MODELLING ENDOGENOUS EMPLOYMENT PERFORMANCE ACROSS AUSTRALIA'S FUNCTIONAL ECONOMIC REGIONS OVER THE DECADE 2001 TO 2011

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ABSTRACT: Patterns of spatial differentiation in endogenous regional employment performance across Australia's Functional Regions over the decade 2001 to 2011 are mapped and analysed. A range of spatial econometric models taking account of the spatial autocorrelation issue are used to investigate the factors which might explain that variation in performance, using the same approach as in previous studies of decadal inter-census periods. Implications for regional development policy are canvassed.

KEY WORDS: Endogenous growth, regional performance, functional regions, spatial differentiation, spatial econometric modelling.

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1. INTRODUCTION

Modelling regional economic performance has long been a concern of regional scientists. In recent times, there has been considerable emphasis on focusing on *endogenous growth* (see, for example, Stimson, Stough and Roberts, 2006; Johansson *et al.*, 2001; Stimson, Stough and Nijkamp, 2011; Stimson and Stough (with Salazar), 2009) providing a framework for measuring and modelling spatial variation in endogenous regional economic performance over time.

The modelling approach requires:

(a) specification of a *dependent* variable that measures how change in economic performance over time (both growth and decline) might be attributable to factors and processes that are endogenous to the region; and

(b) deciding on a set of *independent* variables that might provide explanation for the variation across regions in the incidence of that dependent variable, which is achieved using spatial econometric modelling.

That approach proposed by Stimson and Stough [with Salazar] (2009) has been adopted in several studies investigating the *endogenous* economic performance of regions across Australia over successive inter-census decadal periods (see Stimson, 2012; Stimson, Robson and Shyy, 2009a; 2009b; 2011; Stimson, Mitchell, Rohde and Shyy, 2011), and it is continued in this paper for the decade 2001-2011. It has also been used in the paper by Plummer *et al*. (2014). Importantly, in the research reported here, *functional* regions rather than *de jure* regions are used as the spatial base for the modelling. This has been shown to largely overcome the issue of spatial autocorrelation that is inherent in spatial econometric modelling based on using *de jure regions* as the spatial base for regional demarcation.

The modelling reported in this paper employs a framework in which:

(a) the spatial base is 134 *Functional Economic Regions* (FERs) across both the capital city metropolitan regions and the non-metropolitan regions of Australia that have been derived by the authors (and reported in Stimson *et al*., 2016);

(b) the *dependent variable*, measuring endogenous regional employment performance, is the regional (or differential) component derived from a shift-share analysis of employment change over the decade 2001-2011; and

(c) the *independent (explanatory) variables* that potentially might explain variation in the dependent variable, are a set of 27 measures derived from census data that relate to factors and processes that regional scientists have been suggesting might influence endogenous regional performance, plus five locational variables.

The paper is structured as follows. The next section briefly reviews past approaches to research investigating regional economic performance in Australia. That is followed by an outline of the data and methodology used in the analysis. Next, the spatial patterns of endogenous regional performance - the dependent variable - over the decade 2001-2011 are mapped and described. The bulk of the paper then presents the results of the spatial econometric modelling performed to identify those factors that might explain the variations in endogenous regional employment performance across Australia's FERs. Finally, there is a brief discussion of the policy implications of the model findings.

2. OVERVIEW OF APPROACHES TO RESEARCH INTO REGIONAL PERFORMANCE IN AUSTRALIA

Since the 1970s Australia has undergone as series of significant structural economic transitions. The impacts of these shifts have not been homogeneous over space and there is considerable variation in the economic performance of regions across Australia, both within the major large metropolitan cities and beyond into regional Australia.

Stimson (2012) has provided a detailed review of research investigating regional economic performance in Australia, most of which has been based on using *de jure* rather than *functional* regions—such as Local Government Areas or Statistical Local Areas (SLAs), or aggregations of them—as the spatial unit of analysis.

The nature of those economic and social 'divides', as they were emerging in the decade or so up to the late 1990s, was discussed in a book by O'Connor *et al.* (2001) on Australia's changing economic geography. Divides have also been identified in other studies (such as Baum *et al*., 1999; Baum *et al.*, 2006). Spatial mismatches were shown to be evident in regional shares of population and population change and in shares of investment in economic activity.

The O'Connor, *et al.* (2001) study raised a series of challenging implications for people-based and for place-based policy responses in

addressing those spatial disparities. In particular, the infrastructure needs required to enhance the performance of those segments and places in the space economy that are significant contributors to national wealth and competitiveness were a focus.
Stimson (2012: p. 162) pointed out that:

> "… Understanding the dynamics underlying the spatial differences that exist in the economic development and performance of Australia's regions is a complex task."

Regional research studies conducted over the last two to three decades have identified a range of factors influencing patterns of regional development and performance for specific periods of time. But:

> "… the specific conclusions reached and the relationships identified are not necessarily consistent because of the different focus of the studies and their different methodologies, variations in the spatial units of analysis used, and the different time periods that are analysed" (p. 162).

Stimson pointed out that many studies have investigated:

> "… regional differentials in, and inter-relationships between, regional population size and growth, employment changes, structural shifts in industry employment, income levels, resource endowments, and the locational characteristics of regions" (p. 162), along with aspects of human capital.

Among other things, they had shown that a region's industry structure, its occupation mix, and its human capital structure are affected not only by the size of the region's economy and its resource endowments, but also by its level of remoteness in the context of the nation's settlement system. Some examples of such regional research include the following:

- work by the Commonwealth Government's Bureau of Transport and Regional Economics (BTRE, 2004a; 2004b) has modelled relationships between regional shifts in industry structure diversification/specialisation, structural change in employment, unemployment, human capital, and the size of regional economies;
- research by Trendle and Shorney (2003) investigated the relationship between regional industry diversity and unemployment in the State of Queensland;

- studies by Bradley and Gans (1998) and Hogan *et al*. (1999) focused on analysing increasing regional industrial diversity;
- a study by Garnaut *et al*. (2001) investigated regional influences on employment and population growth;
- studies by Harrison (1997) and Garnett and Lewis (2000) focused on relationships between regional education participation rates and qualifications, migration, and labour markets;
- a study by the National Centre for Social and Economic Modelling (Lloyd *et al*., 2000) investigated the 'hollowing out' of income across regions; and
- a study by Plummer, *et al*. (2014) investigated uneven development and local competitiveness across Western Australia's regional cities.

