DEMARCATING FUNCTIONAL ECONOMIC REGIONS ACROSS AUSTRALIA DIFFERENTIATED BY WORK PARTICIPATION CATEGORIES

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ABSTRACT: Analysing spatial variations in regional economic performance is a common focus for research by regional scientists. Typically such investigations suffer from using de jure regions (such as Local Government Areas) as the spatial base because data tend to be readily available for such administrative areas to derive the variables that researchers use in econometric modelling. But using those *de jure* regions means we encounter the modifiable area unit problem (MAUP) which necessitates making adjustments to address spatial autocorrelation issues. It is preferable to use functional regions as the spatial base for such investigations, but that is often difficult to achieve. This paper outlines how, in Australia, we have undertaken research to derive functional economic regions (FERs) to provide an improved spatial data base that is *functional* and not *de jure*-based to address the autocorrelation issue. To do that we employ the Intramax procedure applied to journey-to-work (JTW) commuting flows data that is available from the 2011 census. The research has generated not only a national framework of FERs based on aggregate employment but also a series of regionalisations of FERs differentiated by occupational categories, employment by gender and mode of travel to work. As expected the strength and reach of commuting is reflected in the size of regions for each of the demarcations.

KEY WORDS: Functional economic regions, differentiated functional demarcations, spatial autocorrelation, journey-to-work

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1. INTRODUCTION

For a long time regional scientists have been investigating spatial variations in regional economic development/performance using spatial econometric modelling to help identify factors that might explain that variability (for example, Molho, 1995; Niebuhr, 2003; Patacchini and Zenou, 2007; Mitchell and Flanagan, 2016). Invariably such investigations are dependent on using aggregated data that is usually readily available for *de jure* regions, that are usually designed for administrative purposes, to cater to local authorities in historically defined regions, for example Local Government Areas (for example, Randolph and Holloway, 2005). This extends from the early regional science literature where one of the factors considered when delineating regions was that they be designed to match political or administrative boundaries (see, for example, Berry, 1968; and Richardson, 1973). These administrative regions though, while useful to the local authorities, do not reflect the underlying processes that generate economic data and, as a result, we encounter the modifiable areal unit problem (MAUP) (Openshaw, 1984). The MAUP proposes there are literally thousands of ways small areal units can be aggregated to regions to provide different regionalisations and hence different data, varying in terms of the size of regions (scale problem) and the grounds on which areal units are joined (aggregation problem). A manifestation of the MAUP is the occurrence of spatial autocorrelation, where regions are spatially dependent on regions they are near to. Positive (negative) spatial autocorrelation is where regions with similar (dissimilar) attributes are spatially proximate, which invalidates the OLS assumptions and requires the analyst to employ spatial econometric tools (Anselin, 1988, LeSage and Pace, 2009).

Ideally such modelling would use *functional regions* as the spatial base which, theoretically, should overcome this problem. In their investigation of spatial variations in regional endogenous employment performance over the decade 1996-2006, Stimson *et al*. (2011) showed that when spatial econometric modelling is conducted using functional economic regions (FERs) rather than *de jure* regions (Local Government Areas) as the spatial base for modelling, then the spatial autocorrelation encountered when using *de jure* regions might be overcome.

In contrast, Patacchini and Zenou (2007: 170) found that Travel-To-Work areas (TTWAs) in the UK, regions “which are by definition self-contained labour markets”, do not eradicate the spatial dependence of unemployment. They conclude though that the spatial dependence that occurs is mainly due to spatial spillovers, where workers can search for and work in different TTWAs, and therefore was due to the commuting that occurs between different TTWAs because they are in fact not completely self-contained. TTWAs are designed using a variation of the algorithm first proposed by Coombes *et al*. (1986) and used widely throughout the literature (for example, Andersen, 2002; Watts *et al*., 2006; and Casado-Diaz *et al.*, 2010). In the new statistical geography introduced by the ABS at the 2011 Census, labour markets were a key consideration to the design of the Statistical Areas Level 4 (SA4s), in an attempt to incorporate functional regions (ABS, 2010). As these are the units of dissemination for the Labour Force Survey, their self-imposed constraints (for example minimum populations) somewhat inhibit the regions design (Watts, 2013).

Thus, we are now focusing our modelling of regional economic performance in Australia on using FERs as the spatial base, and we are deriving those FERs using journey-to-work (JTW) commuting flows data that is available in the Australian census. In doing so we employ the Intramax procedure developed by Masser and Brown (1975).

In this paper we report on how, through analysis being conducted at the Centre of Full Employment and Equity (CofFEE) at the University of Newcastle in Australia, FERs have been derived using the 2011 census JTW data. Our intent is to use FERs as the spatial units for modelling the determinants of spatial variations in the performance of regional labour markets over the decade 2001 to 2011, particularly with regard to unemployment and employment growth. Those FERs are designated by us as CofFEE Functional Economic Regions (CFERs).

But we go further than deriving FERs that just relate to aggregate employment across all industry sectors as it is well known that spatial patterns in the degree of spatial concentration or dispersal of jobs differ between occupation categories (Bill *et al*., 2008; Sang *et al*., 2011). In addition, it is likely that the spatial locations of male and female jobs may also differ, as might the spatial patterns of commuting to jobs according to the mode of transport for the JTW (Crane, 2007; BITRE, 2015). To address those issues we have thus developed a series of 10 regionalisations of CFERs across Australia for 2011 as specified in Table 1. Each of those regionalisations is designed using the JTW commuting flows of their respective cohort of worker categories as shown in the table. The implied homogeneity of functional regions was a shortcoming raised by Morrison (2005), and in this was we are recognising a differentiated labour force.

In this paper we first outline the methodology and the data used to derive those ten regionalisations of CFERs. We then proceed to discuss the number of CFERs across Australia that are thus derived, providing a comparison with Labour Force Regions (LFRs) used by the Australian Bureau of Statistics (ABS). We then proceed to briefly discuss the spatial characteristics of the CFERS that have been derived for the 10 regionalisations listed in Table 1.

2. METHOD

The Intramax Procedure

The Intramax procedure (after Masser and Brown, 1975) is used to derive CFERs for all 10 the CFER regionalisations. The procedure considers the size of the interactions in the JTW commuting flows matrix that are in the form of a contingency table. It then formulates the "objective function in terms of the differences between the observed and the expected probabilities that are associated with these marginal totals" (p. 510). A schematic representation of the square JTW flows matrix is shown in Table 2, where the rows are designated as *origins* and the columns are *destinations*.

