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Assessing and projecting on-shore gas effects on regional economic activity in NSW

Final Report - GISERA Project S.13

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1 Executive summary

This report presents findings of the '*Assessing and projecting on-shore gas effects on regional economic activity in New South Wales'* (NSW) project. It summarises analyses to investigate potential economic effects that on-shore gas development could produce in the Narrabri shire and surrounding regions in New South Wales. It builds on previous work conducted in Milestone 2 of the project and is based on methods that involve investigating historical trends, econometric modelling and regional input-output analysis.

Historically, the on-shore gas industry in NSW has been relatively short-lived and small scale with limited experience on which to base projections of possible future effects. To overcome this limited experience, in order to project future effects in this study we employ different methods, including statistical analysis empirically drawing on the experience of Queensland. We do this as a basis to understand potential flow on effects of on-shore gas extraction activity into other sectors over time, while adjusting for the relatively smaller scale of possible expansion of on-shore gas activity in the Narrabri region of NSW.

Key findings of the project are:

- The Narrabri Gas Project is likely to continue increasing the gas sector's economic relevance in the Narrabri region and nearby areas.
- The development of an on-shore gas industry in Narrabri will bring economic benefits to the region. Based on Santos' (2020) estimates of 222 local jobs in an average year generated in the Narrabri region across the life of the project (from 2021 to 2046), we estimate that around 172 jobs on average will be direct jobs related to the natural gas extraction activity.
- Assuming a more conservative figure of direct employemt – 2/3 of total jobs forecasted by Santos (2020) to be direct jobs (approx. 146 jobs in an average year) – we apply scenarios to estimate potential job spillovers into other sectors across Narrabri region. Scenarios show that spillovers could range between 60 and 130 in the peak of the project activity (2024), dropping to a range between 40 and close to zero additional jobs in 2046.
- Following the experience from Queensland, we project that the main gains from job spillovers from natural gas extraction activity will occur in services related to the on-shore gas industry (such as electricians and construction), and some local services (such as accommodation and food services).
- If the gas industry facilitates the development of other economic sectors by providing access to a reliable supply of affordable energy, employment increases

could be substantial. For instance, a potential new fertilizer plant in the region could generate direct and indirect jobs in other sectors. We estimate that every 10 new jobs in the fertiliser industry could generate as much as 18 additional jobs in other sectors. Therefore, if locally available gas facilitated the establishment of a fertilizer plant employing around 100 people, this could generate around 180 additional jobs in the region (on top of potential spillovers from the gas industry).

- More specifically, econometric estimates show that each new job (FTE) in any industry within the manufacturing sector could generate 1.4 jobs in basic services and 0.4 jobs in skilled services (total 1.8). In contrast, by applying an input-output (I-O) model to the Narrabri shire (local government area), we find that each additional manufacturing job in the Narrabri shire would generate 1.36 FTE jobs in other sectors. The difference with our ecometrics derived multiplier of 1.8 can be explained by extra jobs that could be generated in adjacent regions such as Moree and Gunnedah that the I-O table of Narrabri does not capture.

These findings have important implications for local and regional economies in NSW. For the Narrabri Shire, the direct economic gains from the development of a local gas industry could be increased if an affordable and reliable gas supply triggers investments in other manufacturing sectors such as a fertilizer plant. If all gas supply is channelled to other regions, then local economic effects may be marginal.

2 Introduction

In 2019, Australia became the world's largest exporter of natural gas following technological developments that transformed on-shore gas extraction over the last decade.[1] This extraction boom has unequivocally brought local economic effects to communities and regions hosting on-shore gas extraction activity (Fleming and Measham, 2015). To date, effects have been mainly observed in Queensland, where most of the on-shore gas development has occurred in the last ten years. However, NSW regions with on-shore gas exploration activity also experienced effects by way of increases to average household income (Marcos-Martinez et al., 2019). In recent years, the Narrabri Shire has gained relevance as a potential source of on-shore gas production for NSW. This region hosts substantial economically recoverable volumes of on-shore gas that have been the focus of a development proposal (Santos, 2020).

Previous research has focused on regional NSW, notably around the Narrabri Shire, to appraise early economic effects from exploration (Measham et al., 2018) and public perceptions of the on-shore gas industry (Walton and McCrea,. 2017). This report builds on this previous research, presenting the outputs of Task 4 in GISERA Project S.13: "Assessing and projecting on-shore gas effects on regional economic activity in NSW". It presents preliminary findings of a diverse set of analyses to understand the economic impacts that on-shore gas development could produce in the Narrabri shire and surrounding regions in New South Wales. The results presented here are derived from economic and spatial analyses of economic and social indicators with the aim of identifying the potential effects of the on-shore gas industry in NSW.

2.1 Research objectives

This research has two main objectives:

1. To develop comprehensive analytical frameworks to evaluate the potential economic and social effects of on-shore gas extraction, based on domestic and international experiences.
2. To describe and discuss economic and social changes generated by on-shore gas activity in Australia and use secondary data and analyses to estimate potential effects for regions around the Narrabri shire.

[1] https://www.climatecouncil.org.au/australia-worlds-largest-gas-exporter/

To address the first objective, a comprehensive literature review was conducted in milestone 2, which formed the basis of a journal article synthesizing lessons from five years of GISERA economic research (Measham et al., 2020). Milestone 2 informed the discussion and analysis of the effects of potential on-shore industry development in NSW. To achieve the second objective, comprehensive data collection and quantitative analyses were performed to estimate the effects of on-shore gas activity on economic indicators across regions.

The present analysis aims to expand the knowledge provided by previous research by exploring what has happened in NSW in recent years, drawing on analytical processes developed for measuring effects in Queensland where the on-shore gas industry has been active for longer, thereby providing methodological insights for forecasting the likely economic outcomes that Narrabri and other regional areas of NSW could face as the on-shore gas industry expands.

3 Background and methods

The on-shore gas industry has expanded substantially in Australia in the last couple of decades. Robust analysis of effects of potential gas industry development in New South Wales, require assessments of effects in regions with more established gas industries, such as in Queensland. Starting slowly from the 1980s then accelerating during the early 2000s, more than 12,000 on-shore gas wells have been drilled in Queensland, with exploratory and operational wells peaking between 2013 and 2014. As shown in Figure 1, annual drilling rates declined following this peak then started to increase again around 2018.

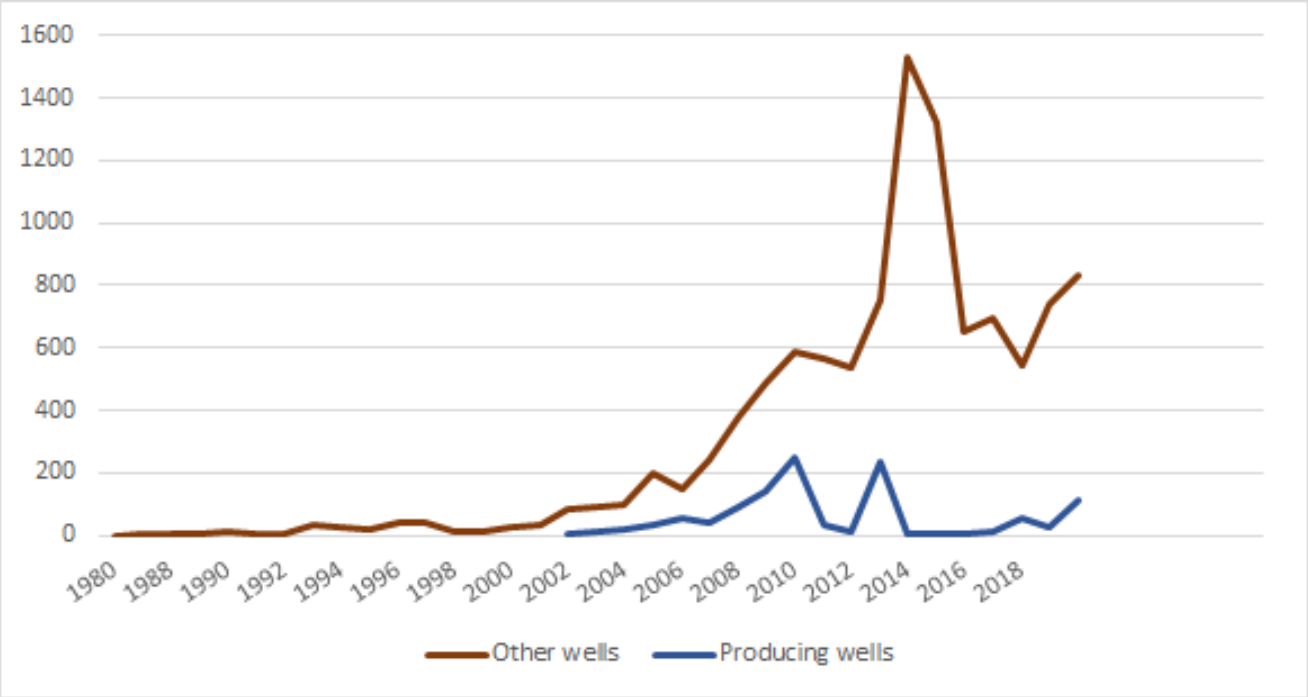

Figure 1 Number of on-shore gas wells drilled in Queensland over the years

Note: 'Producing wells' (1,213 in total) are those with on-shore gas extraction in 2020, while 'Other wells' refer to 'plugged and abandoned' (1,535), 'suspended/capped/shut-in' (9,382) and 'unknown/water bore' (137) wells. *Source*: authors elaboration with data from the Queensland Department of Natural Resources and Mines.

In New South Wales, the on-shore gas activity has been quite different. On-shore gas activity has occurred in the State since the early 2000s (Figure 2) when a number of wells were drilled around the region of Camden. By 2020 there were still 386 wells operating in the SA4 of "Sydney - Outer West and Blue Mountains" – a list of NSW SA4s with on-shore gas wells is provided in the Appendix. However, most of these producing wells are expected to be decommissioned in the coming years (Huddlestone-Holmes et al., 2018). Following

recent government approval of the Narrabri Gas Project (Santos 2020) future drilling is expected to occur in the largest on-shore gas reservoir located in the SA4 region of 'New England and North West'.