However, as Stimson (2012) has noted, relatively few studies have:

> "…incorporated an explicit focus on the nature of occupational structure, occupational status, and education qualifications and skills, all of which are important components in the consideration of human capital differentials in regional development and performance" (p. 162).

Much of the published research on regional performance has been on the level of income and tended to focus on modelling variation in aggregate employment change or the incidence of unemployment. Some of the research on differentials in regional performance has been restricted to measuring and modelling an aspect of patterns of economic performance within Australia's capital city metropolitan regions or within a specific city, while other research has been focused specifically on the nation's non-metropolitan regions.

A variety of methodologies have been used to investigate aspects of regional economic performance in Australia, but predominately the preferred approach has been to use a multiple regression model, most typically an Ordinary Least Squares (OLS) model, and sometimes a backward step-wise regression model.

Modelling approaches other than straight regression analysis have also been used in research investigating regional performance in Australia. Examples include the following:

- using a binomial logit model in a cross-sectional study investigating the relationship between education, skills and qualifications and the economic performance of the five mainland States of Australia (Lawson and Dwyer, 2002);
- using Principal Components Analysis (PCA) to model regional variations in human capital (Stimson, Baum, Mangan, van Gellecum, Shyy and Yigitcanlar, 2004);
- developing typologies of community opportunity and vulnerability and using Multi-Discriminant Analysis (MDA) to describe the characteristics of the categories in those typologies e.g. the study by Baum *et al*. (1999) and Baum *et al*. (2006);
- developing typologies to produce functional classifications of regional cities and towns across Australia and showing how those have evolved over time (Beer, 1999; Beer and Maude, 1995); and
- using Shift-Share Analysis and the national shift component of employment change by industry sector to shed light on the proposition that an explanation of differences in regional employment growth was that some strongly performing regions are more specialized in rapidly growing industry sectors - like mining - across the Australian Bureau of Statistics Labour Market Regions over the period 1996-2001 (BTRE, 2004a; 2004b).

To take account of the spatial autocorrelation problem that is inherent in using aggregated spatial data, especially where it is based on *de jure* regions, it is important for modelling to use a *spatial dependence test*, along with a *multicollinearity test*. In addition, a *Spatial Error Model (SEM)* and a *Spatial Autoregressive (SAR) Model* should be employed. This was the approach used by Stimson, Mitchell, Rohde and Shyy (2011) in their study of variations in endogenous regional employment performance of FERs over the decade 1996-2006, and it is the approach used in this paper.

There have also been attempts to forecast the growth of regions into the future (Adams, 2002; Beer, 2002) looking at the effects of:

(i) national shifts in employment on regional growth;

(ii) initial industry structure on regional growth;

(iii) industrial diversity; and

(iv) the level of education, skills and qualifications.

It is only during the last decade that regional research in Australia has specifically focused on measuring and modelling *endogenous* regional performance, initiated by Stimson, Robson and Shyy (2004; 2005; 2006), and used also by Plummer, *et al*. (2014).

It is worth noting that, while traditionally it has been common for economists to theorize about regional convergence occurring over time in phenomena such as income, it is very clear from the empirical research investigating regional economic performance across Australia that, rather than regional convergence occurring, there appears to be divergence with a considerable degree of unevenness of performance being the rule across regions.

3. DATA AND METHODOLOGY

The analysis of *endogenous regional employment performance* across Australia over the decade 2001-2011 reported in this paper follows the methodology used by Stimson, Mitchell, Rohde and Shyy (2011) in the previous analysis for the decade 1996-2006.

Spatial Units

The spatial unit of analysis used are *Functional Economic Regions* (FERs) that have been compiled by the authors, as reported by Stimson *et al*. (2016), using the Intramax procedure developed by Masser and Brown (1975). The building blocks for the FERs are the Australian Bureau of Statistics' Statistical Areas Level 2 (SA2s). It uses the 2011 census journey-to-work data to analyse commuting patterns with FERs being demarcated to maximise within-region coincidence between where people live and where they work. The advantage of using FERs is that they tend to overcome, or at least minimise, the *spatial autocorrelation* problem encountered in the use of *de jure* regions (such as Local Government

Areas), as has been demonstrated in the Stimson, Mitchell, Rohde and Shyy (2011) paper.

It is worth noting that the method used to demarcate the FERs was *not* constrained by restricting them to be fall within State and Territory borders, as is the case with the Australian Bureau of Statistics Labour Market Regions. That means some FERs cross over the state border between New South Wales and Victoria, along the eastern part of the border between New South Wales and Queensland, and along some of the border between Victoria and South Australia.

Within and around the capital city metropolitan city regions there are multiple FERs: 10 across the Sydney-Newcastle-Wollongong conurbation; seven across the Melbourne-Geelong region; six across the Brisbane-South East Queensland region that extends north to the Sunshine Coast and south to the Gold Coast; four across the greater Perth region; but only two across the greater Adelaide region. That reflects the emergence over time of a multi-centre spatial structure for Australia's big cities and the regionalisation of metropolitan labour markets.

Beyond the metropolitan city regions, the FERs tend to become much larger as the degree of remoteness and sparsity of settlement (and thus remoteness) increases. In addition, they are often elongated in shape along the main roads, which is not surprising.

Model Variables

Following the framework proposed by Stimson and Stough [with Salazar] (2009) and Stimson *et al*. (2009b), the modelling approach here uses, as the *dependent variable*, a surrogate measure of endogenous regional employment performance over time. This is measured as the differential (or regional) component derived from a Shift-Share Analysis of regional employment change over the decade 2001-2011, standardised by the size of the regional labour force at the beginning of the period.

The set of *independent (or explanatory) variables* used is the same set of 32 variables used in the previous studies cited above, 27 of which are derived from census data, and five of which are explicit locational variables (see Table 1).

Modelling Approaches

As per the Stimson, Mitchell, Rohde and Shyy (2011) analysis for the decade 1996-2006, a range of models are applied to investigate the potential causes of the spatial variation in endogenous regional employment performance over the decade 2001-2011:

1. First, an *OLS full model* was run without allowing for spatial effects. *Spatial dependence tests* were then carried out, including the *Lagrange Multiplier (LM) tests*, and the *Moran's I test* which was run on residuals (see Anselin *et al*., 1996; Anselin, 1988). A *multicollinearity test* was also completed.

2. Second, a *backward step-wise regression* (based on AIC) was employed to derive an OLS specific model. Again, spatial dependence tests and a multicollinearity test were implemented.

