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Using functional economic regions to model endogenous regional performance in Australia: implications for addressing the spatial autocorrelation problem*

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Abstract. A new geography of functional economic regions (FERs) has been created for Australia using a methodology that optimizes within-region self-containment of commuting to jobs. The paper tests whether this FER geography might overcome the spatial autocorrelation problem encountered when using *de jure* regions such as local government areas (LGAs). The empirical context for the analysis is an investigation of potential factors that might explain spatial variability in the endogenous regional employment performance over the decade 1996–2006.

JEL classification: R11, R12, R15

Key words: Regional performance, functional economic regions, endogenous regional growth

1 Introduction

In modelling spatial variations in regional economic phenomena, typically researchers are confronted with having to use aggregated data for spatial units that relate to *de jure* regions demarcated by arbitrary boundaries that often reflect administrative areas that formed long ago. As a result, the usual modelling assumptions involved in using a regression modelling approach

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do not strictly hold. Thus, researchers should be aware of the need to address a number of methodological issues when modelling regional economic data. That includes concerns with the following:

- the analysis of complex high dimensional non-experimental data is inherently difficult;
- there is the problem of collinearity;
- how to address which variables are likely to have a positive, negative or no association with the dependent variable being used in the model;
- determining if a spatial model such as the spatial autoregressive model or spatial error model more appropriate than the traditional ordinary least squares (OLS) linear regression model; and
- addressing the problem of causation versus ecological association.

A comprehensive literature has evolved in regional science on how to deal these issues, and in particular with the spatial autocorrelation problem as it is referred to (see, for example, Anselin 1988a, 1988b), and we do not provide a discussion of that literature here.

In this paper we use a new national geography based on functional economic regions (FERs) as the spatial units to investigate spatial differentials in endogenous regional growth employment performance over the decade 1996–2006 across Australia. We seek to determine whether this new functional geographic demarcation might overcome the spatial autocorrelation problem which is typically encountered in spatial econometric analysis when modelling is locked into being based on *de jure* regions.

The paper proceeds as follows. In Section 2 there is a brief discussion of approaches to the investigation of endogenous factors in regional economic growth and development. Section 3 outlines the modelling undertaken in a series of papers by some of the authors and their collaborators to investigate spatial variation in endogenous regional economic performance in Australia as the empirical context for the paper. Section 4 outlines why and how the new national geography of FERs has been developed. Section 5 presents the results of the modelling based on this new national functional geography. Section 6 shows that the FER geography appears overcome the spatial autocorrelation problem and Section 7 concludes.

2 Investigating spatial differentials in endogenous regional employment growth performance

Modelling spatial differentials in regional economic performance has for long attracted attention by regional scientists. The focus of such research has often tended to be on variations in levels of regional unemployment or on variations in the growth in gross regional product (see for example, Molho 1995; Partridge and Rickman 1995, 1998; Martin 1997; Rissman 1999; Lawson and Dwyer 2002; Mitchell and Carlson 2005).

There has also been a focus in some of the literature on investigating the role that specific actors might play in explaining spatial differentials in regional economic performance. That includes consideration of factors such as the following:

- Industry diversification/specialization (see, for example, Kaufman 1993; Lande 1994: Henderson et al. 1995; Bradley and Gans 1998; Productivity Commission 1998; Gordon and McCann 2000; Lawson and Dwyer 2002; Trendle and Shorney 2003; Bureau of Transport and Regional Economics 2004a);
- Human capital (Norris and Wooden 1996; Harrison 1997; Hanushek and Kimko 2000; Garnett and Lewis 2000; Goetz and Rapasingla 2001; Lawson and Dwyer 2002; Draca et al. 2003; Stimson et al. 2004; Bureau of Transport and Regional Economics 2004b); and

- Urban scale/agglomeration (Duranton and Puga 2000; Taylor et al. 2003) in providing explanation in accounting for spatial variation that are typically evident in regional economic performance across a national space economy.

The focus on *endogenous factors* and their role in regional economic development has gained considerable momentum over the last two to three decades with a rise in interest by regional scientists in the 'new growth theory'. Over the last few years there has been a proliferation of books focusing on endogenous regional development (see, for example, Johansson et al. 2001; Capello and Nijkamp 2009).