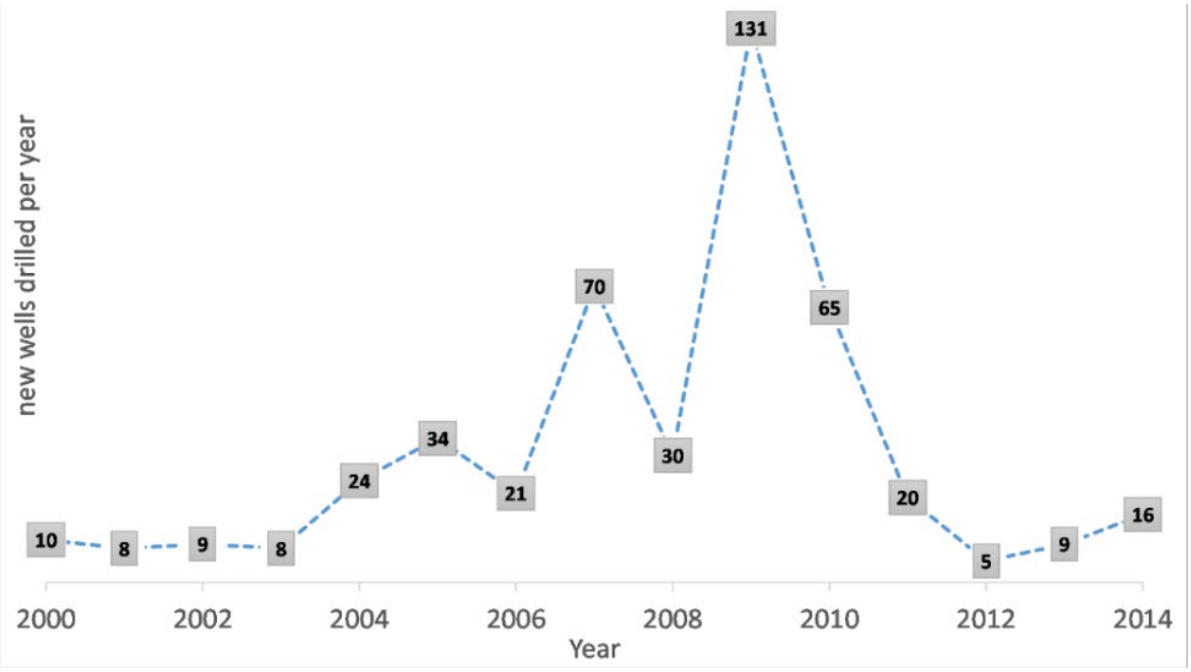

Figure 2 On-shore gas wells drilled in NSW
Source: Measham et al. (2018) with data from the Central Resource for Sharing and Enabling Environmental Data in NSW.

3.1 Previous empirical findings and forecasts from on-shore gas activity in NSW

Previous economic analysis of on-shore gas in NSW (Measham et al., 2018; Marcos-Martinez et al., 2019) found that the exploration phase of the on-shore gas industry in the State was correlated with a 7% (±5%, 95% confidence interval) higher median weekly family income in regions with on-shore gas activity. This effect was estimated with data from 2001 to 2011 and was expected to be temporary due to the observed decrease in industry activity post-2011. The set of regions with and without on-shore gas industry presence (on-shore gas regions and control regions), can be seen in Figure A1 in the Appendix. The same studies also reported no employment spillover effects from on-shore gas activity in NSW during that period.[2] The slow industry development in NSW, and the need for highly specialized labour and capital from outside NSW regions during the exploration phase were some factors that

[2] Although the authors showed that changes in employment in the 'Rental, hiring and real estate services' and the 'Professional, scientific and technical services' industries were positively correlated with employment changes in the mining sector, these spillovers were not associated with on-shore gas activity.

explained the lack of employment spillover effects during the exploration phase (Measham et al., 2020).

As inputs to the social impact assessment of Santos' on-shore gas expansion project in the Narrabri region, the company recently updated its original estimate of economic effects (Santos, 2020). In their updated report, Santos estimates that the Narrabri Gas Project could generate a total of 222 (FTE) direct and indirect jobs for the SA3 region of 'Moree-Narrabri' (including the Narrabri shire). Across all NSW, the estimated number of new FTEs would be 912, on average across the whole life of the project, from 2021 to 2046 (Santos, 2020).

In terms of job spillovers into other sectors, Santos (2020) estimate that in percentage terms, transport, construction, services and retail (including wholesale trade) would be sectors that could benefit the most from on-shore gas activity. Agriculture, forestry and fishing would be negatively affected with a decrease of 0.15% in the number of jobs in the SA3 of 'Moree-Narrabri' in contrast to an economy with no on-shore gas activity – see table 6.2 in Santos (2020).[3] This percentage is in line with calculations for other regions, notably the findings of Fleming and Measham (2015) for the on-shore gas effects in Queensland.

The analysis developed in this research project complements and expands the analysis developed in previous GISERA economic studies (Measham et al., 2018; Marcos-Martinez et al., 2019) by including data from the 2016 Census and focusing on the regional and spatial effects of potential on-shore gas activity in regions and townships within the SA4 of 'New England and North West' (Figure 4), where the core of the new on-shore gas expansion in the State is set to happen. The analysis considers previous studies of on-shore gas effects in Queensland and NSW, as well as data estimates provided by Santos (2020) for the Narrabri regions to better understand the potential impacts on different socioeconomic indicators across regions.

3.2 Research methods

3.2.1 Baseline analysis of demographic and socio-economic trends

We first analysed historical trends of social, demographic and economic indicators. These tasks helped us to understand how key indicators of the Narrabri shire's socioeconomic performance have evolved in recent years and inform what hypotheses to set for the rest of the analysis . We also compared historical trends with data from other shires in NSW and with the Western Downs region in Queensland (where most of the on-shore gas activity in Australia has occurred in recent years). Results are presented in section 4.

[3] Santos (2020) argues that such negative impacts would be mainly due to the assumed reduction in farmland, competition for labour and small increases in local costs, and that this impact is relative to changes from the baseline, not implying an absolute contraction in employment in the agricultural sector.

3.2.2 Econometric approaches to analyse local economies

As informed by Milestone 2 of this project, we evaluated the effects of on-shore gas development in local economies employing a two-stage empirical approach based on statistical analysis and econometric modelling. This two-stage analysis (described in Figure 3) tested the potential effects of the initial on-shore gas industry development in different regions in and around the Narrabri shire. This analysis went beyond the baseline analysis described in section 3.2.1, by exhaustively comparing average regions with and without on-shore gas in NSW. To do so, we relied on this analysis on SA2 level data, which provided a more nuanced variability across space, while controlling for local economic conditions.

The first stage of this analytical framework employed a type of treatment-control statistical model to evaluate quantitatively whether the on-shore gas industry has produced effects on different socioeconomic and demographic indicators (including effects observed in 2016 Census data), across multiple local economies in NSW.

Once this statistical description was completed, in the second stage of the analysis, we used the statistically valid results of stage one and identified and assessed the marginal impact of the on-shore gas industry (Figure 3). This was performed using difference-in-difference econometric models to control for confounding factors affecting changes in the indicators. In this way, the marginal effect of on-shore gas activity could be empirically isolated, providing better insights on the specific impact generated by the industry to 2016 (the latest Australian Census data available at the moment of writing).

Considering the econometric model results, we subsequently forecast future potential changes in socioeconomic and demographic indicators in NSW, by predicting future changes given the projected jobs and income that the industry would generate – according to the report of Santos (2020). In other words, the economic forecasts that Santos (2020) claimed the on-shore gas industry would generate were used to estimate projections of future paths (given by different scenarios) that different socioeconomic and demographic indicators could have in the future, as a consequence of potential on-shore gas expansion in NSW.

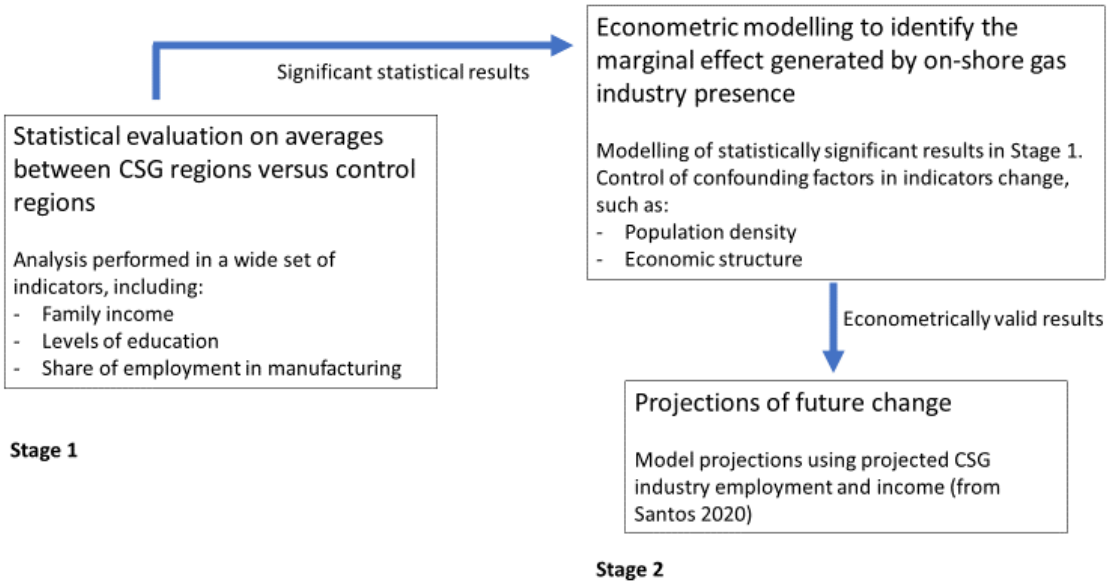

Figure 3 Empirical research design of the statistical and econometric modelling

In addition to evaluating the impact of on-shore gas expansion across NSW regions, in this report, we also assessed the impacts of a potential fertiliser plant in the Narrabri region. We did this because on-shore gas development in NSW is expected to provide affordable feedstock to enable the development of a fertiliser manufacturing plant located in the Narrabri Shire. The company seeking to develop the fertiliser plant has indicated it would use on-shore gas extracted in the region and generate around 200 direct and indirect local jobs (Perdaman, 2019). To analyse the impacts of such a development, we dedicate a section to the analysis of the impacts of manufacturing in regions predominantly dependent on agricultural activity such as the Narrabri region.