If we view Table 2 as a contingency table, then the expected values of each element are derived as the product of the relevant column sum (Equation 3 below) times the ratio of the row sum (Equation 2) to total interaction (Equation 4). For example, the expected flow out of region 2 into region 1, a_{21} in Table 2, where a_{ij} is the element in row *i* and column *j* of the contingency table (JTW matrix), is given as:

$$(1) \qquad a_{21}^{*} = \sum_i a_{i1} \left(\sum_j a_{2j} / \sum_i \sum_j a_{ij}\right) = \sum_i a_{i1} \left(\sum_j a_{2j} / n\right)$$

This is the "flow that would have been expected simply on the basis of the size of the row and column marginal totals" (Masser and Brown, 1975: p. 512).

The row sum of the JTW matrix is:

$$(2) \qquad a_{i*} = \sum_j a_{ij}$$

The column sum of the JTW matrix is:

$$(3) \qquad a_{j*} = \sum_i a_{ij}$$

The total interaction, *n*, is the sum of the row sums:

$$(4) \qquad n = \sum_i \sum_j a_{ij}$$

The null hypothesis for independence between the row and column marginal totals of a contingency table is defined as:

$$(5) \qquad H_o : a_{ij}^{*} = \left(\sum_j a_{ij} \sum_i a_{ij}\right)/n = \left(a_{i*} a_{j*}\right)/n$$

The objective function of the hierarchical clustering algorithm, using a non-symmetrical JTW matrix, is defined as:

$$(6) \qquad \max I = \left(a_{ij} - a_{ij}^{*}\right) + \left(a_{ji} - a_{ji}^{*}\right), \quad i \neq j$$

Table 1. The ten regionalisations of functional economic regions across Australia derived from JTW data available in the 2011 census.

All workers: 1. **Original CFERs** (CFER2011)
Gender-based: 1. **Male CFERs** (MCFER2011) 2. **Female CFERs** (FCFER2011)
Occupation-based: 2. **Skilled CFERs** (SCFER2011) - workers in ANZSCO categories: • Managers • Professionals 3. **Less Skilled CFERs** (LSCFER2011) - workers in ANZSCO categories: • Community and Personal Service Workers • Clerical and Administrative Workers • Sales Workers • Machinery Operators and Drivers • Labourers 4. **Trades CFERs** (TCFER2011) - workers in ANZSCO categories: • Technicians and Trades Workers
JTW Mode of Transport-based: 5. **Road JTW CFERs** (RoCFER2011) - workers who used one (and only one) of the following modes of transport to travel to work: • Car as driver • Car as passenger • Bus • Motorbike • Taxi • Tram • Truck 6. **Rail JTW CFERs** (RaCFER2011) - workers who travelled to work by train (only) 7. **Bicycle JTW CFERs** (BCFER2011) - workers who travelled to work by bicycle (only) 8. **Multiple Transport Mode JTW CFERs** (MTCFER2011) - workers who used more than one mode of transport (those above as well as a classification of ‘Other’)

Source: the authors

Table 2. JTW Flow Matrix With *j* Regions

Destination / **Origin**	**Region 1**	**Region 2**	**...**	**Region *j***	**Total**
Region 1	1 to 1	1 to 2	...	1 to *j*	$\sum_j a_{1j}$ Sum of flows out of Region 1
Region 2	2 to 1	2 to 2	...	2 to *j*	$\sum_j a_{2j}$
…	...	...	...	...	...
Region *j*	*j* to 1	*j* to 2	...	*j* to *j*	$\sum_j a_{jj}$
Total	$\sum_i a_{i1}$ Sum of flows into Region 1	$\sum_i a_{i2}$	...	$\sum_i a_{ij}$	$n = \sum_i \sum_j a_{ij}$ **Total Interaction**

Source: the Authors, after Masser and Brown, 1975.

In the Flowmap software, which we used to perform the Intramax procedure for the CFERs, Equation (6) is modified as follows (Breukelman, *et al.*, 2009):

$$(7) \qquad \max I = \frac{T_{ij}}{O_i D_j} + \frac{T_{ji}}{D_j O_i}, \qquad i \neq j$$

where:

T_{ij} is the interaction between the origin SA2 i and destination SA2 j;
O_i is the sum of all flows starting from origin i; and
D_j is the sum of all flows ending at destination j.

This alters the focus from the absolute difference between the observed and expected flows to the proportional difference.

At each stage of the clustering process, fusion occurs between the regions that have the strongest commuting ties (interaction), as represented by Equation (7). The stepwise procedure then combines the clustered interaction, and the matrix is reduced by a column and a row. The remaining actual and expected commuting flows are re-calculated and the *i*,*j* combination of regions maximising (Equation 7) is again calculated, and so-on. If there is a continuous network of flows across the study area, with *N* regions, after *N*-1 steps, all regions would be clustered into a single area, and by construction, all interaction would be intra-zonal with one matrix element remaining.

To render the concept of functional regions operational, some level of clustering (number of steps) has to be chosen and the resulting regionalisation defined. There are two main approaches to deciding how and when to stop the clustering process:

1. The first is by reference to intra-regional flows, where the user may stop the clustering process when a certain percentage of flows are intra-regional, or where there is a large increase in the intra-regional flows.

2. Alternatively, the user may want to stop the Intramax method when a pre-determined number of regions has been formed. We stop the clustering for the regions around the 75 percent mark.

The Data Used

Data from the ABS's 2011 census was used to design the CFERs employing the ABS TableBuilder product. The spatial area building blocks we use to derive the CFERs are the SA2 units within the hierarchy of the new Australian Statistical Geography Standard (ASGS) that was introduced for the first time in the 2011 census. Those SA2s tend to equate to suburbs within the metropolitan cities and larger regional cities and to towns and surrounding areas in regional Australia. It is the SA2s that are used by the ABS as the origin and destination zones for reporting commuting flows for JTW data in the 2011 census.

In the case of all of the CFER regionalisations we have derived, a commuting flow matrix was designed listing the flows between all possible SA2s, which are local areas that basically equate to suburbs and towns.

The JTW data from the 2011 census has two notable limitations:

1. First, the ABS has strict rules on confidentialising its data for the purpose of making it impossible to identify a particular person, which does provide some limitation to the data's accuracy at small numbers. For small numbers the ABS randomises the data and the smallest flow is a value of 3.

2. The second limitation is a result of the different reference periods for the questions asked in the Census. While our origin SA2 is the usual address of workers (at which they will have lived for 6 months or more in 2011), the workplace address is taken for the main job held in the week prior to the date of the census count. To address this limitation we enforce a one-way threshold commuting distance of 300km, above which the flow is excluded from the dataset, so as to exclude flows where it is obvious a person was not carrying out a daily commute. The distance of a commute was taken as the distance between the population-weighted centroids of the origin and destination SA2s.