But in general in the literature there has been a paucity of attempts to explicitly develop and empirically test operational models that seek to measure endogenous regional growth and which seek to identify the factors that might explain regional variations in it. Stimson et al. (2005) and Stimson and Stough (2009a, 2009b) have proposed a model framework to do just that. These authors and their associates have empirically tested operational models to investigate spatial differentials in endogenous regional employment regional growth performance in two empirical settings, namely:

1. across non-metropolitan LGAs in Australia (Stimson et al. 2008; 2009a; 2009b); and
2. across metropolitan statistical areas (MSAs) in the US (Stough et al. 2007; Shyy et al. 2009).

Most recently Stimson et al. (2009a) have used the same modelling framework, but in this case the authors applied it to an analysis of the endogenous regional employment growth performance of FERs across Australia. In this paper we build on that work.

3 Modelling spatial variations in endogenous regional employment performance in Australia

In the modelling approach to investigate endogenous regional growth performance proposed by Stimson et al. (2005) and Stimson and Stough (2009a, 2009b), the measure used for the dependent variable is the regional (or differential) component derived from a regional shift share analysis of employment change over a period of time (standardized by size of the regional labour force at the beginning of the period). Thus, a region's score on the dependent variable may be positive or negative. These authors have argued that it is a reasonable surrogate measure of endogenous regional performance, and it is one that may in most nations be readily derived for regions at a disaggregated level of spatial scale by using employment data available from the census.

That measure has been the dependent variable in the modelling used in a series of papers modelling spatial variability in endogenous regional employment performance across Australia (Stimson et al. 2008, 2009a, 2009b, 2009c). In those investigations Stimson and his collaborators chose a set of independent variables – all derived from data available in the Australian Census of Population and Housing which is held every five years – purporting to measure the effects of constructs that the literature has suggested may influence regional economic growth performance such as:

- industrial structure, including industry specialization and structural change;
- population size and growth;
- labour force participation;
- human capital (skills) and income distribution;
- occupational shifts;

- social capital; and
- creative capital.

Some of the variables are cross-sectional measures at the beginning or end of the study period (a decade), while others are change-over-time dynamic variables. In addition, a number of locational proxies are used.

In the empirical application discussed in this paper, the focus of the modelling was on the decade 1996–2006, and the full set of variables (the dependent variable and the 32 independent variables) used in the operational model are listed in Table 1. The rationale for the selection of those variables and their compilation is documented elsewhere (see Stimson et al. 2008, 2009b, 2009c) and is not rehearsed here.

In those studies Stimson and his collaborators first employed a standard OLS regression approach to derive a general model solution. That was followed by a backward elimination step-wise regression approach to derive a specific model solution.

In the Stimson et al. (2008) study based on *de jure* non-metropolitan LGAs, in order to address the spatial autocorrelation issue both a spatial error and a spatial lag model were also run and the Moran's *I* test and the Lagrange multiplier test statistics applied. In that modelling, spatial autocorrelation was found to be an issue, and the preferred solution was identified as being the spatial error approach for the specific model. The data set used was large comprising (N = 429 spatial units). But for many of the LGAs there would have been a considerable leakage out of the region of workers who live there working in other LGAs. That is because the data in the Australian Census of Population and Housing relates to persons recorded as being located within that a spatial unit on census night and not by place of work location.

Thus, overall while that modelling did provide some useful insights into identifying factors that might potentially have some explanatory power in differentiating between LGAs and their endogenous regional growth performance over a period of a decade, the reliance on a *de jure* regional demarcation spatial data exacerbated the spatial autocorrelation problem. That is an unsatisfactory state of affairs, and one which is common but sometimes not actually explicitly acknowledged in some of the other studies conducted in Australia that have investigated variation in aspects of regional economic performance.

Thus, we were driven to look to an alternative approach investigate aspects of spatial variability in regional economic performance in Australia that might overcome that problem arising from the use of data that is embedded in a *de jure* based regional demarcation.

4 Creating a new national geography: Functional Economic Regions (FERs)

4.1 Background

There have been many attempts to create geographies based upon the concept of a functional region (OECD 2002). Governments have long been aware of the need to make an appropriate choice of territorial unit when making assessments of sub-national regional performance and determining policy interventions at that level. In many cases, this choice has been based on the concept of a local labour market which is "where labour demand and supply are relatively well matched" (OECD 2002, p. 3). The OECD has reported that most of its member countries:

> either on an official or semi-official basis . . . define and delineate functional regions in terms of local labour markets [which are] based on the same principle as **commuting conditions** (emphasis in original) (OECD 2002, p. 11).

