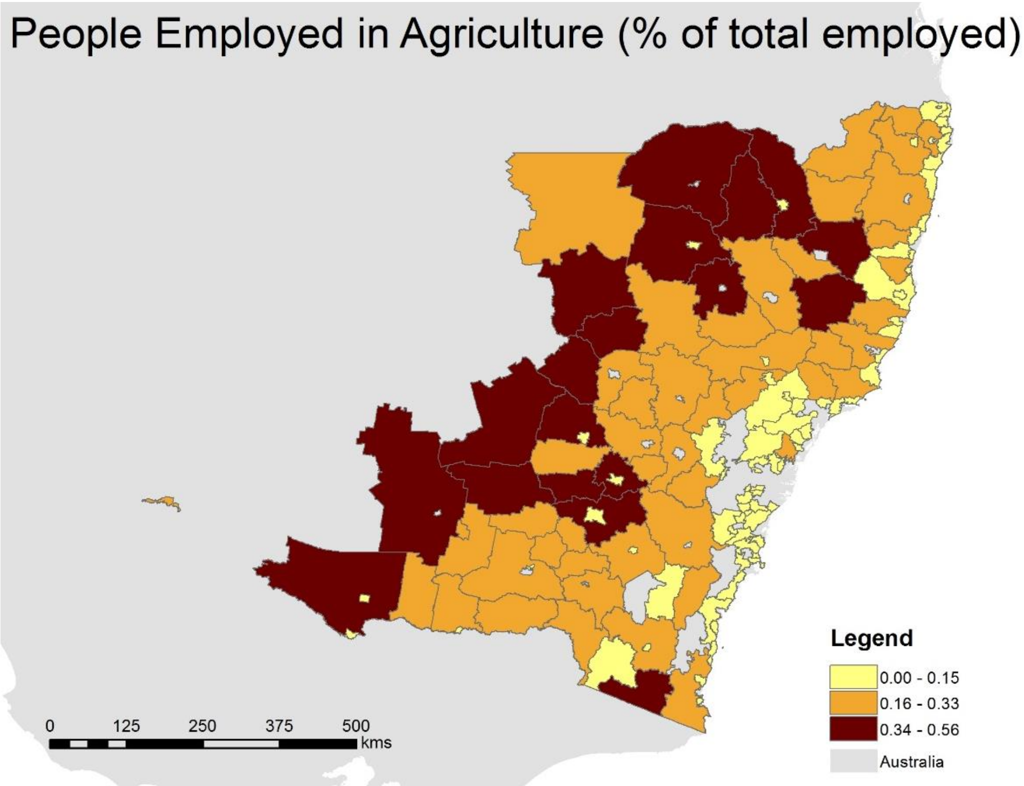
MaxTemperature (degrees C, 5 year moving SD)



8.3 Socioeconomic indicators






People Employed in Agriculture (% of total employed)
Legend
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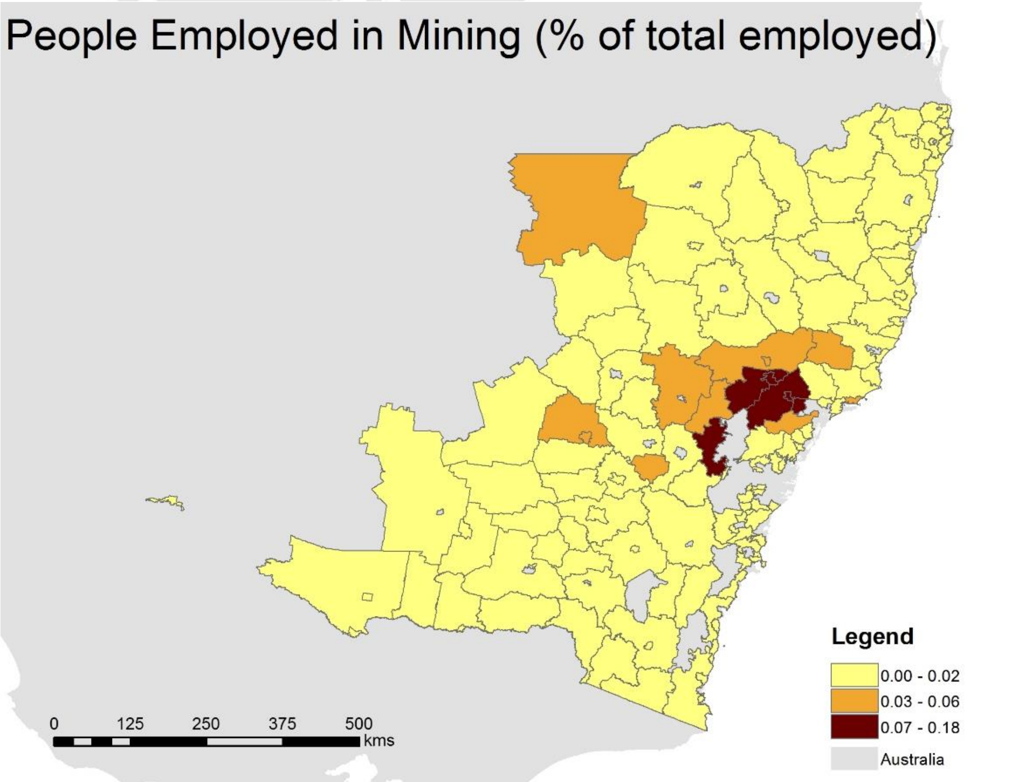
0.16 - 0.33
0.34 - 0.56
Australia
0
125
250
375
500
kms