Using the Flowmap Software

In using the Flowmap software to run the Intramax procedure, there is a requirement that all spatial areas (that is, the 2011 census SA2s) used in the calculation be interactive. That interactivity is defined as an SA2 being required to have both resident workers and workplaces, and at least one of these must interact with another SA2. Hence, prior to running the Intramax, we needed to remove SA2s that were non-interactive.

When we included flows from all workers there were 25 SA2s across Australia with no flows, plus another 11 SA2s with only an intra-zonal flow. In addition there were 38 SA2s that had inflows but no outflows, and there were two SA2s with outflows but no inflows. SA2s with only an intra-zonal flow represent self-contained labour markets, and are given the same status as regions that are formed through the Intramax process. SA2s with only one direction flow were placed into regions after the Intramax procedure completed. SA2s with no flows were removed and are classified separately.

For the JTW 'mode of transport' regionalisations there were many SA2s with flows in just one direction. As these flows were important in the design of the CFERs (as opposed to the others where their number was very small), an intra-zonal flow of 1 was added to those SA2s so they became interactive and remained part of the flow dataset utilised in the Intramax procedure.

Dividing Australia Into Large Regions

There was substantial commuting between towns on either side of State and Territory boundaries in Queensland and NSW, NSW and ACT, NSW and Victoria, and Victoria and SA. As there were negligible JTW commuting flows between the other States and Territories, we divided up Australia into the following four large regions:

1. *East Coast plus South Australia* (EC+SA), consisting of these states/territories:
    - New South Wales
    - Australian Capital Territory.
    - Victoria
    - Queensland
    - South Australia.

2. *Western Australia* (WA).

3. *Tasmania* (TAS).

4. *Northern Territory* (NT).

The Intramax procedure was run separately for each these large regions.

3. OVERVIEW OF RESULTS DERIVED FROM THE INTRAMAX PROCEDURE TO PRODUCE CFERS

Australia is a very large country and its relatively small population of around 24 million is highly concentrated geographically, with almost seven out of ten people living in just five large capital city metropolitan regions (Sydney, Melbourne, Brisbane, Perth and Adelaide) whose populations range from a little over one to almost five million. Those capital city metropolitan areas are 'primate cities' in their respective States, and there is certainly not a well-developed urban hierarchy - as per Zipf's (1949) 'rank size rule' - across Australia's urban settlement system. The vast bulk of the nation's settlement is located within a few hundred kilometres of the east, south-east and south-west coasts of the Australian continent. The interior of the country is very sparsely settled with extremely low population densities, with much of that settlement occurring in remote small indigenous communities. Outside the large state capital city metropolitan regions there are just a handful of urban centres with populations over 100 000, and only one with more than 500 000. The large majority of urban centres outside the metropolitan city areas (in what is commonly referred to as rural and regional Australia) tend to be small.

It might be expected that within the large capital city metropolitan areas there would be a number (probably relatively small) of FERs. And it might be expected that there would be a relatively large number of FERs beyond the capital cities across the vast expanses of rural and regional Australia, with a number of FERs focusing on the larger regional cities and towns often incorporating smaller urban centres in the surrounding hinterlands, and with the FERS in the more sparsely settled interior areas being very large geographically.

The CFERs and Regions for Various Aggregations of the Australian Statistical Geography Standard (ASGS)

Table 3 shows the number of regions across the four large regions into which we have divided Australia that are produced by the Intramax procedure for the Original CFERs (that is, based on the JTW commuting flows data for all workers across all industry categories). The table also indicates the number of areas in the various ASGS classifications that are included in the CFERs.

Across the five states/territories comprising the EC + SA large region, the Intramax procedure produced 79 interactive CFERs, with 5 non-interactive SA2s that are self-contained labour markets (SCLMs). Associated with those CFERs there are 72 SA4s located across the same EC + SA large region at the 2011 census. For the Western Australia large region there are 18 CFERs, with 4 SCLMs, and 9 SA4s; for Tasmania there are 12 CFERs, with no SCLMs and 4 SA4s; and for the Northern Territory there are 14 CFERs, with 2 SCLMs, and 2 SA4s.

Of particular interest is the comparison between the number of CFERs and the regions at which the ABS disseminates data collected through its Labour Force Survey. Previously, under the old Australian Standard Geographical Classification (ASGC) used prior to the 2011 census, this data was made available for the ABS Labour Force Regions (LFRs). However, since the introduction of the new national geography - the Australian Statistical Geography Standard (ASGS) - at the 2011 census, this is now at the SA4 level of the national geography.

Table 3. The Number of Original CFERs Across Australia's Large Regions, and the Various Aggregations of the ASGS Statistical Areas in 2011.

	NSW	Vic	QLD	SA	ACT	WA	Tas	NT	Australia*
States/Territories	1	1	1	1	1	1	1	1	8
Greater Capital City	2	2	2	2	1	2	2	2	15
ASGS:									
Statistical Area Level 1	17891	13335	11039	4087	918	5508	1446	537	54761
Statistical Area Level 2	538	433	526	170	110	250	98	68	2193
Statistical Area Level 3	91	65	80	28	9	33	15	9	330
Statistical Area Level 4	28	17	19	7	1	9	4	2	87
CofFEE FERs (the Original CFERs)			79 (5)			18 (4)	12	14 (2)	123 (11)

Source: ABS, 2010; authors' calculations. Note: * Does not include Other Territories.

As shown in Table 3, there are more of the Original CFERs than there are SA4s; however, there are more SA4s than there were ABS LFRs, partly due to the fact that "labour markets were a key consideration in (their) design" (ABS 2010, p. 27). The SA4s must be large enough to accommodate the ABS sample sizes for its surveys without giving results with standard errors that are too large to make the data meaningful; and the SA4s must also aggregate to capital city/rest of state and state/territory borders. Importantly, those requirements are not placed on our CFERs, whose boundaries are permitted to cross those borders if the JTW commuting flows data are such that they in fact cross those administrative boundaries. This is the big advantage in using functional regions as against *de jure* regions as the spatial data base for the analysis of regional labour markets.

Regions for the Various CFER Aggregations

Turning now to consider the 10 regionalisations for which CFERs have been derived using the Intramax procedure, Table 4 lists the number of regions corresponding to each of the CFER aggregations. In each case we began by removing the Other Territories and Lord Howe Island, which left us with 2 192 SA2s across Australia.

In Table 4 there are three columns for all four of the large regions into which we divided Australia:

- Column (a) is the number of interactive CFERs produced using the Intramax procedure. There are 123 such interactive Original CFERs across Australia.

- Column (b) is the number of SA2s that are non-interactive, which we call Self-Contained Labour Markets (SCLMs). There are 11 SCLMs across Australia, almost all being located in the EC + SA and the WA large regions.

