Centre of Full Employment and Equity

CofFEE Functional Economic Regions 2011

Technical Users Manual

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1. Introduction

The CofFEE Functional Economic Regions (CFERs) continues our work focused on developing a new socio-economic geography for Australia such that the chosen spatial aggregation of data is based on an analysis of economic behaviour. The underlying hypothesis that has motivated this work is that the development of a geographical classification based on underlying economic behaviour will provide new insights into critical issues of regional performance, including unemployment differentials, the impact of industry, infrastructure and changes in local public expenditure on local labour markets. A systematic understanding of the level of interaction between neighbouring regions will facilitate an assessment of the adequacy of the administrative geographical demarcations currently used by the Australian Bureau of Statistics (ABS) to collect and disseminate their labour force data.

Previous Australian studies have analysed spatial patterns of unemployment, housing and related socio-economic phenomena using administratively-defined Australian Standard Geographical Classification (ASGC) spatial aggregations typically at the Statistical Local Area (SLA) and/or Statistical Region (SR) level (for example, O'Connor and Healy, 2002; Lawson and Dwyer, 2002; Baum *et al.*, 2005; Mitchell and Carlson, 2005; Yates, 2005; Yates *et al*., 2006a, 2006b; Mitchell and Bill, 2006, Gregory and Hunter, 1995). Most Australian researchers are reluctant to acknowledge that the interpretation of these spatial data can be compromised by the Modifiable Areal Unit Problem (MAUP), although this problem has long been recognised by geographers. Openshaw (1984:3) says that "the areal units (zonal objects) used in many geographical studies are arbitrary, modifiable, and subject to the whims and fancies of whoever is doing, or did, the aggregating" and resulting analyses are fraught. In short, chosen spatial groupings must be justified and these aggregations are modifiable.

Just as geographical regions may be defined by physical features, we hypothesise that a meaningful socio-economic geography should be defined by socio-economic features of space. It is most unlikely that that these "regions" will correspond exactly to a demarcation based on administrative/political criteria. Significant issues arise when erroneous geography is used. First, a poorly delineated geography invokes measurement error. Thus, a local measure such as SA2 unemployment, may be unrelated to socio-demographic and policy variables at a similar scale, and lead to spurious causality being detected and misguided policy conclusions. 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 correlation. Our conjecture, based on an earlier pilot study (Watts *et al.*, 2006), is that studies relying on ABS administratively-based Census areas, or regions devised for the dissemination of the Labour Force Survey, produce misleading inferences when applied to socio-economic analysis or policy. Watts *et al.* (2006) found significant spatial correlation in key labour market variables and sensitivity to spatial aggregation, when they compared ASGC geography with experimental commuting areas generated using the 2001 Census data. Stimson *et al*. (2009) modelled endogenous regional performance and, using spatial econometric techniques, found that the FER geography seemed to overcome the spatial autocorrelation problem.

Unfortunately, only limited attempts have been made in Australia to create such a space. DEET (1993) outlined an ad hoc urban-centred approach and identified 216 Natural Labour Markets. This was superseded by a new organisational structure in which 450 local labour markets were defined within DEET regions and reflected the organisational imperatives of the DEET Network, training providers, educational institutions, regional development agencies etc. In a commissioned review of the Job Network, Access Economics (2002, p. 36) noted that the DEWR should "review the definition of the boundaries of local labour markets, to reflect more accurately the area within which a resident may find employment." More recently, attempts have been made by researchers to create a functional regionalisation of Australia based on commuting flows and grouping algorithms (see Watts *et al.*, 2006; Mitchell and Watts, 2010; Watts, 2004; 2013).

Journey-to-work (JTW) data provides information about the interaction between a large number of spatial units and is a useful basis for defining a functional regionalisation. The theoretical basis for demarcating regions based on commuting behaviour is outlined in Watts *et al.* (2006). It is applicable to any of the possible aggregation methodologies that are available. A region is conceived as a geographical area within which there is a high degree of interactivity (commuting by residents) and is thus the appropriate spatial scale to capture the interplay between labour supply and demand in a particular localised setting. These spatial markets result from both costs of mobility between jobs and the limitations of information networks (Hasluck, 1983). Employers and workers that interact within a functional area are assumed to be well informed and able to respond quickly to changes in market conditions relative to those outside any particular area. While Hasluck (1983) is critical of such attempts to create regionalisations; on balance, we support Green (1997) who sees commuting clusters as revealing the boundaries of local labour demand and supply and hence a sound basis for an alternative geography for labour market analysis.