Table 1. The variables used in modelling

Variable label	Variable description
Dependent variable	
REG_SHIFT	Regional Shift component of a Shift-Share Analysis of Employment change (1996 to 2006) / Labour Force (1996)
Explanatory variables	
SPEC_96	Specialization Index for 1996 (Herfindahl-Hirschman Index)
SPEC_CH	Change in Specialization Index from 1996 to 2006 (Herfindahl-Hirschman Index)
SCI	Structural Change Index (1996 to 2006)
SCI_CH	Change in the Structural Change Index (from 1996–2001 to 2001–2006)
L_INC_96	(Approximate) Mean Individual Income – 1996 Annual (Log) (real)
L_INC_CH	Change in (Approximate) Mean Individual Income – 1996 to 2006 Annual (Log) (real)
UNEMP_96	Unemployment rate in 1996 (%)
UNEMP_CH	Change in Unemployment rate from 1996 to 2006 (percent points)
L_POP_96	Log of population (1996)
L_POP_CH	Change in Log of population (1996 to 2006)
LQ_MAN_96	Location Quotient for the Manufacturing Industry in 1996
LQ_INF_96	Location Quotient for the Information media & telecommunications Industry in 1996
LQ_FIN_96	Location Quotient for the Financial & insurance services Industry in 1996
LQ_PRO_96	Location Quotient for the Professional, scientific & technical services Industry in 1996
LQ_MAN_CH	Change in the Location Quotient for the Manufacturing Industry, 1996 to 2006
LQ_INF_CH	Change in the Location Quotient for the Information media & telecommunications Industry, 1996 to 2006
LQ_FIN_CH	Change in the Location Quotient for the Financial & insurance services Industry, 1996 to 2006
LQ_PRO_CH	Change in the Location Quotient for the Professional, scientific & technical services Industry, 1996 to 2006
POSTGRAD_96	Proportion of labour force with a Postgraduate Degree of higher in 1996
BACHELOR_96	Proportion of labour force with a Bachelor Degree of higher in 1996
TECHQUALS_96	Proportion of labour force with technical qualifications in 1996
POSTGRAD_CH	Change in the Proportion of labour force with a postgraduate degree of higher, from 1996 to 2006
BACHELOR_CH	Change in the Proportion of labour force with a bachelor degree of higher, from 1996 to 2006
TECHQUALS_CH	Change in the Proportion of labour force with technical qualifications, from 1996 to 2006
SYMBA_96	Proportion of Symbolic Analysts (Managers + Professionals) in Employment in 1996
SYMBA_CH	Change in the proportion of Symbolic Analysts (Managers + Professionals) in Employment from 1996 to 2006
VOLUNTEER_06	Proportion of Volunteers in Working Age Population (15–64) in 2006
CREATIVE_06	Proportion of Total employment in Creative Industries in 2006
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 Government system (1 = Yes, 0 = No)
D_REMOTE	Classified as Remote under Australian Classification of Local Governments system (1 = Yes, 0 = No)

Source: Stimson et al. (2008, 2009a, 2009b, 2009c).

There are variations in approach which broadly divide into defining regions with respect to an urban centre and defining regions "without reference to an urban centre" (OECD 2002, p. 11). In this context, three broad approaches have been used to delineate functional regions.

First, the most popular method has been to base areas on a major urban centre (for example, the United States Office of Management and Budget has used this approach for many years to define metropolitan areas). This approach typically does not result in a nation-wide regionalization which exhausts all areas.

Second, statistical approaches allocate areas into more aggregated regions which are exhaustive at a national level:

> utilise algorithms or cluster analysis based on a combination of distance, closeness, commuting thresholds, travel times . . . [and] . . . are constructed through successive aggregation of adjacent territorial units (OECD 2002, p.11; see also Fischer 1980, for a survey of these methods).

A long-standing statistical algorithm that can produce functional regionalizations is the method of 'intrazonal interaction maximization' known as Intramax (Masser and Brown 1975). This hierarchical clustering algorithm proposed by Masser and Brown (1975, p. 510) maximizes:

> the proportion of the total interaction which takes place within the aggregation of basic data units that form the diagonal elements of the matrix, and thereby to minimise the proportion of cross-boundary movements in the system as a whole

In this paper we employ the Intramax method and provide more detailed explanation of its use in the methodology section.