Sampling design

To approach our analysis, a suitable method is the statistical comparison of treatment and control groups. Here, an ideal experiment would randomly assign regions or communities to natural gas drilling (treatment) and some to non-drilling (control) groups, creating an unbiased estimate of the differential effect of unconventional gas development, given no confounding factors. However, although the location of on-shore gas formations is exogenous, the decision to drill in a particular location (region) is based on a complex set of factors. Hence, the ideal experiment conditions cannot be achieved and we proceed to devising a method for selecting control regions.

Following previous empirical literature evaluating the unconventional gas boom in Australia (e.g., Fleming and Measham, 2015; Marcos-Martinez, 2019) and the USA (e.g., Paredes et al., 2015; Hoy et al., 2018), we control for heterogeneity across regions (given by the set of

complex factors) by selecting from regional NSW those with specific characteristics on the presence of on-shore gas wells drilling and population density.

In particular, for our sampling of NSW regions, we selected the SA2 regions with on-shore gas wells located in the SA4 of 'New England and North West' for our treatment group. This SA4 region was selected because it includes all SA2 regions of the Narrabri shire (the Narrabri Local Government Area) where the on-shore gas development of Santos would happen, our main focus in this research. The on-shore gas wells drilled in this region so far have been established with the dual purpose to explore and pilot on-shore gas activity. Production wells are not drilled (at the time of writing). The most recent on-shore gas drilling activity in the area (and in the whole State) happened in 2014 (see Figure 2). In total, four SA2 regions within the SA4 of 'New England and North West' have had on-shore gas well drilling activity in recent years. The SA2s (from North to South, as shown in Figure 4) are given by regional Moree, Narrabri, Gunnedah and Quirindi. To select our treatment group, with the aim to identify and estimate the effects of the on-shore gas industry, we include these four SA2s plus the three SA2s given by the respective townships of Moree, Narrabri and Gunnedah, which are small SA2 (representing the townships) fully contained within the SA2 selected above. This selection finally gives us seven SA2s conforming our treatment group.

In 2016 the Australian Bureau of Statistics (ABS) Geographical Standard defined 556 SA2 regions in NSW. In our treatment group, population density in 2006 varied from 0.29 to 123.8 persons per square kilometre. Therefore, we selected as a control group SA2 regions in NSW with population density in 2016 within this range. Our control group was then formed by 143 SA2s plus seven treatment SA2s, giving us a cross-sectional sample of 150 SA2 regions across NSW. The control and treatment samples contained approximately 17% of NSW's total population in 2006.[4]

3.2.3 Regional input-output analysis approach

Economic input-output (I-O) models represent flows of intermediate and final outputs (commodities or services) between different sectors of an economy. I-O models allow the estimation of impacts from investments or changes in production and demand conditions in an economic region. For instance, economic I-O models are useful to investigate responses to investments in infrastructure or new businesses.

To investigate potential impacts of investments driven by local gas production on employment and gross regional product at local government area levels, we used the Economic Impact (Input-Output) Analysis Tool (EIAT) for Regional Infrastructure Investment

[4] As comparison, Fleming and Measham (2015) for their analysis of Queensland, had a sample representing 15% of Queensland's population.

Projects. This tool was developed by the Australian Industrial Transformation Institute at Flinders University and is publicly available in the AURIN portal[5]. EIAT combines 2011 census industry of employment data and 2009-10 national I-O information to estimate industry multipliers and economic impacts of regional infrastructure investment projects. Such estimates account for business dependencies, employment opportunities within a region, transport systems (journey to work), infrastructure demand and provision, etc.

I-O models rely on assumptions to approximate linkages and feedbacks between sectors. EIAT models firms within a sector as homogeneous in terms of their use of input and outputs. Changes in demand in a region generate adjustments in industry operations without significant price adjustments. Constant returns to scale and fixed input productions per industry are also assumed by EIAT. More importantly, the model approximates the structure of the economic system (supply and demand) based on data from a particular period. Therefore, projections of drastic changes in a region's economic composition (e.g. large investments in new companies) may generate inaccurate estimates. With those caveats in mind, we used EIAT to estimate changes in gross regional product and employment in Narrabri in response to investments in the Manufacturing sector. The investment scenario simulates potential direct economic gains from the development of a local gas industry if affordable and reliable gas supply triggers investments in manufacturing activities, like through the development of a fertiliser plant.

[5] EIAT was accessed in December 2020 in this site: http://eiat.aurin.org.au/#/eiat/home.

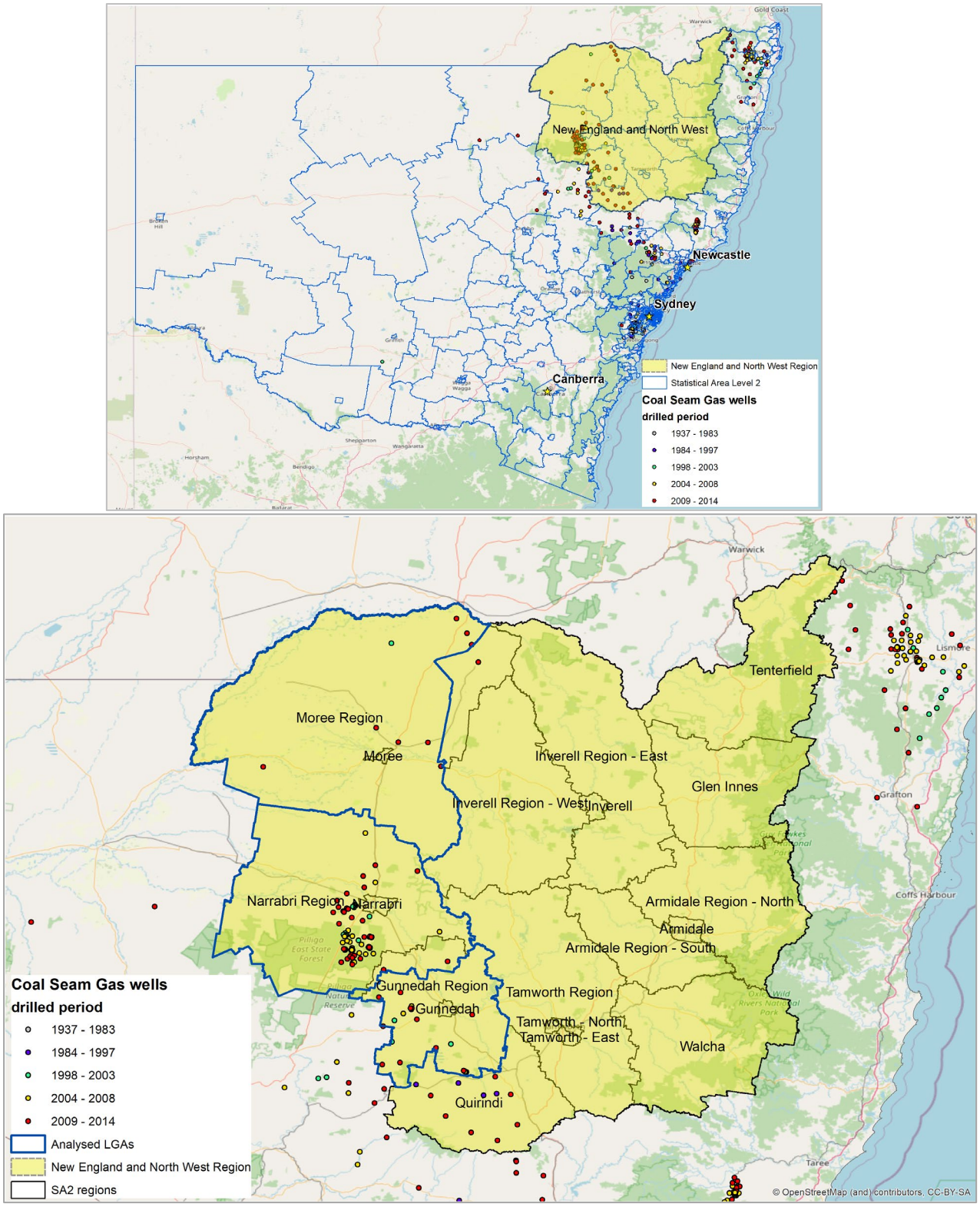

Figure 4 Upper map: Location of SA4 of 'New England and North West' within NSW. Lower map: Zoom in to the 'New England and North West' SA4, showing the three LGAs (blue borders) with on-shore gas activity, and all SA2 regions. Exploration on-shore gas activity is also shown.

4 Results

4.1 Baseline socio-economic and demographic conditions in Narrabri

4.1.1 Population

Population in Narrabri's local government area (LGA) decreased from 14,422 residents in 2001 to 13,477 residents in 2006 (a 6.6% decrease). Between 2006 and 2016 the number of residents decreased an additional 0.8%. In contrast, the Australian population increased by 23% during the same ten-year period. In addition to population reduction, there have been significant changes in the age and sex composition of the population between 2001 and 2016 (Figure 6). In 2001 there were 55 dependents (people aged 0 to 14 and 65 and over) per 100 working-age people (15 to 64 years of age). This ratio increased from 55 in 2001 to 63 by 2016 (a 15% increase). By comparison, the Australian dependency ratio increased from 49 to 52 during the same period (a 5% increase). A reduction in the number of young people combined with the increasing number of dependent populations highlights an ageing trend in the region at more rapid rates than the national trend.