- Column (c) is the number of SA2s that have no flows, for all workers, or for a particular gender, broad occupation class, or mode of commuting. There are 25 of those across Australia, predominately in the EC + SA large region with a few in the WA large region.

Table 4. Regions for the Various CFER Aggregations.

	EC + SA			WA			TAS			NT			Australia		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Original CFERSs	79	5	15	18	4	6	12	0	3	14	2	1	123	11	25
Male CFERS	72	7	18	16	4	6	12	0	3	16	3	2	116	14	29
Female CFERs	95	9	21	19	4	6	12	1	3	15	3	3	141	17	33
Skilled CFERS	65	7	23	16	4	10	12	1	3	15	3	4	108	15	40
Less Skilled CFERs	95	11	16	20	4	6	13	0	3	16	2	2	144	17	27
Trades CFERs	95	12	28	19	4	6	13	1	3	13	5	4	140	22	41
Road JTW CFERs	87	6	16	17	4	5	11	1	3	14	2	2	129	13	26
Rail JTW CFERS*	13	-	-	4	-	-	-	-	-	-	-	-	17	-	-
Bicycle JTW CFERs	131	316	185	18	53	28	10	21	27	15	14	11	162	404	251
Multiple Transport Mode JTW CFERS	70	68	52	21	18	13	12	7	5	5	14	6	108	107	76

Notes: a = interactive CFERs after the Intramax procedure, b = non-interactive SA2s (self-contained labour markets), c = SA2s with no flows.
* Only SA2s that had sufficient rail commuting were included in any analysis. Source: the Author’s calculations.

The SA2s that are SCLMs are considered analogous to interactive CFERs as they represent a labour market and therefore should be included in any analysis. However, SA2s with no JTW commute flows should be excluded from any analysis.

In total, across Australia there are 159 Original CFERs, of which 123 are interactive CFERs, 11 are SA2s that are SCLMs, and 25 are SA2s that have no JTW commuting flows.

From Table 4 it is evident that there is a substantially larger number of Female CFERs than there are Male CFERs across Australia, and this is also the case for Less Skilled CFERs and for Trades CFERs as against Skilled CFERs, while the number of Less Skilled CFERs and Trades CFERs are about the same.

With relation to JTW mode of travel, because the JTW is dominated by road transport there is a large number of Road JTW CFERs across Australia, with that number being similar to the number of Original CFERs. The number of Multiple Transport Mode JTW CFERs is somewhat less numerous. Not unexpectedly there are many more Bicycle JTW CFERs than there are for the other modes of commuting. And the number of Rail JTW CFERs is very small. But with respect to the latter, it needs to be noted that Rail JTW CFERs exist only in and around the capital cities of Sydney, Melbourne, Brisbane, Adelaide and Perth. In some cases the Rail JTW CFERs do extend outside the ABS defined area of the capital cities, however, in general there were very few workers from outside these areas that indicated they used the rail network for their mode of commuting. Hence, we excluded any flows from outside the areas that make up the Rail JTW CFERs.

As may also be seen from Table 4, some of the aggregations have many SA2s that are SCLMs, and also many SA2s with no flows. This reflects the type travel mode that is being used for the JTW commute. For example, in the case of the Bicycle JTW CFERs there are naturally many non-interactive SA2s as, generally, the distance someone would ride a bike is small and it is quite likely that bike riders do not leave their SA2 of origin. In addition, the Bicycle JTW CFERs also have many SA2s with no flows, reflecting the lack of popularity of using a bike to commute to work in those areas.

4. CONVENTIONS FOR NAMING THE CFERS

For all of the 10 regionalisations we followed the same naming conventions. Each unique area has an area name, whether it is an interactive CFER, an SA2 with only an intra-zonal flow (a SCLM), or an SA2 without any flows. For those that were classified as CFERs their name attempts to explain where they are placed in Australia. If a CFER crossed a state/territory boundary we included the name of at least one area from each state in the CFER name to indicate this, except in the case of the ACT which in most cases was part of a CFER that included surrounding towns in NSW, where the name for the CFER is ACT and surrounds. If a CFER was a single SA2 it took on the name of the SA2. SCLMs also took on the name of their SA2, as did those without flows.

Each area also has a corresponding area code. CFER codes are four-digit numbers:

- The first digit aligning with the state/territory the most (or all) of the CFER (or self-contained or no flows SA2) is in: NSW = 1; Victoria = 2; Queensland = 3; SA = 4; WA= 5; Tasmania = 6; NT = 7; and ACT = 8.

- The second digit indicates the type of region it is: 1= the region is an interactive CFER, formed through the Intramax procedure; 2 = the region is a single SA2 that only has an intra-zonal flow (that is, a SCLM); and 3 = indicates the region is an SA2 that had no commuting flows and as such was excluded from the analysis.

- The final two digits then start at 01 for the region incorporating the capital city CBD, and increase as the regions fan out. While SCLMs should be treated as interactive CFERs in most analyses, this coding structure allows analysts to consider the difference between these types of regions.

The SA2s that were not part of interactive Rail CFERs were combined, given the name Not Included and the code 9000. There were more than 100 SCLMs in NSW for the Bicycle CFERs, hence these begin at 1195 and continue to 1299.

5. MAPPING THE CFERS

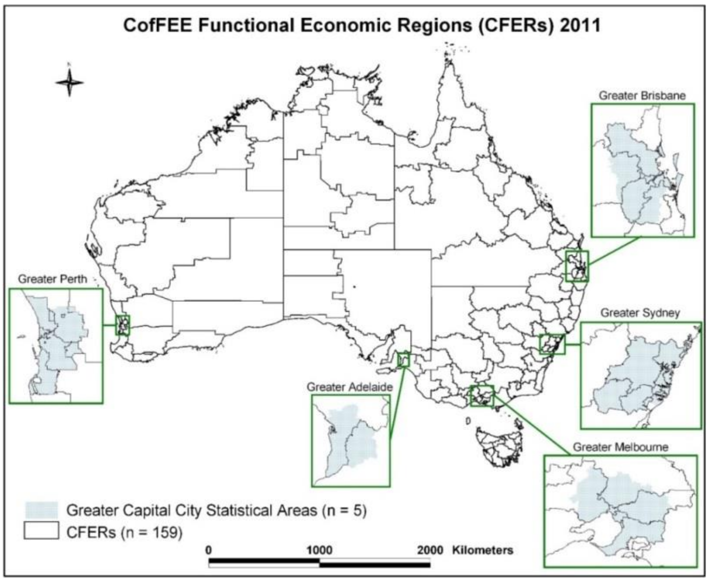
We have mapped the 10 regionalisations of CFERs to show the spatial pattern of these functional economic regions across Australia, with map inserts focusing on the Greater Capital City Statistical Areas (GCCSAs) of Sydney, Melbourne, Brisbane, Perth and Adelaide. Those maps are

provided in Figures 1 through 10. Alternatively, an interactive map can be found at
http://e1.newcastle.edu.au/coffee/maps/CFER2011/AusByCFER2011.html. Note that in these maps the boundaries of all of the CFERs derived from the Intramax procedure are shown, not just for the interactive CFERs.