Different terminology has been employed to identify these areas including *Commuting Area*, *Local Labour Market Areas*, *Functional Labour Market Areas* and *Commuting Zones*. Early on, Berry (1968) referred to these aggregations as functional regions. Consistent with the *extant* literature (on intramax techniques) we use Functional Economic Regions to describe our regional aggregations based on JTW data. In line with our conjecture above we seek alternative aggregations of the JTW data, which reflects economic behaviour (commuting interaction) rather than administrative structures.

Previous work by Watts (2004) and Watts *et al.* (2006) used a non-hierarchical, rules-based demarcation method first developed by Coombes *et al.* (1986) to determine a new "behavioural-based" geography (for a detailed description of the method see Coombes *et al.*, 1986: 948-52 and Papps and Newell, 2002: 9-14). In summary, the Coombs *et al*. algorithm is based on: (a) the *a priori* specification of the magnitudes of a number of parameter values; and (b) a complex sequence of stages in which areas are identified as foci according to particular criteria, which are then combined according to a weighted interaction function and then further combined into temporary or proto groups of areas, again by reference to the interaction function and other criteria. These proto-groups are then entirely dismembered if the associated value of an objective (spline) function does not exceed a critical value. There are two obvious shortcomings of the algorithm. First, the choice of foci and protogroups as the sequence of steps is implemented is dependent on the set of arbitrarily specified parameter values. The sensitivity of the solution to these values is hard to gauge without extensive experimentation. Second, the dismemberment process would appear to generate a final set of groupings with numerous singleton groups, but also some very large groups, at least using Australian SLAs. A simplified version of the 1986 algorithm was used on the 2001 UK Census data (Bond and Coombes, 2007), but these deficiencies appear to remain (Watts, 2009).

The CofFEE Functional Economic Regions take an alternative approach to functional regionalisation and deploy the Intramax method. JTW flows between areas can be depicted as a square matrix with each row denoting an origin (residential location) and each column representing a destination (workplace location) (see Table 1). The Intramax method is a hierarchical clustering algorithm (Masser and Brown, 1975) that acts to maximise:

> 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" (Masser and Brown, 1975: 510).

Masser and Scheurwater (1980: 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) across the regional boundaries. Looking at Table 1, the main diagonal elements of the JTW (at any stage of aggregation) capture the journeys that begin and end in the same region, whereas the off-diagonal elements show journeys that cross regional borders. Masser and Brown (1975: 509) 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: 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, we seek to define our functional economic areas, 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: 510).

The results reveal the Intramax technique to be very useful for understanding the operation of labour markets in Australia and demarcating commuting areas. At each stage of the clustering process fusion occurs between regions in such a way as to maximise commuting flows or interaction – providing valuable insight into those SA2s whose labour markets are most linked in metropolitan and non-metropolitan areas. Overall the technique collapses many of the standard regions used by the ABS in the dissemination of its statistics (formerly Labour Force Regions, more recently SA4s, see below) in metropolitan areas and splits many non-metropolitan Labour Force Regions, particularly around major regional centres.

This help file is set out as follows. The Intramax method is explained in Section 2, followed by a discussion on the data used to design the regions. Section 4 discusses the results of the original CFERs. The next section introduces our alternative CFERs for differentiated labour markets. Section 6 provides details on the conventions we used for the CFERS. This is followed by concluding remarks.

2. The Intramax method

The Intramax method considers the size of the interaction (JTW flows) to be "of fundamental importance" (Masser and Brown, 1975: 510). To express this concern the method considers the "interaction matrix", that is, the JTW matrix to be a "form of contingency table" and then formulates the "objective function in terms of the differences between the observed and the expected probabilities that are associated with these marginal totals" (Masser and Brown, 1975: 510).