3. Third, using the same variables, a *Spatial Error Model (SEM)* was run, which includes a lagged spatial error term.

4. Finally, for completeness and for comparison, a *Spatial Autoregressive (SAR) Model* was carried out on the same variables, which includes a lagged dependent variable.

Table 1. The Variables Used to Model Change in Endogenous Regional Employment Change over the Decade 2001-2011 Across Australia's Functional Economic Regions.

DEPENDENT VARIABLE	
REG_SHIFT	Regional Shift component of a Shift-Share Analysis of Employment change (2001 to 2011)/Labour Force (2001)/1000
INDEPENDENT VARIABLES	
Derived from Census Data	
SPEC_01	Specialisation Index for 2001 (Herfindahl-Hirschman Index)
SPEC_CH	Change in Specialisation Index from 2001 to 2011 (Herfindahl-Hirschman Index)
SCI	Structural Change Index (2001 to 2011)
SCI_CH	Change in the Structural Change Index (from 2001-2006 to 2006-2011)
L_INC_01	Median Individual Income – 2001 Annual (Log) (real)
L_INC_CH	Change in Median Individual Income – 2001 to 2011 Annual (Log) (real)
UNEMP_01	Unemployment rate in 2001
UNEMP_CH	Change in Unemployment rate from 2001 to 2011
L_POP_01	Log of population (2001)
L_POP_CH	Change in Log of population (2001 to 2011)
LQ_MAN_01	Location Quotient for the Manufacturing Industry in 2001
LQ_INF_01	Location Quotient for the Information media & telecommunications Industry in 2001
LQ_FIN_01	Location Quotient for the Financial & insurance services Industry in 2001
LQ_PRO_01	Location Quotient for the Professional, scientific & technical services Industry in 2001
LQ_MAN_CH	Change in the Location Quotient for the Manufacturing Industry, 2001 to 2011
LQ_INF_CH	Change in the Location Quotient for the Information media & telecommunications Industry, 2001 to 2011
LQ_FIN_CH	Change in the Location Quotient for the Financial & insurance services Industry, 2001 to 2011
LQ_PRO_CH	Change in the Location Quotient for the Professional, scientific & technical services Industry, 2001 to 2011
POSTGRAD_01	Proportion of labour force with a Postgraduate Degree or higher in 2001
BACHELOR_01	Proportion of labour force with a Bachelor Degree or higher in 2001
TECHQUALS_01	Proportion of labour force with technical qualifications in 2001
POSTGRAD_CH	Change in the Proportion of labour force with a postgraduate degree or higher, from 2001 to 2011
BACHELOR_CH	Change in the Proportion of labour force with a bachelor degree or higher, from 2001 to 2011
TECHQUALS_CH	Change in the Proportion of labour force with technical qualifications, from 2001 to 2011
SYMBA_01	Proportion of Symbolic Analysts (Managers + Professionals) in Employment in 2001
SYMBA_CH	Change in the proportion of Symbolic Analysts (Managers + Professionals) in Employment from 2001 to 2011
VOLUNTEER_11	Proportion of Volunteers in Working Age Population (15–64) in 2011
Location Variables	
A_COAST	Border is adjacent to coastline (No = 0; Yes = 1)
P_METRO	Border is adjacent to metropolitan statistical division (No = 0; Yes = 1)
D_URBAN	Classified as Urban under Australian Classification of Local Governments system (1 = Yes, 0 = No)
D_REMOTE	Classified as Remote under Australian Classification of Local Governments system (1 = Yes, 0 = No)
W_METRO	Border is within metropolitan statistical division (No = 0; Yes = 1)

Source: the Authors.

4. SPATIAL PATTERNS OF ENDOGENOUS REGIONAL EMPLOYMENT PERFORMANCE

It is important to understand the economic context of the decade 2001-2011 in Australia. The decade began just after the 2000 Sydney Olympics. The long-boom years of economic growth that had begun following the recession of the early 1990s continued until later in the first decade of the new millennium.

Not surprisingly then, one would expect there to be marked variations in the direction and the magnitude of endogenous regional employment performance over the decade 2001-2011 across Australia's FERs, and that is the case as clearly shown in Figure 1.

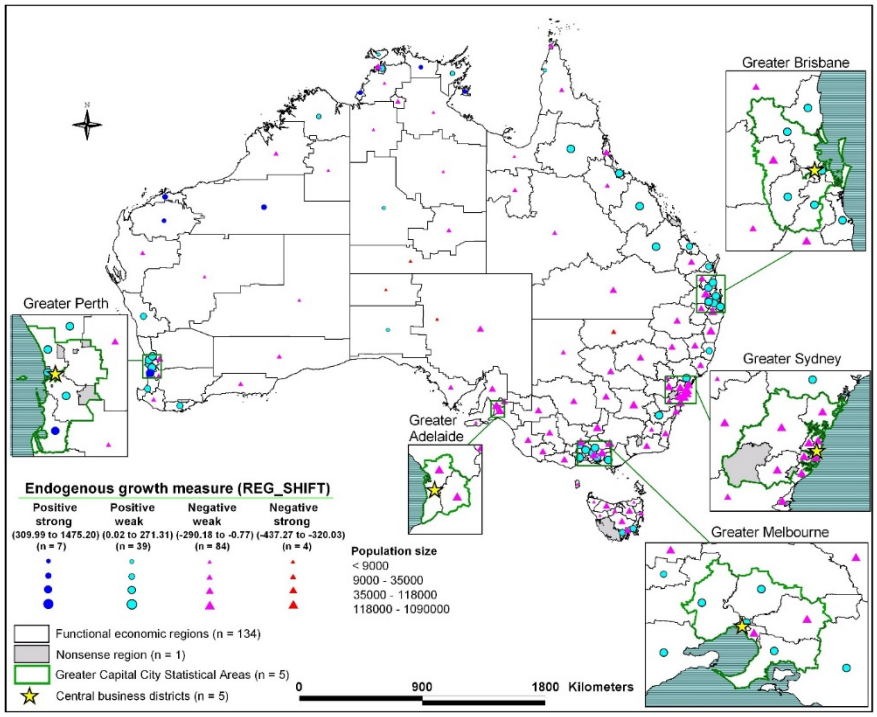

Figure 1: Map of Positive and Negative Scores on the Endogenous Regional Employment Performance (REG_SHIFT) Dependent Variable Measure, 2011-2011. Source the Authors.