The discussion that follows draws attention to some of the significant features of those maps for the 10 regionalisations of the CFERs.

Original CFERs

The boundaries of the Original CFERs derived from the 2011 census JTW commuting flows data for all workers across all industry categories are shown in Figure 1. There are 159 Original CFERs across Australia.



Source: the Authors.

Figure 1. Original CFERs.

There are multiple Original CFERs in Australia’s five GCCSAs - with the boundaries often extending beyond the *de jure* defined GCCSAs - indicating that those large metropolitan concentrations of people are characterised by a poli-centric structure in which distinct functional labour market regions have emerged. The spatial shape of these Original CFERs tend to be elongated stretching out along major transport routes

For the Sydney GCCSA there are 7 Original CFERs, with an additional three adjoining to encompass the Newcastle region to the north and the Wollongong region to the south. For Melbourne there are 6 CFERs with a further one adjoining encompassing the Geelong-Surf Coast. Brisbane has 4 CFERs plus the adjoining Gold Coast-Tweed to the south and the Sunshine Coast to the north to encompass what is known as the Brisbane-South East Queensland region. For Perth there are 4 CFERs. However, for Adelaide, the smallest of the GCCSAs, there is only one CFER which encompasses Greater Adelaide and the Barossa, with an adjoining CFER to the east that includes the Adelaide Hills-Murray Bridge-Fleurieu Peninsula.

In and around the National Capital area of Canberra there is only 1 large interactive CFER. And there are 4 Original CFERs in and around Hobart, and 3 in and around Darwin.

Outside the GCCSAs, across regional Australia the Original CFERs tend to focus largely on the larger regional cities and towns and encompass surrounding hinterland areas that may include a number of smaller urban centres, with the shape of those CFERs tending to be elongated (linear) along major transport routes. It is significant (but unsurprising) that the Original CFERS in regional Australia tend to cross over the State borders in the EC + SA large region, especially along the Murray River which forms the border between NSW and Victoria, along the eastern part of the NSW-Queensland border, and in what is often referred to as the Green Triangle section of the Victoria-SA border.

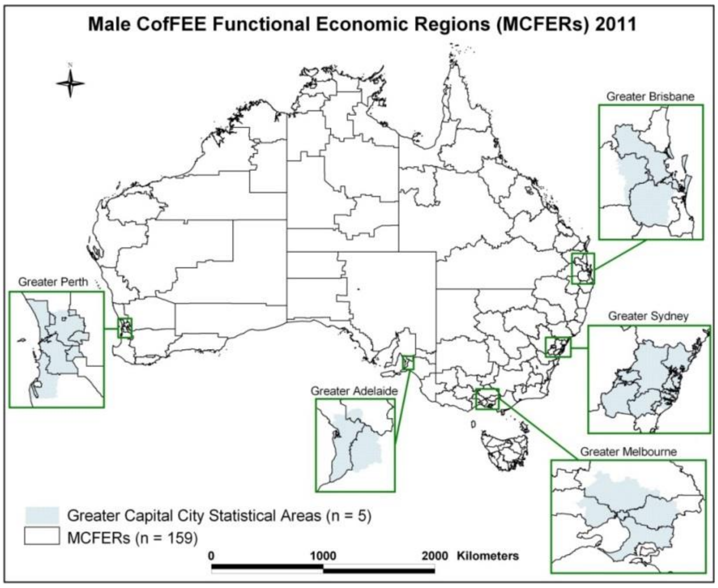
The Original CFERs tend to become less numerous and much larger in size with increasing distance inland from the coastal fringes of Australia, reflecting the rapid decrease in population density and the lack of larger urban centres in the inland and more remote areas of Australia. In some of the remote inland areas - especially in outback Queensland, in the Northern Territory, and in the inland and north-west Western Australia - there are some more self-contained CFERs. These are associated with mining settlements or Indigenous communities and many of these regions, particularly the Indigenous communities, have very small economies with very little commuting, and as such, maintain the default boundaries applied by the ABS for their SA2.

Gender-differentiated CFERs

The boundaries of the Male (MCFERs) and the Female (FCFERs) regions are shown in Figures 2 and 3 respectively.

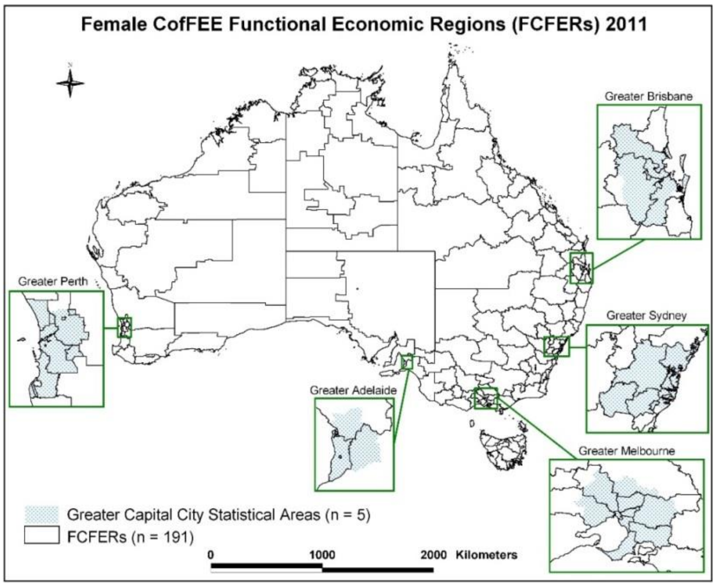
Across Australia there are 159 Male CFERs (the same as the number of the Original CFERs), but the number of Female CFERs is considerable greater at 191. This could reflect the gender differences in the incidence of male and female employment in different industry and occupation categories and the patterns of spatial concentration and dispersal of male and female jobs in those sectors of economic activity. But within and around the GCCSAs there is not a lot of difference. For the area in and around Sydney there are 12 Male CFERs and 13 female CFERs; for Melbourne it is 7 and 10; for Brisbane it is 6 and 6; for Perth it is 4 and 4; and for Adelaide it is 2 and 3. The ACT has 5 Male CFERs and 7 Female CFERs. Hobart has 4 CFERs for both Males and Females.