A third approach to functional labour markets (or travel-to-work areas) has been used in Britain using a methodology that combines elements of the previous two approaches (see Coombes 1996). The Coombes method is an iterative statistical approach that aggregates around some urban centre.

4.2 The objective and methodology

To date research in Australia modelling aspects of regional economic performance has tended to be based on *de jure* spatial units, such as statistical divisions and LGAs. Recently an alternative national geography for Australia has been developed at the Centre of Full Employment and Equity (CofFEE) (see Mitchell and Flanagan 2009; Mitchell and Watts 2010), that is based on functional regions, namely the FER. The building blocks for FERs are statistical local areas (SLAs), for which time-series data across three censuses is available.

The objective underlying this innovation was two-fold, namely to:

- regionalize the nation into more meaningful labour market regions than those that have been used to date
- eliminate the spatial autocorrelation problem referred to above.

The genesis of the new FER geography was the concern that the administrative geographical demarcations – the Australian standard geographical classification (ASGC) – currently used by the Australian Bureau of Statistics (ABS) to collect and disseminate its labour force and Census data, is unsuited to the task of providing a systematic understanding of the level of economic interaction within and between neighbouring regions.

The chosen regionalization or spatial aggregation of data that produces the FERs is based on an analysis of economic behaviour in the form of commuting flows. Just as geographical regions may be defined by physical features (such as water catchments) the FERs are based on the hypothesis that a meaningful socio-economic geography should be defined by socio-economic features of space rather than through administrative convenience. It is most unlikely that these 'functional regions' will correspond exactly to a demarcation based on administrative/political criteria.

Significant issues arise when an erroneous geography is used for spatial econometric analysis in modelling regional economic performance. First, a poorly delineated geography invokes measurement error. Thus, a local measure such as unemployment for an SLA or an

LGA, may be unrelated to socio-economic and policy variables at a similar scale, and will lead to spurious causality being detected and possibly misguided policy conclusions being deduced through analysis based on such a regional demarcation. Second, analysing erroneously aggregated spatial data with standard statistical tools will yield results that may not only lack economic meaning but also suffer bias due to spatial autocorrelation.

Mitchell and Watts (2007) first generated FERs for Australia using the Intramax method based on data derived from the 2001 Census of Population and Housing data (see also Mitchell and Watts 2010 for application to 2006 Census of Population and Housing data). Masser and Scheurwater (1980, p. 1361) say that:

> [the] Intramax procedure is concerned with the relative strength of interactions once the effect of variations in the size of the row and column totals is removed . . . relative strength is expressed in terms of the difference between the observed values and the values that would be expected on the basis of the multiplication of the row and column totals alone.

The Intramax method is concerned with how the aggregation impacts on interaction flows (journeys-to-work in our case) across the regional boundaries. Masser and Brown (1975) say that:

> the most important distinction that must be made in the grouping procedure is between the proportion of interaction in the *diagonal* as against the *nondiagonal* elements of the basic flows matrix (emphasis in original).

Barros et al. (1971, p. 140) refer to the "strength of interaction" as the proportion of total journeys that cross regional boundaries. Clearly, as we aggregate smaller regions into larger functional areas, the proportion of interaction that cross boundaries should decline and a rising proportion of interactions thus would be considered intra-regional.

As a way forward, the new FERs for Australia compiled by Mitchell and Flanagan (2009) were defined by aiming to:

> maximise the proportion of the total interaction which takes place within the aggregations of basic data units that form the diagonal elements of the matrix, and thereby to minimise the proportion of cross-boundary movements in the system as a whole." (Masser and Brown 1975, p. 510)

Using the Australian Standard Geographical Classification from the Australian Bureau of Statistics (ABS), the FERs were derived by aggregating areas based on commuting flows between the statistical local area. Mitchell and Flanagan (2009) produced a final set of 141 FERs for Australia that are used for the analysis reported in this paper. They used commuting data derived from the 2006 Census of Population and Housing which is conducted every five years by the ABS (see also Mitchell and Watts 2010).

Table 2 compares by state/territory the new FER geography with two other administrative geographies for which the ABS collects and publishes data, namely SLAs and the ABS labour force regions (the latter being the basis for the ABS's monthly Labour Force Survey collection) that are quite widely used in spatial econometric research. In comparison with the ABS labour force regions, there are more FERs in rural and regional areas and less in the more densely populated areas.