When the world was impacted by the sharp downturn of the Global Financial Crisis (GFC), fortunately it had a relatively low aggregate impact on Australia. But it did have significant variable regional impacts. The decade was also characterised by the resources boom led by high commodity prices and an escalation in mining investments, output and exports, which was to create circumstances for what has been described as a 'two-speed economy'.

Following the elimination of some of the very remote and barely inhabited areas characteristic of a vast continent such as Australia, 134 FERs remained. Over the decade 2001-2011 only 46 of these FERs (or 34%) recorded a *positive* score on the endogenous regional employment performance measure, with only seven of those FERs having a *strong positive* performance. Thus, the big majority of the FERs (88 or 66%) recorded *negative* scores on the endogenous regional employment performance variable, with four of them having a *strong negative* performance.

Table 2 lists the FERs that were the top 25 positive performers and those that were the bottom negative performing FERs on the endogenous regional employment performance measure for the decade 2001-2011.

Some distinctive characteristics are evident from the pattern, across Australia, of *positive* and *negative* performance of FERs on the endogenous regional employment performance variable over the decade 2001-2011, and these are discussed below.

Table 2. The Bottom 25 Negative Performing FERs on the Endogenous Regional Employment Performance Variable for the Decade 2001-2011.

Bottom 25 *negative* performing FERs (name given)	**State/Territory, type of region**	**REG_SHIFT score**
1. Petermann - Simpson	NT: Remote	-437.2739166
2. APY Lands	SA: Remote indigenous lands, north west	-367.6052307
3. Bourke - Walgett	NSW: Inland far west, remote	-359.6419387
4. Coober Pedy	SA: Inland, remote	-320.0340477
5. Renmark - Loxton	SA: Inland, irrigation area	-290.1754182
6. Victoria River	NT: Remote, indigenous	-287.7707821
7. Dorset	TAS: Coastal, rural, north east	-281.1617911
8. King Island	TAS: Island, rural remote	-265.9318968
9. Swan Hill - Deniliquin - Wentworth	NSW-VIC: Inland irrigation area	-263.4774996
10. Snowy Mountains	NSW: Inland south, rural	-248.6266220
11. Griffith - Narrandera	NSW: Inland, irrigation area	-244.0103606
12. Manjimup - Bridgetown	WA: Coastal, rural, south west	-243.3089350
13. Longreach and surrounds	QLD: Inland far west, pastoral	-217.2412607
14. Carnarvon - Exmouth	WA: NW remote mining	-214.1387132
15. Moree - Inverell - Goondiwindi	NSW- QLD: Inland north, rural	-213.3415212
16. Charters Towers - Ayr	QLD: Coastal and inland north	-204.8155484
17. Brookton - Narrogin - Katanning	WA: Inland, rural	-202.4857934
18. Parkes - Cobar	NSW: Inland western plains, rural	-196.4080787
19. Cape York Peninsula	QLD: Far North Cape, remote	-195.2428712
20. Ingham - Innisfail	QLD: Coastal north, rural	-194.9280890
21. York - Dalwallinu - Merredin	WA: Inland, rural	-193.7412466
22. Carpentaria	QLD: Coastal, far north, remote	-192.9291385
23. Tennant Creek - Barkly	NT: Inland remote	-189.3799572
24. Northern Darwin suburbs	NT: Metropolitan suburban	-187.5386101
25. Mildura and surrounds	VIC-NSW: Inland, irrigation area	-185.2242600

Source: the Authors.

Table 2 Continued: The Top 25 Positive Performing FERS on the Endogenous Regional Employment Performance Variable for the Decade 2001-2011.

Top 25 *positive* performing FERs (name given)	**State/Territory, type of region**	**REG_SHIFT score**
1. Ashburton	WA: North west, remote mining	1475.2003860
2. Thamarrurr	NT: Indigenous area, remote	991.9831003
3. Port Hedland - Newman - East Pilbara	WA: North west, remote mining	751.6731816
4. Karratha - Roebourne	WA: North west, remote mining	708.2806127
5. Rockingham - Mandurah	WA: Metropolitan outer suburban, south	443.3334812
6. Anindilyakwa	NT: Indigenous land council area, remote	439.2604002
7. West Arnhem	NT: Remote, indigenous	309.9875564
8. Darwin City - Inner suburbs	NT: Metropolitan inner	271.3055835
9. Western	SA: Inland, remote	253.3676169
10. Weipa	QLD: Coastal, far north, remote	243.8628282
11. Mackay - Whitsunday	QLD: Coastal, regional city and rural	232.8954608
12. Gladstone and surrounds	QLD: Coastal, north	218.6443992
13. Sunshine Coast	QLD: Metropolitan outer suburban northern	197.4943849
14. Palmerston - Litchfield	NT: Inland, remote	183.0851687
15. Melbourne West - North West - Bacchus Marsh	VIC: Metropolitan outer suburban, north and west	162.6978148
16. Gold Coast - Tweed	QLD-NSW: Metropolitan outer suburban, south	158.5154890
17. Bunbury - Margaret River	WA: South west coastal, regional city and wine area	142.9204609
18. Ipswich - Springfield	QLD: Metropolitan outer suburban, west	138.8049684
19. Hervey Bay - Maryborough	QLD: Coastal, regional city and rural	136.4600045
20. Midland - Mundaring - Gingin	WA: Inland rural	134.8232042
21. Brisbane North - Moreton Bay Region	QLD: Metropolitan suburban, north	128.5096330
22. Mornington Peninsula - Dandenong - Pakenham	VIC: Metropolitan outer suburban, southeast	98.1366192
23. North Perth - Joondalup	WA: Metropolitan outer suburban, north	98.0774790
24. Greater Townsville	QLD: Coastal regional city	91.2981568
25. Fremantle - South Eastern Perth	WA: Metropolitan suburban, south	90.9848153

Source: the Authors.

Positive Endogenous Regional Employment Performance

The *positive performing* FERs are located across much of the capital city metropolitan regions, including Melbourne, Brisbane, Perth, Darwin, Hobart and across the ACT. But this was *not* the case for Adelaide or Sydney.

Positive performance was also spread across some areas of coastal NSW, Queensland, eastern Victoria, Western Australia and much of the nation's inland wheat-sheep belt. Furthermore, positive performance is found in some of the mining regions and in some of the indigenous settlement regions of Western Australia, Queensland and the Northern Territory. The existence of *positive* endogenous regional employment performance for some of the FERs that are indigenous settlements is surprising, but probably explained by the concerted public policy efforts of governments to create indigenous employment, which is in fact an exogenous factor but is picked-up by default in the measure of the REG_SHIFT dependent variable.