Thus it is beyond the large metropolitan city regions into regional Australia where there are a substantially larger number of Female CFERs than Male CFERs with a tendency for the Female CFERs to be more confined to focusing on country towns and lesser inclined to encompass the hinterland areas surrounding the larger regional cities, and that is the case across all four of the large regions into which we divided Australia.
In the remote areas of NT and WA there are quite a large number of both Male and Female CFERs that are confined largely to Indigenous settlements and to mining settlements.



Source: the Authors.

Figure 2. Male CFERs.



Source: the Authors.

Figure 3. Female CFERs.

Occupation and Skills differentiated CFERs

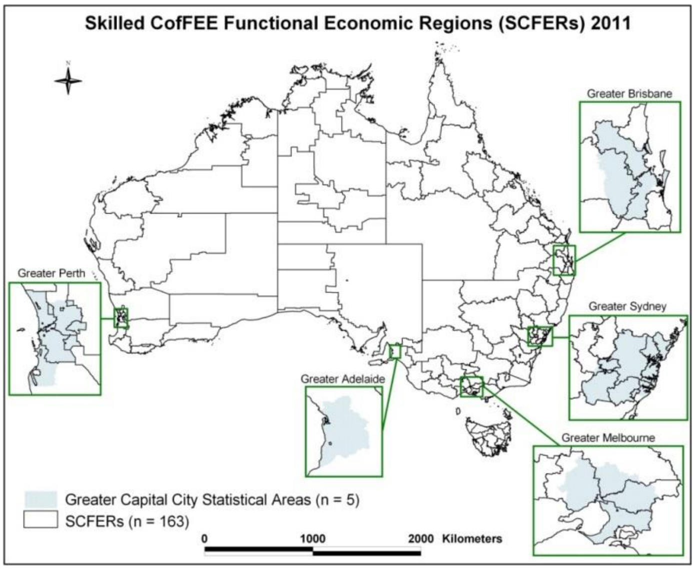
The boundaries of the Skilled CFERs, the Less Skilled CFERs, and the Trades CFERs are shown in Figures 4, 5 and 6.

Skilled CFERs

From Figure 4 we see there are a total of 163 Skilled CFERs across Australia. Focussing on the Sydney GCCSA, there are 6 Skilled CFERs, plus another 3 taking in the Central Coast and Newcastle-Hunter area to the north and Wollongong-Illawarra-Batemans Bay area to the south, and another 2 encompassing the Blue Mountains to Sydney's west. In and around Melbourne there are 6 Skilled CFERs, including the area around Geelong. However, in and around Brisbane there is just 1 Skilled CFER covering Greater Brisbane, plus 3 further Skilled CFERs taking in the Gold Coast-Tweed to the south, Ipswich-Toowoomba to the west, and Sunshine Coast to the north. A single large Skilled CFER encompasses Adelaide-Barossa-The Coorong. In and around Perth there are 5 Skilled CFERs. It is noteworthy again that in and around the ACT there is only 1 interactive Skilled CFER which, while there are 4 in Hobart, and Darwin has 4.

Beyond the areas within and surrounding the GCCSAs the Skilled CFERs tend to take on somewhat similar forms to the previously-discussed original and Male and Female CFERs, except that there are a slightly larger number of them compared to the Male CFERs but fewer than the Female CFERS. The Skilled CFERs in regional Australia are certainly focused largely on the economic functions in those larger regional urban centres that depend on skilled workers draw from large hinterlands, indicating the smaller regional urban centres do not have local skilled worker labour markets.

In remote areas - especially in WA - there are distinct Skilled CFERS focused on mining settlements, and also on remote indigenous settlements. But across the inland remote areas of Australia there are few very large Skilled CFERs.



Source: the Authors.

Figure 4. Skilled CFERs.

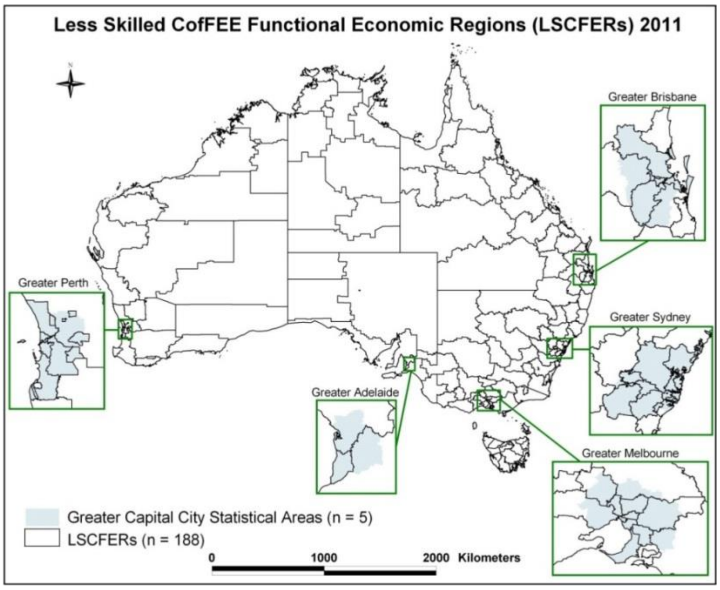
Less Skilled CFERs

As shown in Figure 5 there are substantially more Less Skilled CFERs across Australia at 188 compared to the 163 Skilled CFERs.

The Less Skilled CFERs are also more numerous in and around the GCCSAs. There are 14 across the Sydney-Newcastle-Wollongong areas; 12 in and around Melbourne-Geelong; 7 across the Brisbane-SEQ region; 3 across the Adelaide area; and 6 across the Perth area. Again in and around the ACT there is just 1 interactive Less Skilled CFER. Hobart has 4 Less Skilled CFERs, and Darwin has 3.

Beyond the GCCSAs and their surrounds into regional Australia the Less Skilled CFERS are considerably more numerous than is the case for the Skilled CFERs. They tend to focus not only on the larger regional cities and towns, but also on some of the smaller regional urban centres, which indicates that many urban centres in regional Australia can sustain local labour markets for Less Skilled workers.

Across the inland remote areas of Australia there are few in number but large Less Skilled CFERs. But there are a considerable number of Less Skilled CFERS in the remote areas of NT and WA focusing on mining settlements and indigenous settlements.



Source: the Authors.

Figure 5. Less Skilled CFERs.