4.3 The resultant regions

The physical size of the FERs is highly variable, and so too is their population size. That is not surprising given the vast size of Australia and its relatively small population that is highly concentrated in just five mega- metropolitan regions with the vast majority of the nation being very sparsely populated.

Table 2. The ABS geography and the new CofFEE FERs

Geographical unit	ABS SLAs	ABS LF regions	CofFEE FERs
New South Wales	201	21	87*
Victoria	211	14	across the 4
Queensland	480	14	eastern and
South Australia	129	6	southern states
Australian Capital Territory	110	1	and the ACT
Western Australia	157	7	17
Tasmania	45	4	14
Northern Territory	97	1	22
Australia	1,430	68	140

Note: *Note that the CofFEE FERs may cross state boundaries, which is the case along the New South Wales-Queensland border, the New South Wales-Victoria border, the Victorian-South Australian border and between New South Wales and the Australian Capital Territory. The ABS is constrained to ensure that the boundaries it uses for its geographies do not cross state-territory borders. Thus there are 87 FERs in the new national geography developed by CofFEE in the eastern and southern states of Australia comprising Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory.
Source: Mitchell and Flanagan (2009).

Within and surrounding Australia's five largest cities – which are the capitals of the mainland states – there is considerable variation in the number of FERs. In the five major metropolitan cities – in which about 70 per cent of the nation's population live – we see that there are seven FERs in and around Sydney in New South Wales and six FERSs in and around Melbourne in Victoria. There are five FERs in and around Brisbane in the South East Queensland region, and there are four FERs in and around Perth in Western Australia. But in South Australia there is only one FER covering all of Adelaide.

In the non-metropolitan parts of Australia it is common for FERs to focus on a large regional city or town and for the size of FERs in the more sparsely populated inland areas to be large in size and for them often to be elongated in shape along the major road transport routes. In some of the remote parts of Australia, such as the Northern Territory, there appear to be a large number of SLAs with small populations.

It is also evident that there is a tendency for FERs to cross state boundaries and this is particularly so along parts of the New South Wales-Queensland border and along the New South Wales-Victoria border. In contrast it is noteworthy that the boundaries for the *de jure* regions for which the ABS provides census data are not permitted to cross state or territory borders.

5 Modelling to test how the FER geography mitigates the spatial autocorrelation problem

Preliminary analysis by Mitchell and Flanagan (2009) shows that, when using the new FER national geography, the presence of spatial correlation in summary spatial economic statistics, which is evident when using *de jure*-based regional data – such as the SLA and the ABS labour force regions referred to in Table 2 – is eliminated (see also Mitchell and Watts 2010). In this paper we extend that result using a more detailed regression modelling approach discussed in what follows.

The new FER geography has now been used by Stimson et al. (2009c) to model the potential determinants of spatial variation across Australia in the endogenous regional employment growth over the decade 1996 to 2006. That study has used the same set of variables listed in Table 1 that were used in the earlier analysis by Stimson et al. (2008) based on data for *de jure*

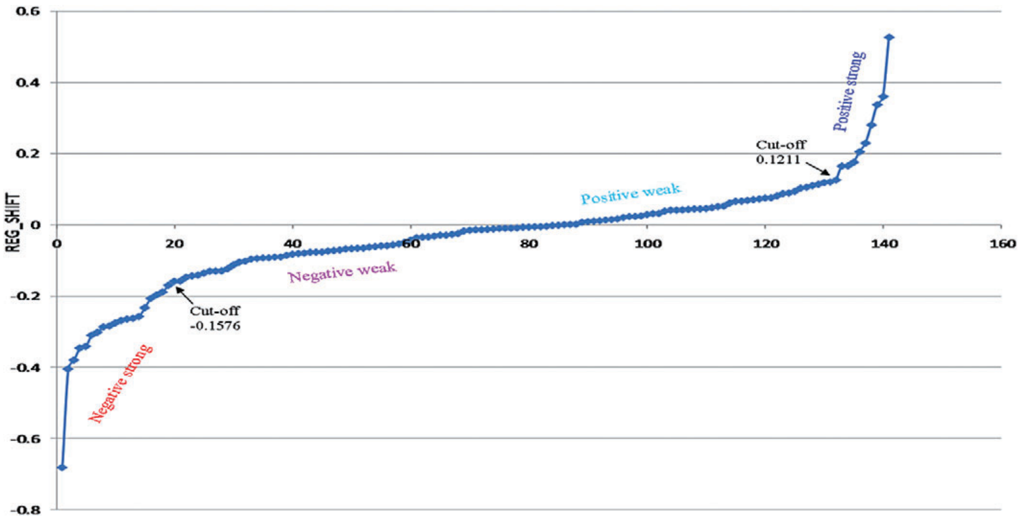

Fig. 1. Plot of the distribution of FER scores on the endogenous regional employment growth, 1996–2006, performance measure REG_SHIFT (the dependent variable)