Negative Endogenous Regional Employment Performance

The *negative performing* FERs are located widely across regional Australia beyond the capital cities and especially across the nation's vast remote areas. That includes farming and grazing regions of western Victoria, South Australia, parts of central and western Queensland, and Western Australia. Those regions largely form Australia's extensive wheat-sheep belt. Some of the *negative* performing FERs are also found in parts of coastal New South Wales, Queensland, Victoria, South Australia and Western Australia. Most of the FERs in Tasmania also had *negative* performance.

Within the capital city metropolitan regions, *negative* performance on the endogenous regional employment performance dependent variable was also present across all of Adelaide, all of Sydney, in eastern Melbourne, and in the north-west of Brisbane.

5. THE MODELLING AND RESULTS

As indicated earlier, several approaches were used to model the role the *independent* variables might play in explaining the variation in the dependent variable across the FERs. These models and their results are discussed below.

The Ordinary Least Squares Full Model

First the *OLS regression full model* was run without allowing for spatial effects (see Table 3). The R^2 is quite high (0.9414). Only nine of the independent variables are significant in explaining the variation in the dependent variable, six having a *positive* and three having a *negative* influence on the endogenous regional employment performance of FERs. The *positive* effects result from variables relating to:

- industry diversification/specialization at the beginning of the decade and the decade 2001-2011;
- the region's structural change index at the start of the decade;
- population change over the decade;
- the level of unemployment at the beginning of the decade;
- change in the incidence of information jobs; and
- the measure of remoteness.

The *negative* effects are from the variables relating to:

- the initial level of income; and
- change in the incidence both of people with bachelor qualifications and of people with technical qualifications.

It is noteworthy that some variables have a different direction (positive/negative) to model outcomes in the Stimson, et al. (2011) paper analysing the decade 1996-2006.

The Anselin Lagrange Multiplier (LM) tests—both the original and the robust tests—were used to test for spatial dependence, both error and lag (Table 4). In addition, the Moran's *I* test on residuals was run (Table 5). The full model shows no evidence of spatial dependence (lag or error) according to the LM tests or Moran's *I* on residuals.

A test for multicollinearity using variance inflation factors (VIF) was run (Table 3). Obviously, some of these are very high.

Table 3: Full OLS Model Results and Multicollinearity Test Results.

Coefficient	Estimate	Std. Error	*t* value	*p* value	Multicollinearity test (VIF)
(Intercept)	510.084	412.418	1.237	0.219025	-
SPEC_01	542.682	249.199	2.178	0.031756*	8.907465
SPEC_CH	725.606	372.764	1.947	0.054366	8.835060
SCI	799.754	192.563	4.153	$6.87e^{-05}$***	8.300719
SCI_CH	67.315	212.352	0.317	0.751898	2.712929
L_INC_01	-369.200	131.331	-2.811	0.005929**	7.720642
L_INC_CH	114.551	182.396	0.628	0.531398	6.698806
UNEMP_01	13.761	5.238	2.627	0.009956**	6.533965
UNEMP_CH	-6.573	5.943	-1.106	0.271349	10.313893
L_POP_01	24.596	23.474	-1.048	0.297240	8.789758
L_POP_CH	3441.275	153.338	22.442	$< 2.0e^{-16}$***	2.708974
LQ_MAN_01	19.628	25.393	0.773	0.441342	3.479791
LQ_INF_01	160.601	40.129	0.669	0.505141	13.368863
LQ_FIN_01	402.623	203.362	1.980	0.050444	20.924515
LQ_PRO_01	-133.266	124.184	-1.073	0.285772	26.257744
LQ_MAN_CH	-67.364	39.632	-1.700	0.092259	1.823345
LQ_INF_CH	73.053	280.635	2.042	0.043759*	1.653523
LQ_FIN_CH	-170.392	218.090	0.781	0.436459	5.857960
LQ_PRO_CH	96.262	98.370	0.979	0.330131	4.123870
POSTGRAD_01	42.977	1296.986	0.033	0.973631	13.713052
POSTGRAD_CH	-1179.092	1739.547	-0.678	0.499439	17.156961
BACHELOR_01	90.571	499.123	0.181	0.856370	28.413478
BACHELOR_CH	-2557.620	730.100	-3.503	0.000687***	6.886694
TECHQUALS_01	238.953	162.494	1.471	0.144524	4.083310
TECHQUALS_CH	-1484.946	294.507	-5.042	$2.03e^{-06}$***	6.622777
SYMBA_01	259.703	315.795	0.822	0.412798	14.158755
SYMBA_CH	183.322	632.459	0.290	0.772521	16.353417
VOLUNTEER_11	2.412	2.367	1.019	0.310660	5.758360
A_COAST	-20.734	15.912	-1.303	0.195511	1.778726
P_METRO	4.405	21.777	0.202	0.840116	1.281645
D_URBAN	-4.909	21.746	-0.226	0.821847	3.626887
D_REMOTE	84.127	42.356	1.986	0.049723*	3.107093
W_METRO	-14.090	28.492	-0.495	0.621997	2.633234

Notes: Residual standard error: 65.91 on 101 degrees of freedom; Multiple $R^2 = 0.9414$; Adjusted $R^2 = 0.9229$; F Statistic = 50.73(32, 101); p value < $2.2\ e^{-16}$. *= significant at 0.05 level; ** = significant at 0.01 level; *** = significant at 0.00 level. Source: the Authors.

Table 4. Anselin Lagrange Multiplier test: Spatial Error and Spatial Lag Results.

est	χ^2	df	*p* value
LM error	1.0049	1	0.3161
LM lag	1.3566	1	0.2441
Robust LM error	2.6684	1	0.1024
Robust LM lag	3.02	1	0.08224

Source: the Authors.

Table 5. Moran's I Test Results

Moran's *I*	*z* value	*p* value
0.062399	1.814	0.06967

Source: the Authors.

The Backward Step-Wise Regression Model

A *backward step-wise regression* (based on AIC) was run to derive an *OLS specific model* (Table 6). This reduces, to 15, the number of independent variables that are relevant to explaining the dependent variable. Once more, the R^2 is quite high (0.937).

Twelve variables are significant, 10 having a positive effect and two having a negative effect. Again, some variables have a different direction (positive/negative) to model outcomes in the Stimson, Mitchell, Rohde and Shyy. (2011) paper analysing the decade 1996-2006.