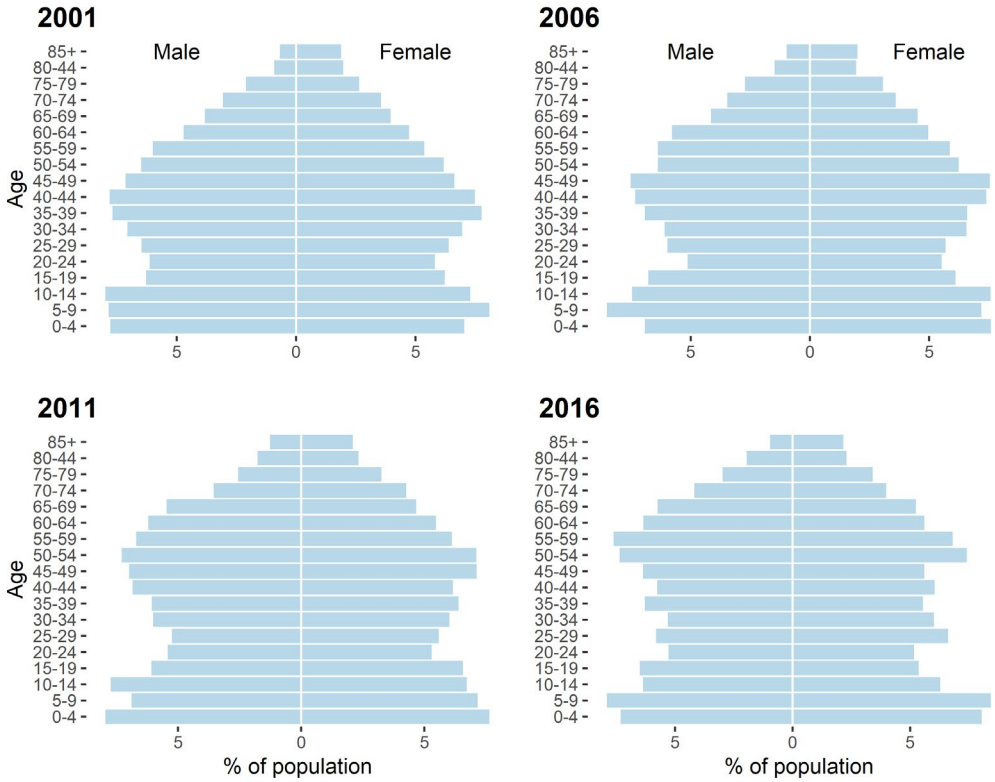

Figure 5 Population composition (age and sex) in Narrabri's Local Government Area.

4.1.2 Unemployment

One in four jobs in Narrabri were in the Agriculture, Forestry, and Fishing sector in 2001 (Table 1). Between 2001 and 2006, the relevance of this sector in terms of jobs remained unchanged (Figure 7). However, between 2006 and 2016 the proportion of people employed in this sector reduced by around 6%. From 2001 to 2016, employment in the manufacturing and wholesale trade sectors have reduced 4% and 3% respectively. In contrast, the mining sector increased from 0.2% of the total employment in Narrabri in 2001 to 5.5% by 2016 —most of the change occurred after 2006 (Figure 7). Jobs in the health care and social assistance sector increased from 7% in 2001 to 10% in 2016. Changes in other sectors were marginal. Overall, historical employment trends suggest a gradual reconfiguration of the local economy with an increasing role of the mining sector.

Table 1 Employment trends across sectors, by gender, in the Narrabri Shire.

	2001			2006			2011			2016		
	Total	M	F	Total	M	F	Total	M	F	Total	M	F
Agriculture, Forestry and Fishing	1,558	1,114	444	1,450	1,063	387	1,249	908	342	1,107	831	276
Mining	11	8	3	28	25	0	227	206	20	313	276	34
Manufacturing	420	309	111	297	215	79	289	223	59	173	122	46
Electricity, Gas, Water and Waste Services	45	40	5	57	55	7	70	60	8	72	66	9
Construction	333	290	43	324	281	42	345	293	52	333	287	45
Wholesale Trade	342	261	81	165	113	55	210	141	62	143	91	51
Retail Trade	616	239	377	576	219	354	568	207	366	508	169	335
Accommodation and Food Services	403	135	268	349	117	238	360	112	250	352	136	214
Transport, Postal and Warehousing	390	305	85	390	308	77	362	281	84	266	196	68
Information Media and Telecommunications	45	27	18	41	24	23	32	6	25	35	16	24
Financial and Insurance Services	82	27	55	71	25	49	78	16	65	61	18	42
Rental, Hiring and Real Estate Services	59	29	30	47	26	24	48	21	29	46	19	20
Professional, Scientific and Technical Services	310	161	149	276	132	142	250	100	147	260	110	146
Administrative and Support Services	151	54	97	136	69	68	113	40	72	184	59	125
Public Administration and Safety	214	131	83	247	160	82	267	165	106	282	167	119
Education and Training	356	100	256	369	80	291	360	73	287	393	83	312
Health Care and Social Assistance	416	59	357	453	53	399	559	77	483	571	64	502
Arts and Recreation Services	28	20	8	33	23	15	37	27	12	31	25	8
Other Services	222	144	78	260	167	97	244	159	81	262	157	99
Inadequately described and not stated	135	76	59	184	102	80	164	103	67	273	175	94
Total	6,136	3,529	2,607	5,756	3,244	2,513	5,836	3,235	2,606	5,657	3,084	2,576

Notes: M = Males, F = Females. *Source*: ABS.Stat

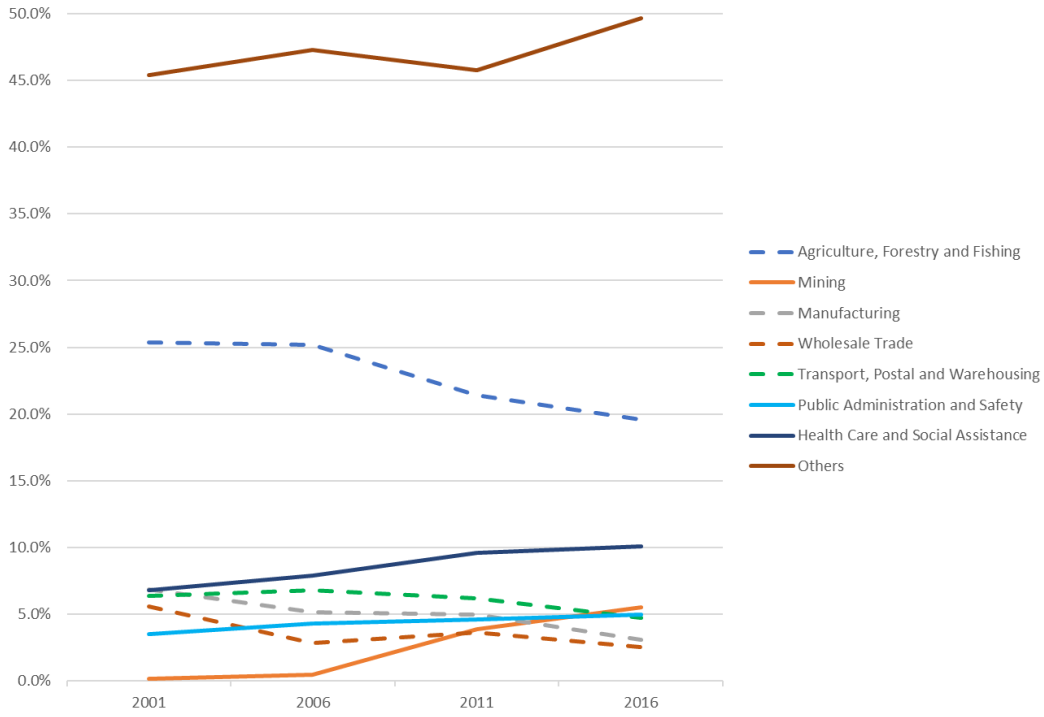

Figure 6 Changes in employment by sector between 2001 and 2016. Source: Census data retrieved from ABS Stats.

4.1.3 Gross Regional Product

The gross regional product (GRP) measures the net wealth generated in a region. This metric follows the same approach used to estimate the Gross Domestic Product of Australia. Using data from REMPLAN (Table 2) we estimated changes in GRP per capita for Narrabri, the Regional Development Australia (RDA) Northern Inland region of NSW[6], and NSW during the period 2009-2019. In real terms, GRP per capita in Narrabri was 123% higher in 2019 than in 2009. While the rest of the region and the State also grew 33% and 19%, respectively. Investments directly or indirectly related to the mining sector appear to have driven increases in GRP per capita in Narrabri in 2013, and the growing trend post-2016.

[6] The RDA Northern Inland Region includes Armidale Regional, Glen Innes Severn, Gunnedah, Gwydir, Inverell, Liverpool Plains, Moree Plains, Narrabri, Tamworth Regional, Tenterfield, Uralla and Walcha.

Table 2 Real Gross Regional Product in Narrabri, RDA Northern Inland and NSW (2009-2019)

	Narrabri ($M)	RDA Northern Inland ($M)	New South Wales ($M)
2008	831	9,604	442,464
2009	879	10,432	487,829
2010	816	9,859	479,975
2011	849	10,233	499,451
2012	1,214	10,321	512,411
2013	1,013	10,238	523,707
2014	933	10,592	525,496
2015	933	10,849	539,571
2016	1,068	12,164	560,331
2017	1,325	12,205	588,698
2018	1,823	13,293	604,414
2019	1,922	13,437	615,599

Note: Values show nominal $AUD.

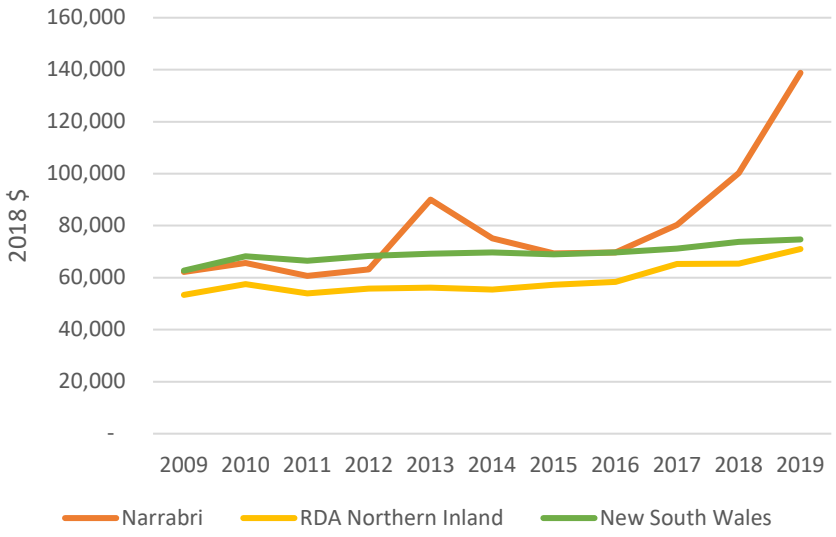

Figure 7 Gross Regional Product per Capita (2009-2019).

4.2 Recent trends in the labour market of selected local government areas

We used quarterly smoothed unemployment rate and labour force data from the Labour Market Information Portal (LMIP) to compare trends in Western Downs, Queensland, and Narrabri, Moree Plains, and Gunnedah in NSW from December 2010 to June 2020. During this period, average unemployment rates have been consistently higher in Moree Plains (8.4%), relative to the rates observed in Gunnedah (6.9%), Narrabri (6%), and Western Downs (3.9%) (Figure 7). Western Downs had higher unemployment rates than Narrabri and Gunnedah only during 2019. Long-term trends indicate a gradual decline in unemployment

in the analysed LGA's in NSW and an increase in Western Downs. Contrastingly, the labour force in Western Downs has increased around 11% during the last ten years. Gunnedah and Narrabri recorded a 6% and 3% growth in their labour force, and Moree Plains had a 2% reduction (Figure 8).