regions, namely LGAs, in which – as discussed earlier – spatial autocorrelation was shown to be an issue necessitating the adoption of a spatial error regression approach to the modelling. The same sequence of modelling approach also has been used by Stimson et al. (2009c) but applied to the new FER geography (N = 140). But in addition, the jacknife test (or leave-one-out), which is a cross-validation test has been used (Efron and Gong 1983). It represents an alternative method for searching for those variables that might be significant in explaining the spatial differentials in the performance of FERs on the dependent variable (REG_SHIFT).

6 Results

In what follows, the Stimson et al. (2009c) modelling results using the new FERs geography are summarized. In this paper we do not provide tables giving details of the results of the various regression approaches used in the modelling that is now discussed. Here our concern is to demonstrate how this new national geography based on functional regions has overcome the spatial autocorrelation problem that was inherent in the previous modelling of endogenous regional employment growth performance based on the *de jure* geography LGAs.

6.1 The distribution of performance scores on the dependent variable

The plot of the distribution of scores on the dependent variable (REG_SHIFT) measuring endogenous regional employment growth/decline over the decade 1996 to 2006 is shown in Figure 1. It is evident that the minority of FERs (N = 55) had positive scores on the dependent variable while a majority (N = 85) has a score on the dependent variable. By identifying the natural break points on the plot in the figure it is shown that for a relatively small number of FERs (N = 11) there was strong positive endogenous regional employment growth performance, while for a larger number of FERs (N = 20) there was a strong negative performance on the

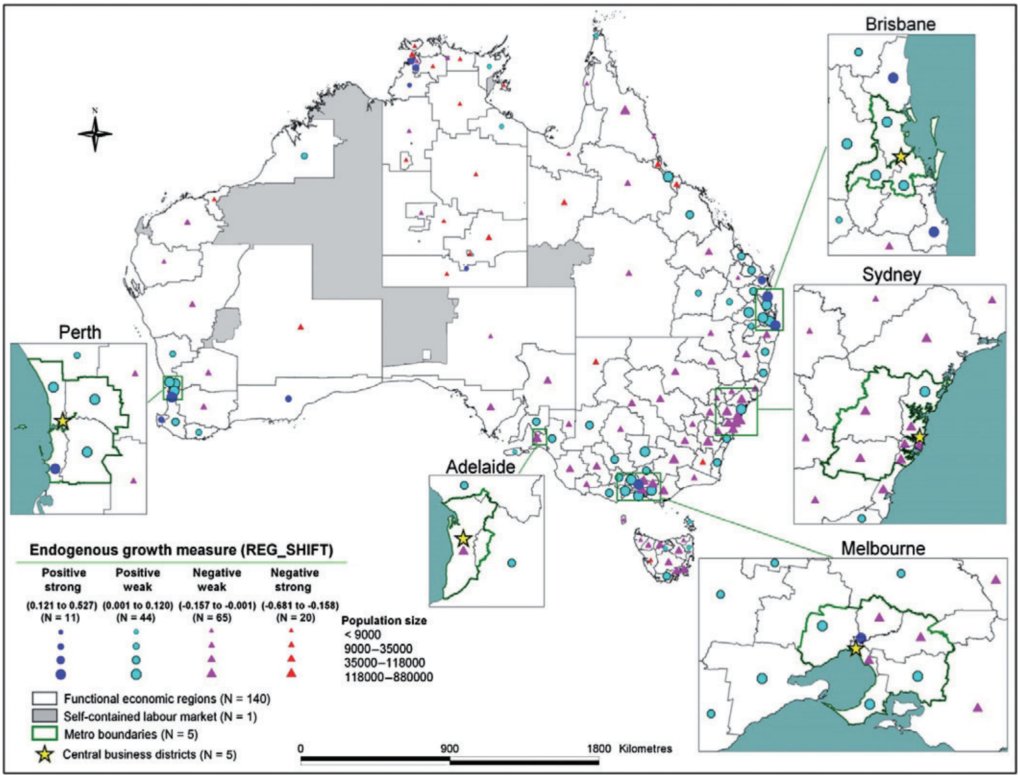

Fig. 2. Spatial pattern of FER performance on the endogenous regional employment growth/decline, 1996–2006, performance measure REG_SHIFT (the dependent variable)