The independent variables having a significant *positive* effect on FER endogenous regional employment over the decade 2001-2011 relate to:

- industry diversification/specialisation at the beginning of the period and for the change in it over time;
- the region's structural change index at the beginning of the decade;
- population change over time;
- the level of unemployment at the beginning of the decade;
- the change in the degree of concentration of jobs in information and in finance;
- the incidence of volunteering (as a surrogate measure of social capital); and
- the degree of regional remoteness.

Negative effects on endogenous regional employment performance are related to:

- the level of income at the beginning of the decade; and
- the change in the incidence both of people with bachelor qualifications and of people with technical qualifications.

Results of the Anselin's LM and Morans *I* tests are presented in tables 7 and 8, respectively. There is no spatial dependence according to the Anselin LM tests, but there is significant (at the 0.05 level) error due to spatial dependence using the Moran's *I*. Multicollinearity test results are reported in Table 6. According to most of the literature, these results are quite acceptable, though some authors advocate for VIFs less than 6.

Table 6. Backward Step-Wise Regression OLS Specific Model and Multicollinearity Test Results.

Coefficient	Estimate	Std. Error	*t* value	*p* value	Multicollinearity test (VIF)
(Intercept)	486.664	257.791	1.888	0.061506	-
SPEC_01	534.036	206.619	2.585	0.010966*	6.646055
SPEC_CH	895.148	288.790	3.100	0.002423**	5.755288
SCI	1006.150	128.078	7.856	$2.05e^{-12}$***	3.985473
L_INC_01	-372.183	101.600	-3.663	0.000374***	5.015021
UNEMP_01	14.410	3.648	3.951	0.000133***	3.438619
UNEMP_CH	-5.928	3.941	-1.504	0.135236	4.922926
L_POP_CH	3340.952	111.646	29.924	$2.00e^{-16}$***	1.558675
LQ_FIN_01	195.943	87.959	2.228	0.027800*	4.248533
LQ_MAN_CH	-66.334	33.987	-1.952	0.053339	1.455343
LQ_INF_CH	511.158	232.272	2.201	0.029705*	1.229364
BACHELOR_CH	-2704.582	389.691	-6.940	$2.26e^{-10}$***	2.129349
TECHQUALS_01	201.311	122.432	1.644	0.102783	2.515898
TECHQUALS_CH	-1531.763	218.177	-7.021	$1.51e^{-10}$***	3.944820
VOLUNTEER_11	4.172	1.310	3.184	0.001858**	1.915148
D_REMOTE	96.245	32.977	2.919	0.004212**	2.044094

Notes: Residual standard error: 63.26 on 118 degrees of freedom; Multiple $R^2 = 0.937$; Adjusted $R^2 = 0.9289$; F Statistic = 116.9(15, 118); p value < $2.2\ e^{-16}$. *= significant at 0.05 level; ** = significant at 0.01 level; *** = significant at 0.00 level. Source: the Authors.

Table 7: Anselin Lagrange Multiplier Test Results: Backward Step-Wise Regression OLS Specific Model.

Test	χ^2	df	*p* value
LM error	2.3964	1	0.1216
LM lag	0.4289	1	0.5125
Robust LM error	3.7228	1	0.0537
Robust LM lag	1.7553	1	0.1852

Source: the Authors

Table 8. Moran's I Test on Residuals Results.

Moran's *I*	*z* value	*p* value
0.096359	2.0674	0.0387*

Source: the Authors.

Spatial Regression Models

Spatial Error Model (SEM)

Given the possibility of spatial error dependence evidenced from the Moran's *I* test on residuals, the same variables were run in a *Spatial Error Model (SEM)*, which includes a lagged spatial error term (Table 9).

The results show there is little difference between the OLS and the SEM. Those variables that were significant in the OLS are still significant in the SEM, all coefficient directions are the same, and there are only minor variations in magnitudes. Regarding the SEM, the spatial error coefficient, lambda, is significant (*p* value 0.028) and the AIC is slightly lower, but the Likelihood Ratio test is not significant (*p* value 0.0733), thus pointing to the OLS as the preferred model.

Table 9. Spatial Error Model Results.

Coefficient	Estimate	Std. Error	*z* value	*p* value
(Intercept)	505.5062	241.1581	2.0962	0.0360679*
SPEC_01	586.9817	194.5074	3.0178	0.0025463**
SPEC_CH	1054.3037	274.7729	3.8370	0.0001245***
SCI	1010.0631	115.2328	8.7654	$<2.2e^{-16}$***
L_INC_01	395.5645	94.4138	-4.1897	$2.793e^{-05}$***
UNEMP_01	13.8385	3.4481	4.0134	$5.986e^{-05}$***
UNEMP_CH	-5.0196	3.6979	-1.3574	0.1746421
L_POP_CH	3349.6546	109.5279	30.5827	$<2.2e^{-16}$***
LQ_FIN_01	208.8935	88.2814	2.3662	0.0179705*
LQ_MAN_CH	-60.5119	31.2101	-1.9389	0.0525192
LQ_INF_CH	582.1127	214.9754	2.7078	0.0067729**
BACHELOR_CH	-2569.5230	370.7719	-6.9302	$4.202e^{-12}$***
TECHQUALS_01	218.6299	120.1337	1.8199	0.0687761
TECHQUALS_CH	-1442.5091	201.6122	-7.1549	$8.376e^{-13}$***
VOLUNTEER_11	4.4870	1.2194	3.6796	0.0002336***
D_REMOTE	83.4578	30.5998	2.7274	0.0063836**

Notes: Lambda: 0.23906, LR test value: 3.2081, p-value: 0.073276; Asymptotic standard error: 0.10888; z-value: 2.1956, p-value: 0.028124*; Wald statistic: 4.8205, p-value: 0.028124*; Log likelihood: -735.7494 for error model; ML residual variance (sigma squared): 3393.7, (sigma: 58.256); Number of observations: 134; Number of parameters estimated: 18; AIC: 1507.5, (AIC for lm: 1508.7). * = significant at 0.05 level; ** = significant at 0.01 level; *** = significant at 0.00 level. Source: the Authors.

Spatial Autoregressive Model

For completeness and comparison, the *Spatial Autoregressive (SAR) Model* was also run, which includes a lagged dependent variable (Table 10).