People Employed in Mining (% of total employed)
Legend
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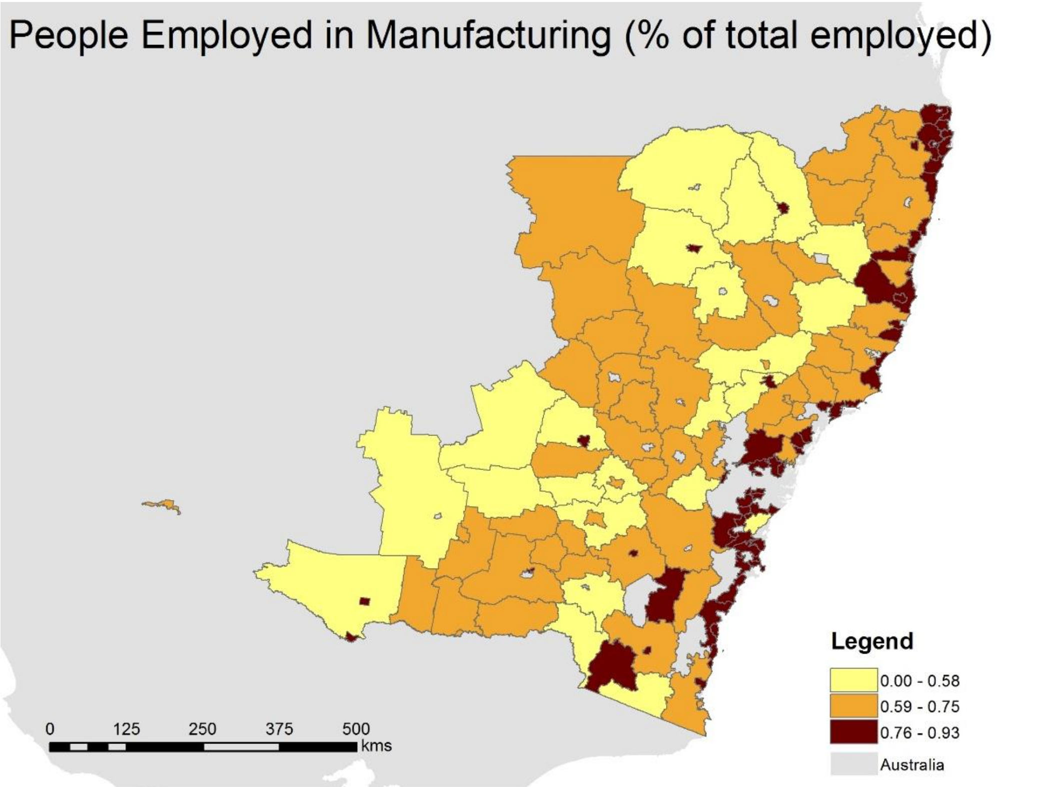
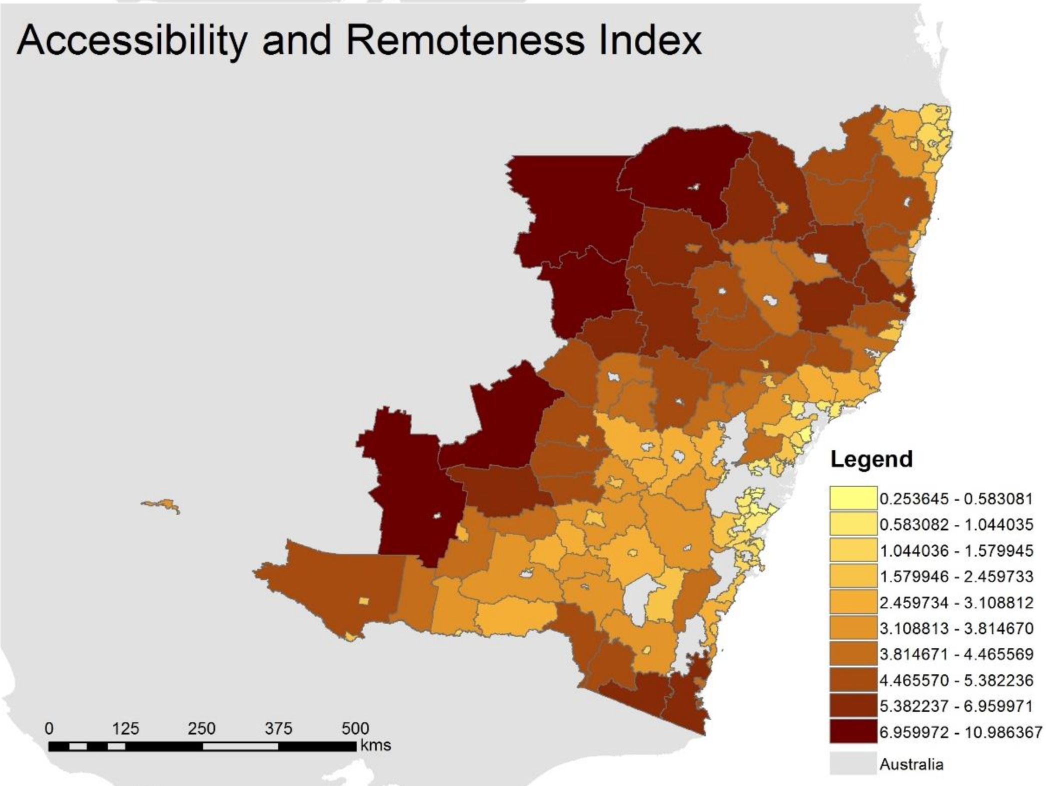
0.03 - 0.06
0.07 - 0.18
Australia
0
125
250
375
500
kms