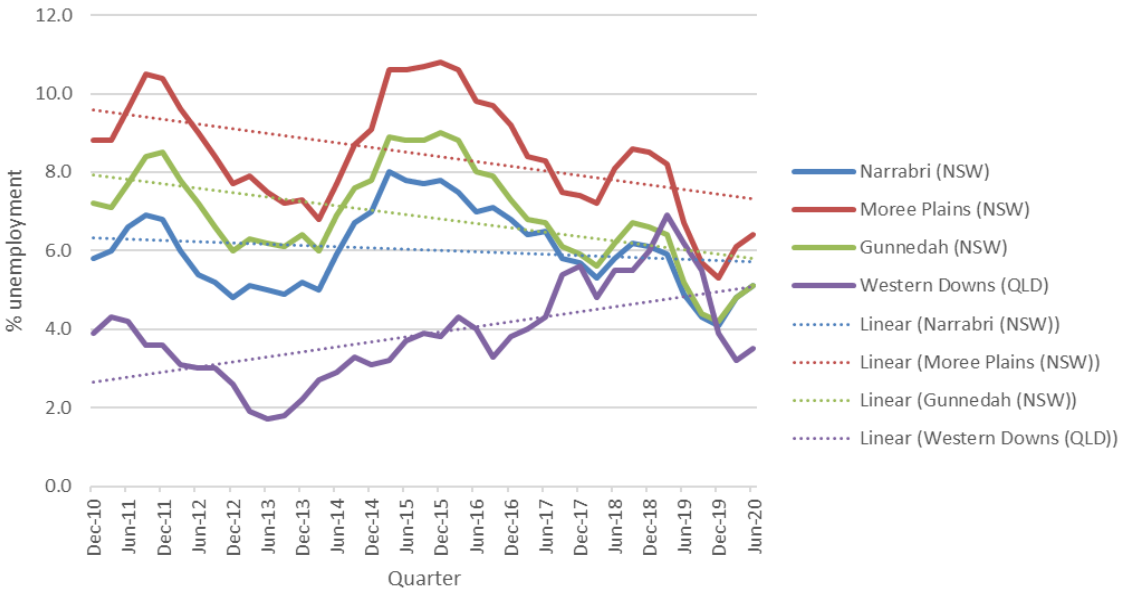

Figure 8 Trends in quarterly unemployment rate for selected LGAs in NSW and QLD.

Data source: LMIP (2020). *Note*: Dotted lines indicate linear trends based on historical unemployment rates data.

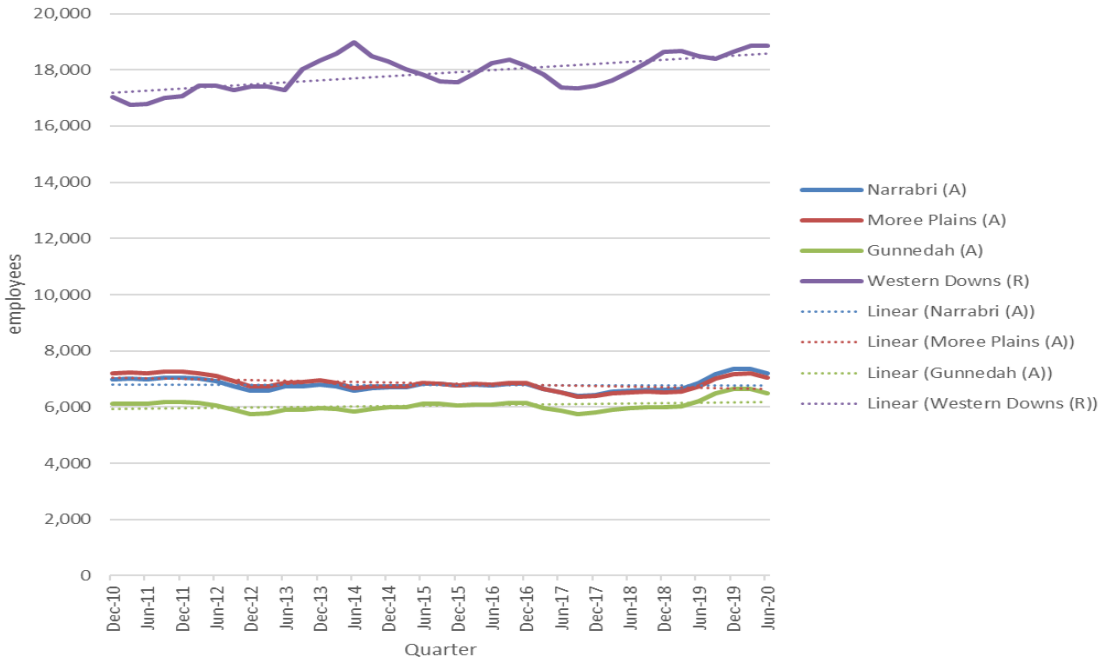

Figure 9 Trends in the quarterly labour force of selected LGAs in NSW and QLD.
Data source: LMIP (2020)

4.3 Statistical and econometric modelling for local economies

The econometric analysis was conducted to evaluate whether key indicators were different across regions with and without the presence of the on-shore gas industry. We did this by contrasting indicators, establishing statistical significance of differences, and exploring econometric models to observe if setting other controls allows better identification of effects. To perform the analysis of this section, we focused on data from SA2s, which represent the scale at which communities interact together socially and economically (ABS, 2020). Thus, the SA2 derived from our sampling strategy (described in section 3.2.2) were used to investigate local economies' performance and run statistical and econometric analyses.

Stage 1 results

Table 3 reports averages of key socio-economic indicators across our samples. As seen, 15 out of the 21 analysed indicators show a statistically different level between our average treatment region and the average control group SA2. In Table 3, we also included the average SA2 across the whole State of NSW for comparison purposes. Results show that basic and skilled services jobs represent a smaller proportion of the labour force in the on-shore gas SA2 regions than in the control group.[7] On the other hand, the on-shore gas regions report a higher share of agricultural employment than the control group. This might be an important factor to consider, as Santos (2020) has shown that the agricultural sector might have a negative impact, in terms of jobs and output, because of on-shore gas activity. The other variable statistically different between groups is the proportion of people employed in manufacturing. The on-shore gas regions report a lower proportion than other State areas, highlighting the opportunity that the Narrabri Shire could increase this proportion of employment if an industry dependent on gas supply, such as a fertiliser plant, is established in the area following the development of the on-shore gas industry.

Stage 2 results

To further investigate the findings provided in Table 2, we explored changes in the assessed indicators over time using a difference-in-difference econometric model. With this model,

[7] Skilled services jobs include employment in 'Electricity, gas and water services', construction, finance and insurance, and 'Professional and scientific services'. Basic services jobs include employment in all other categories not listed here, including employment in 'Wholesale trade', 'Retail trade' and 'Accommodation, food and services', among others.

we attempted to isolate the effect that past on-shore gas activity could have caused in the changes of these indicators in the on-shore gas SA2 regions within the 'New England and North West' SA4 region.

As seen in Table 4, we found mostly no statistical effect of our variable 'on-shore gas regions' in the model, which means that we are not able to assign effects of the past on-shore gas activity in the local economies with on-shore gas presence (and their respective township) across the 'New England and North West' SA4. The only exceptions are a barely (10% level) statistically significant evidence of a decrease in agricultural and manufacturing jobs between 2011 and 2016 as a consequence of on-shore gas development across regions. The decrease in agricultural jobs findings aligns to the finding of Fleming and Measham (2015) who also found a negative effect (a 'crowding-out') of on-shore gas activity on agricultural jobs in Queensland. The manufacturing finding might be capturing a similar sort of 'crowding-out' effect in this case (it could be that some people previously employed in manufacturing-related activity moved to work in on-shore gas related jobs). We further investigate this last result when exploring the potential economic benefits (and costs) that a fertiliser plant could bring to the Narrabri regions.[8]

[8] Given results in Table 2, we did not discuss results evaluating changes in income. In this analysis we obtained mostly non-significant effects, expect for a statistically significant (at the 10% level) effect of a 4% elasticity of on-shore gas activity on family income change between 2006 and 2016. This elasticity result is in line to the 7% elasticity found by Marcos-Martinez et al. (2019) for on-shore gas effect on family income between 2001-2011.

Table 3 Key socio-economic indicators across NSW SA2 regions - State, control and treatment (on-shore gas regions) groups

Variable	State SA2s (n=556)		Control SA2s (n=145)		On-shore gas SA2s (n=7)		T-test Control vs CGS regions
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Median family income 2006	1,251	432	974	204	995	108	
Median family income 2011	1,507	509	1,166	281	1,197	104	
Median family income 2016	1,784	568	1,411	283	1,491	112	
Proportion of Ag employment 2006	4.66	9.12	13.15	11.41	27.15	17.28	***
Proportion of Ag employment 2011	4.07	8.39	11.44	10.60	25.23	17.96	***
Proportion of Ag employment 2016	4.23	8.50	11.50	10.34	24.02	17.64	***
Prop. of Manufacturing emp. 2006	9.62	4.19	8.46	3.74	5.75	1.98	*
Prop. of Manufacturing emp. 2011	8.53	3.78	7.80	3.72	5.28	1.85	*
Prop. of Manufacturing emp. 2016	5.99	2.77	6.03	3.30	3.40	1.18	**
Prop. of Mining emp. 2006	0.86	2.40	1.68	3.49	0.94	1.09	
Prop. of Mining emp. 2011	1.24	3.02	2.53	4.57	3.53	3.32	
Prop. of Mining emp. 2016	1.23	3.07	2.50	4.56	5.51	5.78	*
Prop. of jobs in basic services 2006	63.04	6.87	59.76	9.07	51.44	13.31	**
Prop. of jobs in basic services 2011	63.94	6.77	61.10	8.87	51.85	12.55	**
Prop. of jobs in basic services 2016	63.32	7.23	60.67	8.56	51.19	12.25	***
Prop. of jobs in skilled services 2006	19.14	5.76	14.47	3.80	11.26	3.09	*
Prop. of jobs in skilled services 2011	19.71	6.12	14.85	3.59	11.21	3.44	**
Prop. of jobs in skilled services 2016	20.54	6.26	15.16	4.02	11.26	3.23	*
Prop. of people with a bachelor's degree 2006	19.41	10.04	13.47	4.17	10.90	1.04	
Prop. of people with a bachelor's degree 2011	22.32	10.87	15.58	4.82	12.04	0.88	*
Prop. of people with a bachelor's degree 2016	25.64	11.47	18.13	5.30	14.13	1.02	**

Source: Authors' elaboration with data from ABS (2020). *** p<0.01, ** p<0.05, * p<0.1. Skilled services jobs include employment in 'Electricity, gas and water services', construction, finance and insurance, and 'professional and scientific services'. Basic services jobs include employment in all other categories not listed here.