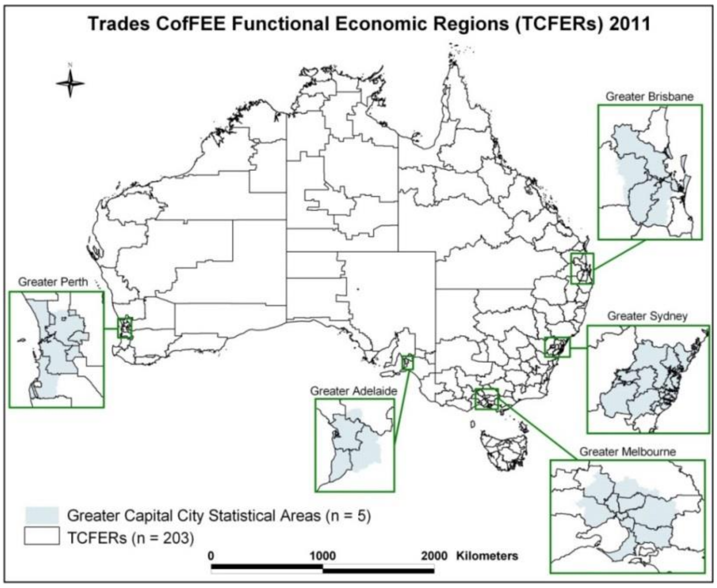
Trades CFERs

Figure 6 shows there are even more Trades CFERs across Australia at 203 in total.

In and around the GCCAs, there are 15 across the Sydney-Newcastle-Wollongong area, and 11 across Melbourne-Geelong. There are 5 Trades CFERs across Brisbane-SEQ; 4 across the greater Adelaide area; and 4 across Perth. Once more in and around the ACT there is just 1 interactive Trades CFER, while Hobart has 4, and Darwin has 3.

Across regional Australia again the Trades CFERs tend to focus predominantly on the larger regional cities and towns, but a few of the less large urban centres do seem to support Trades CFERs.

Again in the remote parts of NT and WA there are Trades CFERs that focus on mining settlements and indigenous settlements.



Source: the Authors.

Figure 6. Trades CFERs.

JTW Mode of Transport differentiated CFERS

The boundaries of the Road JTW CFERs, Rail JTW CFERs, Bicycle JTW CFERs, and Multiple Transport JTW CFERs are shown in Figures 7, 8, 9 and 10. What these maps represent are approximations of largely self-contained commute sheds for specific JTW travel modes for workers at the time of the 2011 census, in which there is a preponderance of that mode of commuters who both live and work within a designated CFER.

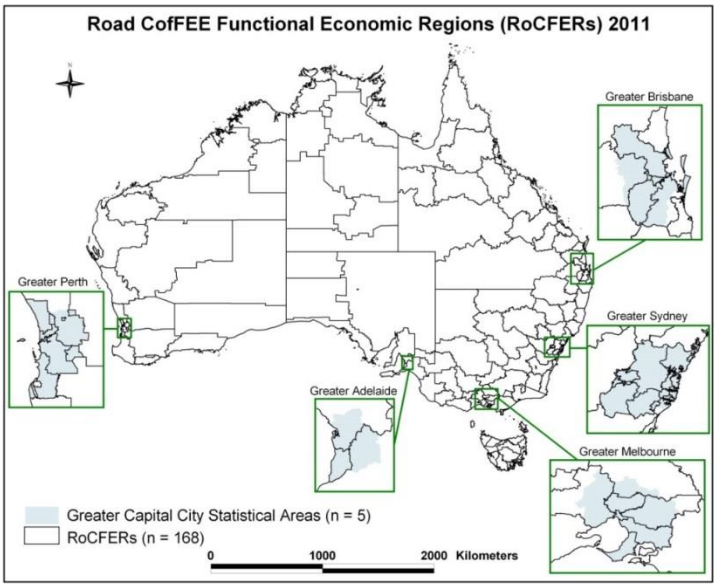
Road JTW CFERs

As shown in Figure 7 across Australia there are 168 Road JTW CFERs, which is slightly more than the number of Original CFERs. It is important to stress the overall high incidence of the private motor vehicle as the predominant model of travel to work in Australia, and the almost total reliance on that mode of travel across regional Australia.

For the GCCSAs, we see in and around Sydney 7 Road JTW CFERs, with another 6 to the north, west and south embracing Newcastle, Wollongong and the Blue Mountains areas. There are 6 Road JTW

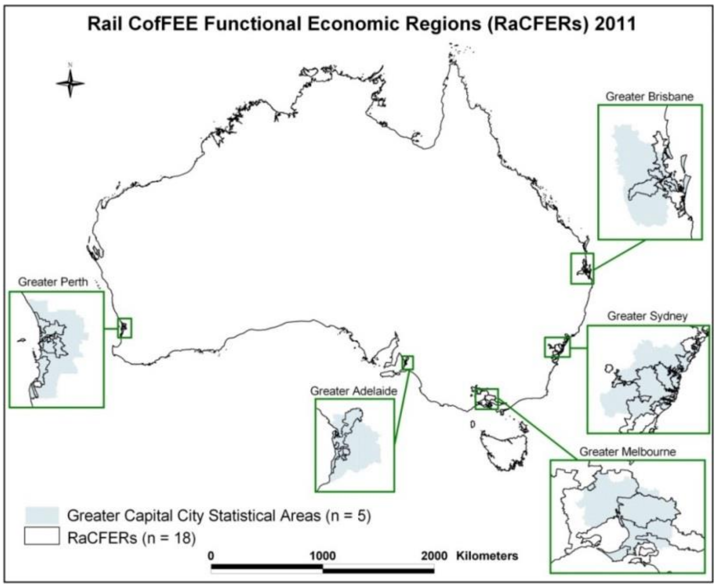
CFERs encompassing the Melbourne GCCSA and Geelong-Surf Coast; 4 across the Brisbane GCCSA plus Gold Coast-Tweed and Sunshine Coast; 3 across the greater Adelaide area; and 6 across the Perth GCCSA. The ACT has only 1 interactive Road JTW CFER, while there are 4 in Hobart and 3 in Darwin.

Across regional Australia the Road JTW CFERs tend to focus on the larger urban centres and to take in smaller urban centres in their hinterlands, often covering quite large areas spread out along the main roads.



Source: the Authors.

Figure 7. Road JTW CFERs.



Source: the Authors.

Figure 8. Rail CFERs.

Rail JTW CFERs

Figure 8 shows that it is only the largest 5 of the GCCSAs with commuter rail networks that have Rail JTW CFERs.