Note: Note that large areas in remote locations in Western Australia, South Australia and Queensland that is shaded light grey in the figure have 100% self-containment and are largely uninhabited with a preponderance of their small populations being indigenous peoples. These areas are identified as a remote FER. Thus the analysis as portrayed is for 140 and not 141 FERs.

Source: The authors.

dependent variable. Thus, across Australia there was a negative endogenous regional employment performance over the decade 1996 to 2006 in about two-fifths of the FERs while it was positive in about three-fifths of FERs.

The map in Figure 2 shows the spatial pattern of positive and negative endogenous regional employment performance across FERs over the decade 1966 to 2006. The map shows the following:

- The incidence of negative endogenous regional employment performance seems marked in inland areas – especially across New South Wales and Victoria – and in particular in the remote FERs of Australia, and negative performance is also evident in some of the FERs in the metropolitan cities, especially in and around Sydney, the eastern parts of Melbourne, and in Adelaide. It is also evident that FERs with a small population tend to have negative endogenous regional employment performance. Much of Tasmania has negative performance.
- The incidence of positive endogenous regional employment performance is more marked in the coastal areas – especially in Queensland and New South Wales away from the urban conglomeration stretching from Wollongong to Newcastle, and in the south west of Western Australia – and in the inland FERs that are dominated by larger population size regional urban

centres, plus many of the mining regions of central Queensland and the remote parts of Western Australia. In addition, the FERs in and around metropolitan Brisbane, Perth and Darwin have positive endogenous regional employment performance as do some of them in Melbourne's west and regions to the west and north of that city. In Tasmania, Hobart and Launceston, and some of the FERs in the north-east have a positive endogenous regional employment growth performance.

6.2 The modelling

In the modelling conducted by Stimson et al. (2009c), the OLS general model solution produces an $R^2 = 0.90$. But there is a considerable degree of multi-collinerarity among the independent variables. Thus, the backward step-wise regression approach is used to derive an OLS specific model. Again the R^2 is high ($R^2 = 0.89$).

In that specific linear model:

- the variables found to have a statistically significant positive impact on the endogenous regional employment performance variable at the $p \leq 0.05$ confidence level are: SPEC_CH, SCI_CH, L_POP_CH, LQ_PRO_96, LQ_MAN_CH, LQ_PRO_CH, TECHQUALS_CH, VOLUNTEER_06, CREATIVE_06; and
- the variables found to have a statistically significant negative impact on the endogenous regional employment performance variable at a the $p \leq 0.05$ confidence level are: SCI, L_INC_96, UNEMP_96, UNEMP_CH, POSTGRAD_96, TECHQUALS_96, SYMBA_CH.

After testing for spatial autocorrelation effects and running a spatial error model and a spatial lag model for the specific model solution, the analysis by Stimson et al. (2009c) found that the following relationships are evident compared with the results obtained from the OLS specific model solution:

- Compared with the OLS specific model, in the spatial error specific model solution, the L_INC_96 and LQ_MAN_CH variables are no longer significant while the L_INC_CH variable becomes statistically significant with a positive impact in explaining spatial variations in endogenous regional employment performance over the decade 1996 to 2006 across FERs.
- Compared with the OLS specific model, in the spatial lag specific model solution, the SPEC_CH, LQ_PROF_96, LQ_PROF_CH, POSTGRAD_96, TECHQUALS_96, and SYMBA_CH variables are no longer significant, while the LQ_MAN_96 becomes significant with a positive impact in explaining spatial variations in endogenous regional employment performance over the decade 1996 to 2006 across FERs.