Table 4 Difference-in-difference regression results for select employment number changes over periods 2006-2011-2016

	(1) Ag. jobs 2006-16	(2) Ag. jobs 2006-11	(3) Ag. jobs 2011-16	(4) Man. jobs 2006-16	(5) Man. jobs 2006-11	(6) Man. jobs 2011-16	(7) Basic srv. 2006-16	(8) Basic srv. 2006-11	(9) Basic srv. 2011-16	(10) Skilled srv 2006-16	(11) Skilled srv 2006-11	(12) Skilled srv 2011-16
On-shore gas regions	0.016	0.016	-0.119*	-0.133	0.055	-0.190*	-0.030	-0.010	-0.029	-0.056	-0.060	-0.004
	(0.087)	(0.087)	(0.063)	(0.117)	(0.092)	(0.092)	(0.046)	(0.031)	(0.025)	(0.077)	(0.048)	(0.057)
Log of family income 2006	0.037	0.037		0.058	0.071		0.082*	0.023		-0.013	-0.029	
	(0.087)	(0.087)		(0.118)	(0.092)		(0.046)	(0.031)		(0.078)	(0.049)	
Pop density 2006	-0.001**	-0.001**		-0.001	-0.001		-0.000	-0.000		-0.000	-0.000	
	(0.001)	(0.001)		(0.001)	(0.001)		(0.000)	(0.000)		(0.001)	(0.000)	
Share agricultural jobs 2006	-0.070	-0.070		-0.603**	-0.804***		-0.513***	-0.243***		-0.355**	-0.127	
	(0.199)	(0.199)		(0.270)	(0.210)		(0.105)	(0.072)		(0.177)	(0.111)	
Share manufacturing jobs 2006	-0.563	-0.563		0.242	-0.956*		-0.248	-0.173		0.423	-0.275	
	(0.480)	(0.480)		(0.649)	(0.506)		(0.253)	(0.173)		(0.427)	(0.268)	
Log of family income 2011			-0.125**			-0.026			0.065***			0.031
			(0.060)			(0.088)			(0.023)			(0.054)
Pop density 2011			0.001***			0.000			0.000			0.000
			(0.000)			(0.001)			(0.000)			(0.000)
Share agricultural jobs 2011			-0.338**			0.178			-0.234***			-0.200
			(0.154)			(0.225)			(0.060)			(0.139)
Share manufacturing jobs 2011			0.081			1.057**			-0.149			0.671**
			(0.348)			(0.510)			(0.136)			(0.315)
R-squared	0.053	0.053	0.258	0.072	0.118	0.064	0.240	0.102	0.288	0.064	0.037	0.089

Notes: N = 149. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Skilled services jobs include employment in 'Electricity, gas and water services', construction, finance and insurance, and 'professional and scientific services'. Basic services jobs include employment in all other categories not listed here. Constant coefficients not reported.

4.3.1 Using past experience in QLD to inform projections in NSW

Thus far, on-shore gas activity in the 'New England and North West' SA4 region has been mainly exploration and drilling activity that stopped in 2014. Therefore, it is not surprising to find negligible effects of the on-shore gas activity on most economic outcomes. With the relatively small scale of the employment related to on-shore gas industry in NSW thus far, projections of economic effects need to draw on estimates from locations where on-shore gas activity has had a larger uptake. Considering this point, in this project, we build part of our analysis based on the effects that the on-shore gas industry produced across local economies of southeast Queensland. In particular, we use the experience observed and measured in the Surat basin to understand the potential effects that the on-shore gas industry could produce in the local economies of the Narrabri shire and surrounding regions.

By using past research findings derived from the Queensland experience, we can apply parameters of interest to model the potential impact that the on-shore gas industry can have in NSW. In table 4, we report the job elasticities that Measham et al. (2019) derived from their analysis of on-shore gas activity effects on socio-economic outcomes across SA1 regions of the Surat Basin. In particular, results show elasticities that on-shore gas job expansion produced over job chnages in other economic sectors. As seen, strong statistical significance levels in the results were only identified for the sectors of electricity services, construction, administration, recreation, other services, and accommodation (highlighted in bold fonts in Table 4).

From the derived elasticities reported in Table 4, we performed an initial analysis to establish how many jobs could be created in other sectors across the local economies of the seven on-shore gas regions (identified as out treatment group above) as a consequence of the potential establishment of the on-shore gas industry in the area. Results, derived in Table 5, indicate that for every ten on-shore gas full time jobs established across these regions, four new jobs could be created in other sectors. The specific potential job multiplier effect across sectors are shown in Table 4.

Table 5 Job multiplier elasticities across sectors in Queensland on-shore gas SA1 regions

Sector	Elasticity	p-value	
Manufacturing	0.003	0.951	
Electricity services	**0.168**	**0.008**	***
Construction	**0.124**	**0.003**	***
Wholesale	-0.053	0.377	
Retail	0.029	0.49	
Accommodation services	**0.151**	**0.002**	***
Transport	0.041	0.465	
Media	0.051	0.332	
Finance	0.013	0.823	
Rental	0.101	0.098	
Public	0.014	0.789	
Education	-0.025	0.584	
Health	0.049	0.280	
Recreation and arts	**-0.107**	**0.024**	**
Other services	**0.114**	**0.034**	**
Scientific professionals	0.001	0.983	
Administration	**0.123**	**0.031**	**
Agriculture	-0.069	0.116	

Note: *** p<0.01, ** p<0.05. *Source:* Adapted form Measham et al. (2019)

Table 6 Ratio sectoral job/mining jobs in 2016 and respective derived job multiplier in on-shore gas regions

Sector	Ratio	Job Multiplier
Electricity services	0.16	0.03
Construction	0.99	0.12
Administration	0.47	0.06
Recreation	0.10	-0.01
Other services	0.74	0.08
Accommodation	1.03	0.16

Notes: Ratios were estimated with the average values of the seven treatment (on-shore gas) SA2 regions. Results provide a net multiplier 0.44 jobs (sum of third column) for each potential on-shore gas job to be generated.

Projection of job spillover factors considering different scenarios

Drawing on the baseline analysis presented here, the next phase of this study developed projections under a range of potential scenarios and on-shore gas employment numbers presented by Santos (2020). These scenarios considered the potential scale of the gas industry in NSW as well as other factors in the economy. These additional factors considered the economic context in which the gas industry may develop, considering, for example, other industries such as agriculture and fertiliser production.

In their 'update of the economics' of the Narrabri Gas Project, Santos (2000) states the project will generate an average of 912 full-time employment during the life of the project – until the year 2046. Most of these new jobs will be located out of Narrabri, with only 222 jobs located in the region – Santos (2020) uses as region the SA3 of Moree-Narrabri. However, the company does not establish clearly how many of these 222 positions will be directly provided by the natural gas extraction activity. In Table 7 we use the estimates of Santos (2020) in terms of changes (per cent deviation from the baseline) on local employment that the project would generate to which we translate the value to employment levels – Santos (2020) only provides the deviation from the baseline value. As seen, based on the data used, we estimate that the project will generate 50 extra jobs in the SA3 of Moree-Narrabri, which we assume are given by the benefits of indirect job generation. This gives us an estimate of potential 172 jobs to be directly generated by the natural gas activity.

Table 7 Local employment per cent deviation from the baseline and respective employment gains (losses) considering 2016 as a baseline.

Sector	(1) Per cent deviation from the baseline	(2) Baseline in 2016	(3) Implied level	(4) Change in number of jobs
Agriculture and forestry	-0.15	2,571	2567	-4
Mining	0.05	240	240	0
Manufacturing	0.58	318	320	2
Utilities	0.15	112	112	0
Construction	0.82	668	673	5
Wholesale and retail trade	0.73	314	316	2
Transports	0.92	464	468	4
Services	0.74			
Total	**0.45**	**11,006**	**11,056**	**50**

Note: Data and estimations are for the SA3 Moree-Narrabri. *Source*: Column (1) values are from Santos (2020), column (2) values are from ABS (2020), and columns (3) and (4) show values estimated by the authors. 'Services' are not included in columsn (3)-(5) because it is not clear what sectors are included in the definition used in Santos (2020).

Assuming 172 direct jobs and our derived spillover of 0.44 jobs from Table 6, our calculation implies that the total indirect jobs to be generated by the project could reach around 76 jobs, which is higher than the 50 jobs we obtained using Santos estimates in Table 6. However, our estimates do not consider the potential detrimental effect on agricultural jobs because our evidence showed that the effect is close, but not statistically significant at the 10% level. Thus, if we consider the marginal negative effect of on-shore gas on agricultural jobs shown in Table 5, our overall multiplier estimate would be much more in line with what Santos (2020) implies. Given this, we can conclude that our econometrically-derived job spillover effects are quite close to the value estimates generated by the CGE in Santos (2020).

Next, we use our derived multipliers to project changes in indirect jobs considering the projections provided in Figure 6.3 of Santos (2020) –assuming a similar pattern of change in on-shore gas jobs as the pattern shown in the figure. To make this projection, we consider three different scenarios:

- Scenario 1: A 'business as usual' scenario that considers the spillover of 0.44 derived from Table 5
- Scenario 2: An 'agricultural effect' scenario that considers the negative spillover of on-shore gas on agricultural jobs, considering the parameter shown in Table 5, and

- Scenario 3: A 'boom/bust' scenario that considers dynamic multipliers given by increasing effects in initial years to later fade in latter years. Specifically, we increase our multiplier by 10% per year to 2027, and then decrease it by a similar percentage in the following years. We do this following the pattern in Santos (2020), where after 2027 the number of indirect jobs generated by the Narrabri gas project decreases in around 20% (a reproduction of the figure from the Santos report is shown in the Appendix).