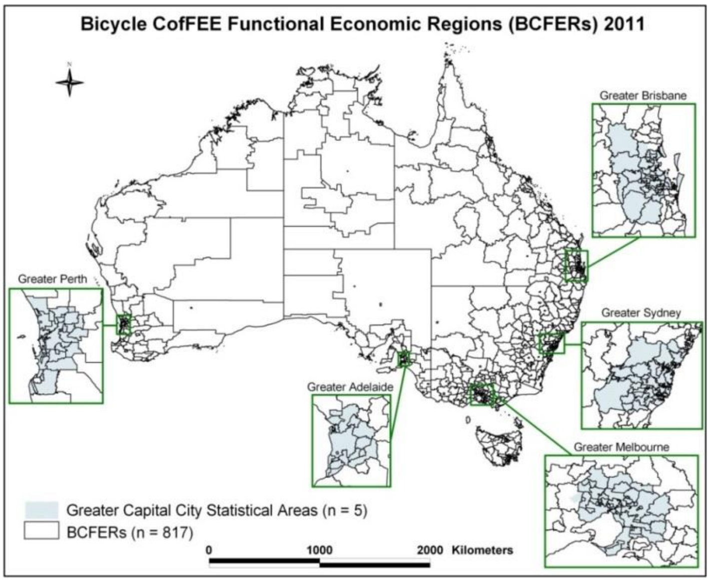
There are only 19 such CFERs in total - just 3 across Sydney and extending south to Wollongong. Across greater Melbourne there are 3 Rail JTW CFERs which extend north-west to Ballarat and south-west to Geelong, and east to Traralgon, plus an additional one that encompasses Bendigo-Castlemaine along a regional rail service. For the Brisbane region there are 3 Rail JTW CFERs that extend south to the Gold Coast and west beyond Ipswich. Adelaide has 3 Rail JTW CFERS, while Perth has 4. As one would expect, these Rail JTW CFERs are extensive in size and elongated in shape which reflects the radial commuter rail networks that radiate out from the capital CBDs.

Bicycle JTW CFERs

There has been a considerable public policy push in Australia to encourage cycling as a mode of travel and while the incidence of cycling for the JTW is increasing it still represents a minute proportion of the

JTW. As shown in Figure 9, these Bicycle CFERs tend to be small geographically and there is a large number of them – a total of 817 across Australia. This is not surprising as it is unlikely that workers who cycle to work would be prepared to travel a long distance.

For the GCCSAs and their surrounding areas, there are about 25 Bicycle CFERs across Sydney, Newcastle, Wollongong and the Blue Mountains area; about 20 across greater Melbourne; almost 30 across Brisbane-SEQ; 17 across greater Adelaide; and 10 across Perth. There is just 1 large interactive Bicycle JTW CFER across the ACT. There are 4 across Hobart and 5 across Darwin.



Source: the Authors.

Figure 9. Bicycle JTW CFERs.

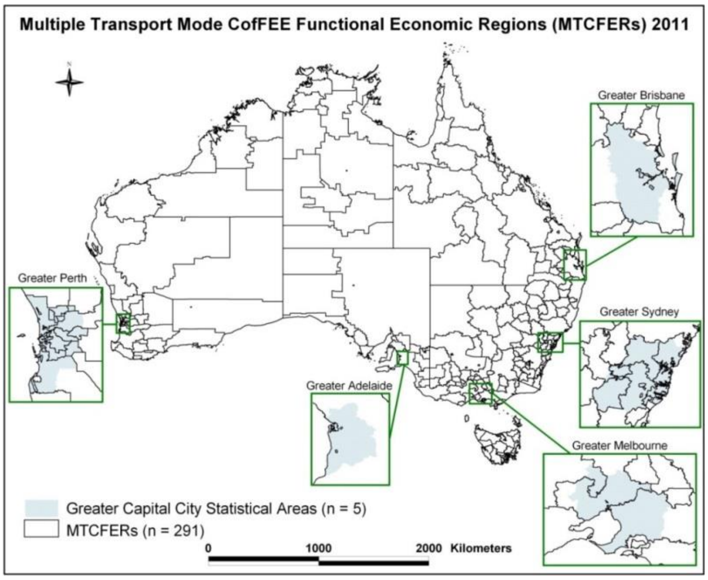
There are a large number of Bicycle JTW CFERs across regional Australia - literally numbering in the hundreds - with them tending to focus on both the larger and the smaller urban centres.

Multiple Transport Mode JTW CFERs

Figure 10 shows the Multiple Transport Mode JTW CFERs which number 291 across Australia.

For the Sydney GCCSAs there are 3 Multiple Transport Mode CFERs, and there are additional ones to the north and south which extend beyond Newcastle and Wollongong and as well into the Blue Mountains. Greater Melbourne has 4 Multiple Transport Mode CFERS which extend well beyond that GCCSA along the regional commuter rail links east into the La Trobe Valley, west to Bacchus Marsh and north to Seymour and west and north-west to Ballarat and Bendigo. It is interesting that there is just a single Multiple Transport Mode CFER covering a large area that encompasses Brisbane-Gold Coast-Toowoomba, with another covering the Sunshine Coast. A single Multiple Transport Mode CFER covers the whole of Greater Adelaide and surrounds. And there are several Multiple Transport Mode CFERs across the greater Perth region. In and around the ACT there is just 1 large interactive Multiple Transport Mode CFER. There are 2 in Hobart and 2 across Darwin.

In the regional areas of Australia the Multiple Transport Mode CFERs are focused largely on the larger urban centres and typically encompass a number of urban centres surrounding them.



Source: the Authors.

Figure 10. Multiple Transport Mode JTW CFERs.

6. CONCLUSION

This paper has outlined how we have been developing a new spatial base for investigating regional performance across Australia employing an approach that seeks to derive functional regions using the Intramax procedure and JTW data available in the 2011 census. In addition to deriving FERS that relate to aggregate employment across all industry categories (the Original CFERS), we have also derived regionalisations that segment workers into gender, occupation / skills categories, and different transport modes for the JTW commute.

The paper discusses the outcomes of the 10 regionalisations derived from the JTW commuting data using the Intramax procedure and highlights some of the spatial patterns that result both across Australia's major capital city areas and across regional Australia. Not surprisingly there are considerable variations in both the number of CFERs that are derived for the 10 regionalisations used for this paper as well as the spatial characteristics of some of the patterns for those employment segmentations.

This research adds further evidence to demonstrate that labour markets are not homogenous across a space economy. The regional demarcations based on gender and occupations /skills of the labour force certainly show that for Australia's large capital city regions there are distinct local labour markets as a result of differences in the emerging patterns of spatial diffusion and concentration of employment that have subtle differences for jobs dominated by male and female work and by levels of skill and occupation. And it is also evident that the mode of travel to work chosen by commuters results in very substantial differences in the incidence and patterns of functional regions.

The research presented in this paper will now be used as the basis for much more detailed interrogation using spatial econometric analytical tools to investigate possible determinant of spatial differentials in the economic performance of the CFERs derived through the Intramax procedure. In that we will concentrate on the distribution of unemployment and employment growth across the regions and investigate the regional disparities that exist. Further, we will endeavour to explore in depth the characteristics of the gender and occupation / skills segmented CFERs on a region-by-region basis for the major capital city areas and across parts of regional Australia. It may also be interesting to compare the Australian case with the situation in Europe and / or the US.

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