In the SAR model, LQ_MAN_CH becomes significant, but otherwise the results are similar to those for the OLS model and the SEM. Importantly, the lagged dependent variable coefficient (rho) is not significant (*p* value 0.548) and the AIC is higher than for the OLS model.

Table 10. Spatial Autoregressive (SAR) Model Results.

Coefficient	Estimate	Std. Error	*z* value	*p* value
(Intercept)	463.0629	243.9175	1.8984	0.0576380
SPEC_01	541.2858	194.2695	2.7863	0.0053320**
SPEC_CH	898.9836	271.0777	3.3163	0.0009121***
SCI	1015.7014	121.0489	8.3908	$<2.2e^{-16}$***
L_INC_01	-366.9723	95.3511	-3.8486	0.0001188***
UNEMP_01	14.5123	3.4177	4.2463	$2.174e^{-05}$***
UNEMP_CH	-5.9810	3.6942	-1.6190	0.1054405
L_POP_CH	369.3973	114.2799	29.4837	$<2.2e^{-16}$***
LQ_FIN_01	192.5118	82.5667	2.3316	0.0197221*
LQ_MAN_CH	67.3119	31.8483	-2.1135	0.0345563*
LQ_INF_CH	469.4857	227.3773	2.0648	0.0389431*
BACHELOR_CH	-2674.0478	371.5417	-7.1972	$6.148e^{-13}$***
TECHQUALS_01	207.3834	115.3710	1.7975	0.0722507
TECHQUALS_CH	-1533.2985	204.4728	-7.4988	$6.439e^{-14}$***
VOLUNTEER_11	4.2163	1.2306	3.4262	0.0006120***
D_REMOTE	96.8746	30.9031	3.1348	0.0017198**

Rho: -0.026617, LR test value: 0.39186, *p* value: 0.53132; Asymptotic standard error: 0.044357; *z* value: -0.60006, *p* value: 0.54846; Wald statistic: 0.36008, *p* value: 0.54846.
Log likelihood: -737.1575 for lag model; ML residual variance (sigma squared): 3513.3, (sigma: 59.273); Number of observations: 134; Number of parameters estimated: 18; AIC: 1510.3, (AIC for lm: 1508.7); LM test for residual autocorrelation; test value: 4.032, *p* value: 0.044646*.
*=significant at 0.05 level; **=significant at 0.01 level; ***=significant at 0.00 level.
Source: the Authors.

Summary

In summary, the *OLS* does appear to be the best model, negating the need for spatial models. This is an interesting finding, and it confirms the supposition that the use of a *functional* rather than a *de jure* spatial base should help overcome the issue of spatial autocorrelation.

By way of an aside, the Moran's *I* statistic for the REG_SHIFT variable is significant, meaning the REG_SHIFT itself shows some spatial dependence. However, it is no longer significant in the SAR model (Table 10), which is interesting.

6. POLICY ISSUES

Regional Policy Interventions in Australia

In Australia it has been common to have government involvement in implementing explicit regional development policy, but that has waxed and waned over time. Such involvement has tended to have been focused almost exclusively on non-metropolitan regions and rarely on metropolitan

regions. Such policies are what O'Connor, *et al*. (2001) have referred to as *'place-specific'* policies. The interventions have typically been about, *inter alia*, the following:

- investments in infrastructure (including transportation projects, dams and irrigation systems);
- grants for community facilities;
- providing higher education facilities; and
- industry attraction schemes, which are essentially about 'picking winners' and which have a long history of failure.

Regional economic development policy and programs are almost exclusively the concern of the state/territory governments.

In addition, some government policy and programs that are 'people-specific' can have regional impacts, one of the most notable being the immigration policy of Commonwealth governments, with immigrants overwhelmingly choosing to live in the major cities, especially Sydney and Melbourne and in specific areas within them.

Over the last two to three decades regional development policy has tended to be focused more on developing local capacity and enhancing competitiveness, which is about bolstering-up endogenous processes. But often the implementation of such policy approaches has been characterised by 'picking winners' as illustrated by the Western Australia experience discussed by Plummer, *et al*. (2014).

It is often the case that attention has been directed towards intervening in poorly performing/lagging regions, rather than making investments to further enhance the performance of successful regions.

Implications of the Modelling for Policy

What might be the implications for policy of the modelling undertaken for this paper? Several are evident if the purpose of regional policy programs is to enhance the *endogenous* performance of regions.

It is evident that marked differences persist in the pattern of endogenous regional employment performance across Australia, with the large majority of FERs displaying negative performance over the decade 2001-2011. There are marked divides between the regional and some of the metropolitan region FERs, but that is not universal. Across regional and rural Australia there are pockets of positively performing FERs, so it is not

all 'gloom-and-doom' across Australia's regional and rural areas. But nor is it all booming across the metropolitan regions.

Of special concern from the experience of the 2000s is the negative performance of FERs in the Sydney metropolitan region, which was a reversal of the situation for prior inter-census decades. Was this a post-Olympics effect? And was it an outcome of planning policy restricting land release and a reaction to the Labor Premier of New South Wales, Bob Carr, declaring that Sydney was closed to expansion? For Australia's global city, this negative endogenous growth employment performance was a disturbing outcome.

It is also disturbing that the Adelaide metropolitan region continues to be a negative performer.

The modelling certainly highlights the difficulty for regional development policy to be formulated in a global sense. This suggests the need for a region-specific policy approach rather than a 'one-size-fits-all' approach.

It is evident that using *functional* in contrast to *de jure* regions as the target for regional policy would make more sense than continuing the common practice of directing programs and investment to Local Government Authorities. It is understandable that that there has been a focus on Local Government Authorities as the third-tier of government in Australia, and they are in fact the creatures of State governments. However, these *de jure* regions are largely historic in origin, although it is not uncommon for State governments to force Local Government amalgamations. At the least, regional development strategies and the investments associated with them should recognise that it is not often the case that a single local government entity equates with a functional economic region (a functional labour market). As a result, there should be an insistence that there be collaboration between the local government entities that might equate with a functional economic unit, and that a regional development strategy be formulated for such a functional entity.

From the modelling undertaken for this paper, it is clear key factors that seem to underpin *positive* endogenous regional employment performance relate to a region's industry diversity/specialisation, its structural characteristics, and the degree of concentration of employment in information jobs and in finance jobs. In addition, population growth seems to be positively associated with positive endogenous regional employment performance. Not surprisingly, the remoteness of a FER also seems to be a factor that enhanced the performance of some FERs as the decade 2001-2011 coincided with the remarkable resources boom experienced by Australia, with mining activities especially, being highly concentrated in

very remote locations and with many highly productive agricultural and pastoral regions that are in relatively remote inland areas. As a hallmark of what was referred to as Australia's 'two-speed' economy, the resources boom sucked jobs out of the non-mining sector adversely impacting non-resource regions.