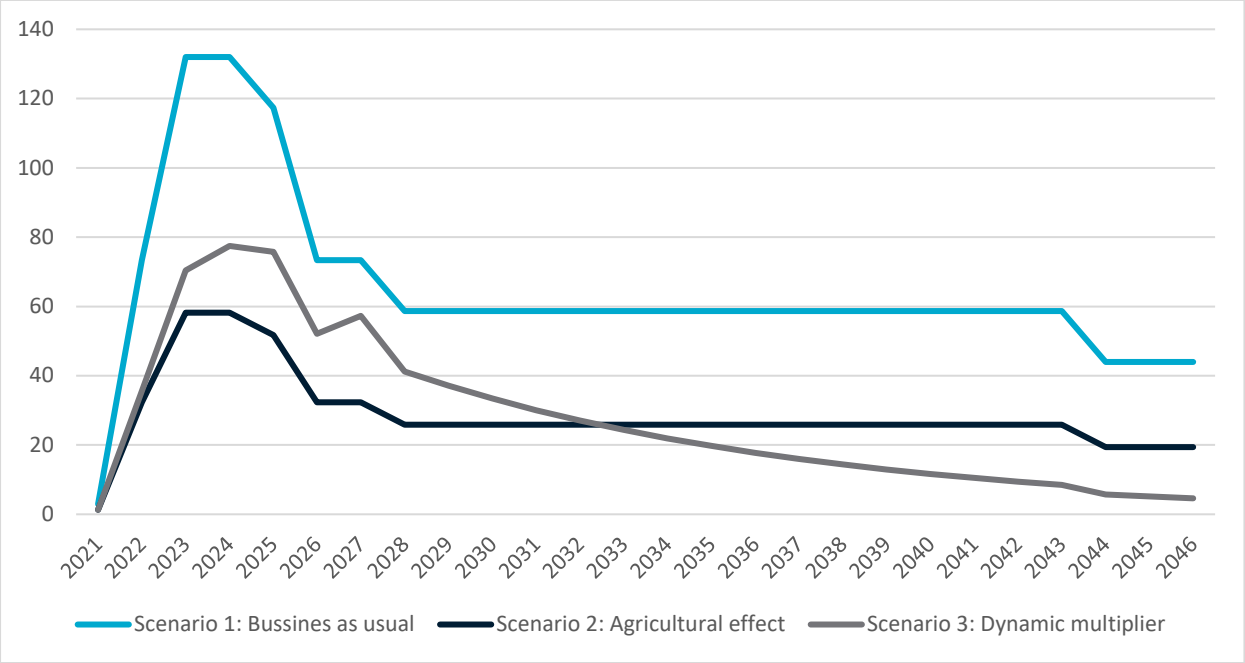

Figure 10 Potential local indirect jobs to be generated by the Narrabri gas project, across the three scenarios

Results of the scenario analysis show that assuming 2/3 of the projected jobs by Santos (2020) being covered directly by the natural gas activity, the number of indirect jobs will peak in 2024 then subsequently decrease over time. Across the potential cases, the scenario considering a stable multiplier effect and no impact on agricultural jobs show the largest number of indirect jobs ranging from around 130 in the year 2024 to around 40 by the end of the project (scenario 1). If the on-shore gas project does affect agricultural jobs (scenario 2), the total gains of indirect jobs decrease to no more than 60 in 2024-25, dropping to around 20 by the end of the project. In the case of the scenario showing a dynamic multiplier effect and impacts on agriculture (scenario 3), indirect jobs first increase more than in scenario 2, but in subsequent years of the project it drops to around zero.

4.3.2 The potential local economic impact of a fertiliser manufacturing plant

One of the industries that could emerge in the Narrabri region, as a by-product of the on-shore gas project, is fertiliser production. A 'heads of agreement' has been signed between Santos and Perdaman, a company specialising in chemical production and fertilisers (Perdaman, 2019). Fertiliser manufacturing is an active industry in Australia: in 2018 there were 305 fertiliser manufacturing businesses, invoicing more than $4.2 billion in sales and employing around 3,500 people across the country (Richardson, 2019a). While fertiliser manufacturing establishments are located in different regions of the country, only one establishment located in the Inverrell Region (approx. 180 Km northeast from Narrabri) is reported for the whole New England and Northwest Regions of NSW (Richardson, 2019b).

According to Perdaman (2019), the potential direct jobs in the Narrabri fertiliser plant could reach up to 100, which is considerably larger than the average fertiliser plant in Australia that employs approximately ten people. The average wage in this industry reaches approximately $AUD 103k per year (Richardson, 2019a).[9] Considering these values, we expand our analysis to better understand the effect that a potential manufacturing employment (and wages) boom can have across local economies and for the Narrabri region, in particular.

We first explored in more detail the share of employment in tradable goods across a range of SA2 areas in the country, from the national level down to the SA2 with on-shore gas wells around Narrabri. Table 8 presents the averages and Table 9 the maximum number of jobs reached across the regions of interest, in manufacturing, agriculture and mining (the three main tradable goods sectors). As seen, the share of manufacturing employment has been consistently decreasing across all samples in the ten-year period 2006-2016. The decrease in the share of manufacturing employment has been noticeably large in major cities, while in the Narrabri on-shore gas regions the drops has meant that less than 3% of all people employed are woking in manufacturing roles. This points to the important gains the Narrabri regions can obtain from a potential manufacturing plant in the region. In terms of the maximum number of jobs across regions, interestingly, the Narrabri on-shore gas region hosts the largest share of agricultural employment in NSW. This is clear evidence of the importance of agriculture in the area and its predominant role across local economies of NSW.

[9] Average employment considering 3,589 people employed across 375 establishments, and wages considering $370 million total, as shown in page 14 of Richardson (2019a), for 2018-19.

Table 8 Average share of tradable goods sectors employment over total resident employment across SA2s

Averages	Whole country (n=2,201)	Major cities (n=1,267)	Regional areas (n=915)	Regional NSW (n=259)	Narrabri on-shore gas regions (n=7)
Share of agricultural employment, 2006	0.049	0.010	0.103	0.093	0.271
Share of agricultural employment, 2011	0.042	0.008	0.089	0.081	0.252
Share of agricultural employment, 2016	0.044	0.009	0.092	0.082	0.240
Share of mining employment, 2006	0.014	0.007	0.023	0.016	0.009
Share of mining employment, 2011	0.020	0.011	0.033	0.024	0.035
Share of mining employment, 2016	0.020	0.010	0.033	0.024	0.055
Share of manufacturing employment, 2006	0.100	0.106	0.092	0.089	0.058
Share of manufacturing employment, 2011	0.086	0.089	0.082	0.080	0.053
Share of manufacturing employment, 2016	0.062	0.062	0.062	0.058	0.034

n denotes the SA2 observations

Table 9 Maximum share of tradable goods sectors employment, over total resident employment, across SA2s

Averages	Whole country (n=2,201)	Major cities (n=1,267)	Regional areas (n=915)	Regional NSW (n=259)	Narrabri on-shore gas regions (n=7)
Share of agricultural employment, 2006	0.750	0.240	0.750	0.501	0.501
Share of agricultural employment, 2011	0.530	0.213	0.530	0.499	0.499
Share of agricultural employment, 2016	0.588	0.500	0.588	0.495	0.495
Share of mining employment, 2006	0.499	0.079	0.499	0.308	0.028
Share of mining employment, 2011	0.550	0.375	0.550	0.306	0.088
Share of mining employment, 2016	0.684	0.119	0.684	0.322	0.155
Share of manufacturing employment, 2006	0.383	0.300	0.383	0.225	0.098
Share of manufacturing employment, 2011	0.429	0.276	0.429	0.223	0.084
Share of manufacturing employment, 2016	0.234	0.214	0.234	0.193	0.056

In terms of economic effects of manufacturing on economic outcomes, from the regression results shown in Table 4, changes in manufacturing jobs shown a negative correlation with the initial shares of agricultural employment (results in columns 4 and 5). To further analyse this result and estimate multiplier effects from a manufacturing jobs boom by econometrically modelling job spillovers we evaluate the effects that a change in manufacturing jobs can produce in other sectors.[10]

[10] Like mining, manufacturing is a tradable goods sector, therefore the identification of spillover effects is theoretically grounded (Fleming and Measham, 2015; Moretti, 2010).

Results are presented in Table 10. The estimated spillover effects are assessed by purely regressing changes in employment in agriculture, basic services and skilled services, on changes in employment on manufacturing. The estimated coefficients show the elasticities of changes. Results show that manufacturing has a statistically positive effect on changes in both basic and skilled services, except for the period 2011-16 in basic services. For agriculture jobs change, the effects are not statistically significant, which suggest that agricultural employment does not seem affected by changes in manufacturing jobs.

Table 11 uses the coefficients in Table 10 and the ratios sectorial jobs/manufacturing to estimate the final multiplier effect. Results suggest that for every ten jobs generated in manufacturing, potentially 14 jobs can be created across basic services sectors and four jobs can be created in skilled job services. These additional indirect jobs would be potentially created by the increased disposable income and demand that well-paid manufacturing jobs can generate in a local economy.

For the Narrabri shire specifically (the Narrabri LGA), where the potential fertiliser plant could be established, the multiplier effect means that the 100 jobs that Perdaman states will be generated in the operation of the fertiliser plant (Perdaman, 2019), basic jobs could increase from 3,065 (from its 2016 value) to around 3,205 (approx. a 4.5% growth) and skilled services jobs could increase from 726 (from its 2016 value) to around 766 (approx. 5.5% growth). Although small, these values could be a significant boost to Narrabri's economy and are in fact higher than the 100 extra indirect jobs that the same Perdaman report suggested could happen as a consequence of their plant (Perdaman, 2019).

Table 10 Spillover from manufacturing in regional NSW

	(1) Ag 0616	(2) Ag 0611	(3) Ag 1116	(4) Basic 1606	(5) Basic 1106	(6) Basic 1611	(7) Skilled 1606	(8) Skilled 1106	(9) Skilled 1611
Log manufacturing jobs difference (2016-2006)	0.032			0.130***			0.147***		
	(0.061)			(0.029)			(0.039)		
Log manufacturing jobs difference (2011-2006)		-0.014			0.098***			0.074**	
		(0.086)			(0.035)			(0.036)	
Log manufacturing jobs difference (2016-2011)			-0.021			0.019			0.124***
			(0.081)			(0.034)			(0.036)
Observations	259	259	259	259	259	259	259	259	259
R-squared	0.001	0.000	0.000	0.071	0.030	0.001	0.051	0.017	0.043

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Constant coefficients not reported.