In comparing the results of the spatial error specific model and the spatial lag specific model, the following are evident:

- the spatial error model has 15 variables that are significant whereas the spatial lag model has 11;
- all significant variables that are common to both the models are SCI, SCI_CH, UNEMP_96, UNEMP_CH, L_POP_CH, TECHQUALS_CH, VOLUNTEER_06 and CREATIVE_06, and they all have the same sign (positive or negative);
- the spatial lag model includes L_INC_96, LQ_MAN_CH, TECHQUALS_96 as significant explanatory variables whereas the spatial error model does not; and

- the spatial error model includes SPEC_CH, L_INC_CH, L_POP_96, LQ_PRO_96, LQ_PRO_CH, POSTGRAD_96, TECHQUALS_96, SYMBA_CH as significant explanatory variables whereas the spatial lag model does not.

These differences between the spatial error and the spatial lag specific models in the significance of the independent variables as explanatory factors impacting the dependent variable is an issue of interest and perhaps of concern. Thus, it is important to be able to ascertain which of the models might be more valuable or the 'preferred' model for furnishing explanation of variation in the dependent variable (REG_SHIFT).

After running *the Lagrange multiplier diagnostics* for spatial dependence, the modelling by Stimson et al. (2009c) reveals that for both the spatial error model and the spatial lag model the null hypothesis of no spatial autocorrelation cannot be rejected at the $p \leq 0.01$ significance level, and that is the case for both the robust and non-robust tests.

Using the jackknife test as an alternative approach to variable search it becomes evident that, when compared to the OLS linear specific model solution, this model solution:

- adds the L_POP_CH, LQ_INF_CH, BACHELOR_96, D_REMOTE variables as being significant; and
- removes theL_INC_96, UNEMP_96, UNEMP_CH, LQ_RRO_96, LQ_MAN_CH, LQ_PRO_CH, TECHQUALS_CH variables as being significant.

The variables that are common to both model solutions – namely SPEC_CH, SCI, SCI_CH, L_POP_CH, POSTGRAD_96, TECHQUALS_96, SYMBA_CH, VOLUNTEER_06 and CREATIVE_06 – all have the same sign on the coefficients. But in the jackknife model solution, according to the *t*-test the variable LQ_INF_CH is not significant at the $p \geq 0.01$ level, and the variable BACHELOR_96 is not significant at the $p \leq 0.05$ level.

7 Conclusion

In this paper we have shown that by using a new national geography based on functional regions (FERs) rather than *de jure* regions to model endogenous regional employment performance we seem to overcome the spatial autocorrelation problem. We believe this new FER geography also has the potential to be more useful than existing administrative geographies that have typically been used by researchers in to shed light on the characteristic and operation of other aspects of regional labour markets in Australia.

The research reported in this paper is a continuation of work by the authors, in association with their collaborators, that has been developing a model framework to empirically investigate factors that might help explain spatial variations in economic across Australia's space economy. In the discussion in this paper the focus has been on investigating that within the context of a new FER geography using the modelling conducted by Stimson et al. (2009c), whereas some of the previous research undertaken by Stimson et al. (2008; 2009a; 2009b) has been restricted to using *de jure* – namely the LGA – which exacerbates the problem of spatial autocorrelation effects. That problem is widely evident in research using spatial econometric analysis and modelling to investigate aspects of uneven regional economic performance conducted to date in Australia, a problem which, sadly, has been overlooked or dismissed in much of that research.

It is planned to use the new geography based on FERs developed by Mitchell and Flanagan (2009) in further modelling that will investigate other aspects of labour market performance, and also to look at the nature of the relationships between the functioning of regional labour markets, population mobility and housing markets.

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Resumen. Mediante el uso de una metodología que optimiza la auto-suficiencia intrarregional en el desplazamiento al trabajo, se ha creado para Australia una nueva geografía de regiones económicas funcionales (FERs, siglas en inglés). El artículo comprueba si esta geografía de FER podría superar el problema de la autocorrelación espacial encontrado al utilizar regiones de derecho tales como áreas de gobierno local (AGL). El contexto empírico del análisis es una investigación de los factores potenciales que pudieran explicar la variabilidad espacial en el desempeño en cuanto a empleo regional endógeno en la década de 1996–2006.

要約　オーストラリアでは、通勤範囲が地域内にあることの自己充足度を最適化する方法論を用いて、機能的経済圏域（FER）の新地理学が開発されている。本稿は、この FER 地理学をノーザンテリトリーの地方自治体および行政区画（LGA）などの法律上の地域に適用した場合に生ずる空間的自己相関の問題を解決できるか否かを検証する。実証的分析として、1996 年から 2006 年の 10 年間での内発的地域の雇用動向における空間的な相違の原因を説明し得る要因について調査する。