The reality is there is little that government interventions could do with respect to these factors that related to structural transition in the economy, with some regions being 'winners' while others were 'losers'. However, since the end of the 2000s, the resources boom ended abruptly, so it might be expected that future modelling focusing on endogenous regional employment performance for the current decade will reveal perhaps a different role being played by those regional factors.

The level of unemployment at the beginning of the decade 2001-2011 does appear to assume some significance in a positive way. This is possibly because many of the more remote regions would have experienced jobs growth relating to the resources boom over the decade, with many such regions traditionally having somewhat higher than normal unemployment.

It is interesting that the modelling for the decade 2001-2011 did *not* reveal population size *per se* to be a statistically significant factor enhancing endogenous regional employment performance, while population growth over the decade did significantly affect *positive* performance.

Thus, positive performance was not necessarily the prerogative of large regional labour markets, and nor were small size FERs necessarily poor performers.

Similarly, and perhaps also surprisingly, regional income levels at the start of the decade were shown to, in fact, have a negative effect on endogenous regional employment performance.

But the most surprising result from the modelling was that factors relating to levels of regional human capital were *not* significant in explaining positive endogenous regional employment performance. Indeed, the modelling showed that change in the incidence of people with bachelor qualifications and change in the incidence of people with technical qualifications, in fact, had a *negative* influence on regional endogenous performance (at least for the decade 2001-2011). These results are counterintuitive to much of the research on regional development which postulates that improved levels of human capital will improve economic performance. This finding poses questions about outcomes of public policy to encourage engagement in tertiary education, including; the increasing investment that has been occurring in post-school education and

training, the massive rise that has occurred in the number of students attending tertiary education institutions and, as a result, the very large increase that has been occurring in the number of tertiary-educated young people of workforce age.

In contrast, the supposed *positive* effect of increasing social capital—as measured, albeit inadequately, by the incidence of volunteering—does appear to be a factor that is a significant *positive* factor for enhancing endogenous regional employment performance. Enhancing social capital has been receiving some attention by governments.

Perhaps the most important lesson to take from the modelling for the decade 2001-2011 is that policy interventions to enhance endogenous regional employment performance might be those that relate to the structural characteristics of a region and enhanced diversification of employment, along with enhancing social capital. Interventions to enhance human capital might be worthwhile goals in themselves, but do *not* appear to be having a positive impact on endogenous regional employment performance.

7. CONCLUSION

This paper continues the research thrust initiated a decade or so ago to investigate endogenous regional employment performance across Australia's regions. That work has operationalised a model framework along the lines proposed by Stimson and his collaborators, and as set out in detail in Stimson, and Stough [with Salazar] (2009) and Stimson *et al.* (2009b).

The study reported here has focused on:

(a) analysing the patterns of endogenous regional employment performance for the decade 2001-2011; and

(b) modelling the potential determinants of variations in that performance.

A *functional* as against a *de jure* spatial base was employed using a new functional geography of FERs (developed by the authors and reported in a published paper by Stimson, *et al*. (2016)) across both Australia's major metropolitan regions and beyond across the vast expanses of regional Australia. The econometric modelling described in this paper indicates that using FERs appears to overcome the spatial autocorrelation issue inherent in using a *de jure* regional demarcation, which was also found to be the case in the earlier work by Stimson, Mitchell, Rohde and Shyy (2011)

which modelled the endogenous regional employment performance of FERs for the decade 1996-2006. A series of econometric models were run:

(a) first a full OLS model and then a backward step-wise regression OLS spatial specific model (for both models the Anselin Lagrange Multiplier (LM) and Moran's *I* spatial dependence tests were run, along with a multicollinearity test); and

(b) second spatial regression models were run, both a Spatial Error Model and also a Spatial Autoregressive Model.

The results from these models were discussed.

We judge that an *OLS model* would be the preferred modelling approach when using a *functional* spatial base to investigate potential factors explaining the *positive* or *negative* performance of FERs in regard to endogenous regional employment over the decade 2001-2011. This finding confirms what Stimson, Mitchell, Rohde and Shyy (2011) also found in their analysis for the decade 1996-2006. It certainly leads us to conclude that a *functional* spatial base is preferable to a *de jure* spatial base that has more commonly been used in econometric modelling investigating regional economic performance in Australia. Modelling based on *de jure* regions has typically been the focus for regional development policy interventions, which is probably not a suitable policy approach.

It is evident from the empirical findings of research investigating regional economic performance in Australia that considerable regional differentiation persists. The gaps are wide. That is particularly evident from the research explicitly focusing on measuring endogenous regional employment performance across the nation's FERs as reported in the paper by Stimson, Mitchell, Rohde and Shyy (2011) for the decade 1996-2006 and in this paper for the decade 2001-2011.

Regarding the findings from the modelling, and depending on which model is used, it appears that a *positive* influence on regional endogenous employment for FERs over the 2001-2011 period is significantly related to factors to do with:

- regional industry diversification/specialisation at the beginning of the decade;
- the structural change index for the region; population change over time;
- the incidence of employment in information jobs and possibly in finance jobs;

- the initial level of unemployment;
- the level of social capital as measured by the incidence of volunteering; and
- regional remoteness.

A *negative* influence is significantly related to factors to do with:

- the initial level of regional income; and
- the incidence of people with bachelor and technical qualifications.

There is a need for further work to be undertaken to enhance our understanding of endogenous regional employment performance across FERs in Australia. For example, it would be worthwhile to explicitly focus the modelling exclusively on FERs beyond the major metropolitan regions. It might also be worthwhile partitioning Australia into groups such as the capital city metropolitan regions and for regional Australia into size category or remoteness category FERs to explicitly analyse endogenous processes in the FERs encompassing the larger and smaller regional cities and towns. Additionally, segmenting the analysis into the two five-year inter-census periods that comprise a decade might be worthwhile.

We also need to be aware that, over time, there will be changes in the boundaries of FERs due to both improvements to the transport infrastructure and changes in the distribution of employment across space. In addition, we need to be cognisant that the macro-economic conditions within which the processes of endogenous regional performance play out do change over time, will be specific to an inter-census period and will have exogenous impacts on regional performance.

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