Table 11 Employment, ratios and job multipliers

Number of manufacturing jobs in regional NSW	Number of basic services jobs in regional NSW	Number of skilled jobs in regional NSW
66,252	723,532	182,272
	Ratio basic serv / manuf.	**Ratio Skilled serv / manuf.**
	10.92	2.75
	Job multiplier into basic services	**Job multiplier into skilled services**
	1.42	0.4

4.4 Regional input-output projections

Potential economic impacts of gas extraction in Narrabri and its surrounding region estimated by Santos (2020) for the Narrabri Gas Project (NGP) include the generation of around 900 jobs in NSW during the life of the project. Around 220 of those jobs were projected for the Narrabri-Moree region. Over the life of the NGP, the Gross Regional Product (GRP) in the Narrabri-Moree region was estimated to increase around $500 million (2018 dollars) per year, relative to a case without NGP investment. The rest of the NSW was projected to increase its GRP by $81 million (Santos, 2020).

Previous research suggests that access to reliable and cost-effective gas resources by manufacturing industries could generate significant regional economic benefits (Measham, Porushi and Marcos-Martinez, 2020). In this context, the potential development of a fertiliser plant incentivised by access to local gas resources could generate *"at least 70 jobs during construction, and sustain 100 direct and 100 ongoing indirect jobs during operations"* in the Narrabri region (Perdaman, 2019). Given that other manufacturing industries could benefit from accessing cheaper gas resources, we used the EAIT input-output model to estimate the average impact on employment and GRP in Narrabri's economic sectors per million dollars invested in the manufacturing sector (Table 12). The results indicate that around 50% of the GRP and employment effect from investments in the manufacturing sector would remain in the manufacturing sector. Retail and wholesale trade would have a combined 12% increase, and Agriculture, Forestry and Fishing will account for a 9% positive impact. Around 40% of the employment and GRP effects would be direct. These estimates suggest that the fertiliser industry may need to spend around $35 million per year to reach the indicated 200 jobs per year.

Table 12 Employment (FTE) and Gross Regional Product (GRP) impact by sector in Narrabri per $1 million invested in Manufacturing.

	Jobs	GRP ($M)
Agriculture, Forestry and Fishing	0.50	0.05
Mining	0.11	0.06
Manufacturing	2.86	0.34
Electricity, Gas, Water and Waste Services	0.08	0.02
Construction	0.07	0.01
Wholesale Trade	0.23	0.03
Retail Trade	0.44	0.03
Accommodation and Food Services	0.25	0.01
Transport, Postal and Warehousing	0.34	0.04
Information Media and Telecommunications	0.02	0.00
Financial and Insurance Services	0.05	0.02
Rental, Hiring and Real Estate Services	0.04	0.03
Professional, Scientific and Technical Services	0.22	0.02
Administrative and Support Services	0.08	0.01
Public Administration and Safety	0.03	0.00
Education and Training	0.12	0.01
Health Care and Social Assistance	0.15	0.01
Arts and Recreation Services	0.02	0.00
Other Services	0.21	0.01
Total effects	5.84	0.72
Direct effects	2.47	0.29
Flow on – indirect effects	3.36	0.43

5 Conclusions and implications for Narrabri, the broader SA4 region and NSW

The main conclusions of this analysis can be summarised as:

- The Narrabri Gas Project is likely to continue increasing the gas sector's economic relevance in the Narrabri region and nearby areas.
- The development of an on-shore gas industry in Narrabri will bring economic benefits to the region. Santos (2020) estimates that 220 local jobs on average will be generated in Narrabri regions across the life of the project (from 2021 to 2046), of which we estimate that around 172 jobs on average will be direct jobs related to the natural gas extraction activity.
- Assuming the average of 172 jobs in the next 25 years, we apply scenarios to estimate potential job spillovers across Narrabri regions. Scenarios show that spillovers could range between 130 and 60 in the peak of the project activity (2024), dropping to a range between 40 and close to zero additional jobs in 2046.
- Following the experience from Queensland, we project that the main gains from job spillovers from natural gas extraction activity will occur in services related to the on-shore gas industry (such as electricians and construction), and some local services (such as accommodation and food services).
- If the gas industry facilitates the development of other economic sectors by providing access to a reliable supply of affordable energy, employment increases could be substantial. For instance, a potential new fertilizer plant in the region could generate direct and indirect jobs in other sectors. We estimate that every 10 new jobs in the fertiliser industry could generate as much as 18 additional jobs in other sectors.
- More specifically, econometric estimates show that each new job (FTE) in any industry within the manufacturing sector could generate 1.4 jobs in basic services and 0.4 jobs in skilled services. In contrast, employment spillover effects estimated through an input-output analysis indicate that each additional manufacturing job in the region could generate 1.36 FTE jobs in other sectors.

These findings have important implications for local and regional economies in NSW. For the Narrabri Shire, the direct economic gains from the development of a local gas industry could be increased if affordable and reliable gas supply triggers investments in other sectors. If gas supply is exclusively channelled to other regions, then local economic effects may be marginal.

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Appendix – Supporting Materials

Differently from Marcos-Martinez (2019) who performed a regional analysis for all on-shore gas activity across NSW (all SA2s reported in Table A1), in this project we pay special focus on the potential effects that on-shore gas extraction activity could generate in the Narrabri shire and surrounding regions.

Table A1 SA4 regions with on-shore gas wells in New South Wales

SA4 Region	Exploration or Pilot	Production
Central Coast	12	
Central West	1	
Coffs Harbour - Grafton	4	
Far West and Orana	19	
Hunter Valley exc Newcastle	46	
Illawarra	10	
Mid North Coast	54	
New England and North West	221	
Newcastle and Lake Macquarie	6	
Richmond - Tweed	77	
Riverina	1	
Southern Highlands and Shoalhaven	1	
Sydney - Baulkham Hills and Hawkesbury	4	
Sydney - City and Inner South	2	
Sydney - Inner West	1	
Sydney - Outer South West	33	
Sydney - Outer West and Blue Mountains	5	386
Sydney - South West	6	
TOTAL	503	386

Notes: One well was reported as 'Piezometric'. Production wells are active on-shore gas wells as per 2020.

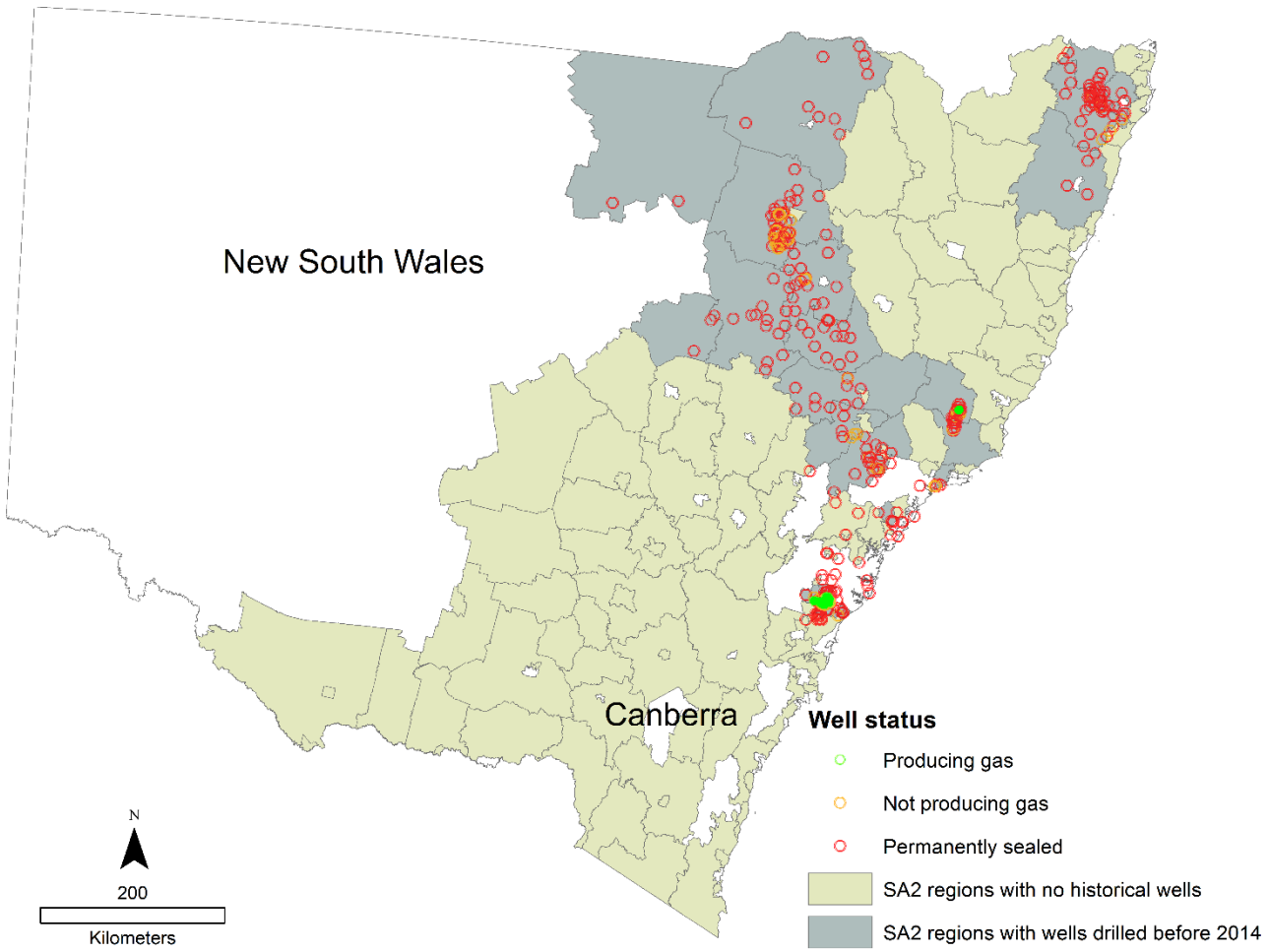

Figure A1 Status of past on-shore gas wells drilled since 2000 across NSW. Regional borders correspond to Statistical Areas (SA2). *Source*: Measham et al., 2018.

Figure A2 Job creation: Narrabri gas project (FTE job years). *Source*: Santos (2020), page 36.

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