People Employed in Manufacturing (% of total employed)
Legend
0.00 - 0.58
0.59 - 0.75
0.76 - 0.93
Australia
0
125
250
375
500
kms


Accessibility and Remoteness Index
Legend
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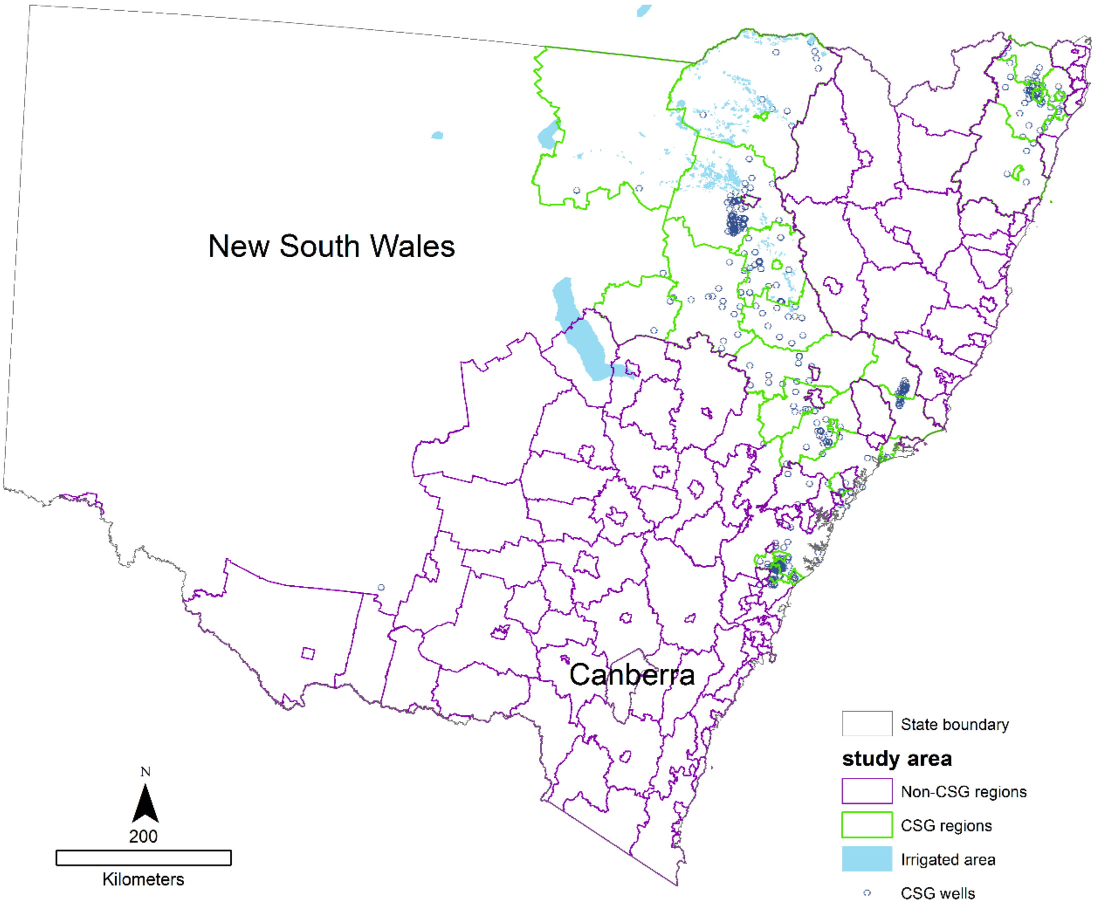
0.583082 - 1.044035
1.044036 - 1.579945
1.579946 - 2.459733
2.459734 - 3.108812
3.108813 - 3.814670
3.814671 - 4.465569
4.465570 - 5.382236
5.382237 - 6.959971
6.959972 - 10.986367
Australia
0
125
250
375
500
kms

Actual irrigated land



Based on information from