To help in the explication of the Intramax technique, Table 1 provides a schematic representation of the square JTW flow matrix where the rows are designated as origins and the columns are destinations.

Table 1 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**

If we view Table 1 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 1, where a_{ij} is the element in row *i* and column *j* of the contingency table (JTW matrix), is given as:

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

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: 512).

The row sum of the JTW matrix is:

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

The column sum of the JTW matrix is:

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

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

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

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

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

If the grand total of the flows is normalised such that $n = 1$ and $a_{ij}^{*} = a_{i*}a_{*j}$ then Masser and Brown (1975: 512) note that:

> the difference between observed and expected values $(a_{ij} - a_{ij}^{*})$ for the flow between zone i and zone j may be taken as a measure of the extent to which the observed flow exceeds (or falls below) the flow that would have been expected simply on the basis of the size of the row and column marginal totals.

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

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

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

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

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.

In relation to Equation (7), Goetgeluk and de Jong (2005: 9) say that "the proportional amount of within group interaction is maximised in each step of the procedure … two areas are fused that have the strongest relative relations" in terms of commuting flows.

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 (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. In contrast to the Coombes algorithm, there is no dismemberment of groups of regions during the operation of the algorithm.

To render the concept of functional regions operational, some level of clustering (number of steps) has to be chosen and the resulting regionalisation defined. The exact point at which we stop the algorithm is a matter of judgement and cannot be determined in any rigid way. A convention adopted in the literature is to define a stop criterion as some level of clustering (number of steps) where homogeneity within a cluster is lost. Goetgeluk (2006: 11) states that a large increase in the intra-zonal flows during the fusion process does not generally indicate "a merger of two rather homogenous zones." The "stop criterion" would thus use the regionalisation that was defined "just before the high increase in intra-zonal flows".

Masser and Brown (1975) place a contiguity constraint on the maximisation process to eliminate the possibility that clusters between non-contiguous regions would form. However, with respect to commuting, there is no logical reason why two non-contiguous regions could not belong to the same local labour market. The Intramax algorithm as well as other algorithms, would not identify that, in these circumstances, commuting entailed crossing a boundary out of the region and then re-entering the region, since only the identity of the origins and destinations would be recorded. Peculiarities of the housing, occupational and transport patterns overlaying employability could generate such a result. In our data, the contiguity constraint is not enforced and indeed there are a few instances in remote areas where non-contiguous areas form a functional economic region.

3. Data

Australian Bureau of Statistics Journey to Work (JTW) data is available through the five-yearly Census of Population and Housing (hereafter Census). A new statistical geography was introduced for the 2011 Census by the ABS called the Australian Statistical Geography Standard (ASGS) (ABS, 2010), replacing the Australian Standard Geographical Classification (ASGC) (ABS, 2007a). A JTW matrix was designed, using the Statistical Area Level 2 (SA2) level as the basic spatial unit. The origin of the Journey to Work data collected by the ABS at Census time was to assist State and Territory public transport planners in analysing transport patterns and developing appropriate systems for their customers (ABS, 2007b). When collating Journey to Work data the ABS codes a person's workplace address to Destination Zones. These are zones defined by the transport authorities in each State and Territory and cover all of Australia. These are then coded into the relevant basic spatial unit to provide an origin, a person's place of usual residence, and a destination, a person's workplace.

The ABS has strict rules on confidentialising its data, which does provide some limitation to the data's accuracy at small numbers. One of the techniques used by the ABS is to confidentialise small flows, for the purpose of making it impossible to identify a particular person. For small numbers the ABS randomises the data. Hence, in our raw data the smallest flow is a value of 3.

The other main limitation of our data arises from the nature of the questions asked in the Census Household form. The two questions which JTW data is derived from relate to a person's usual place of residence and a person's workplace address; however the reference periods for the two questions differ. The question about a person's usual address states "… 'usually live' means that address at which the person has lived or intends to live for a total of 6 months or more in 2011" (ABS, 2011: 2). In contrast the question asking for a person's workplace address asks in reference to the previous week: "For the main job held *last week*, what was the person's workplace address?" (ABS, 2011: 12). The most obvious example of where this would show a meaningless JTW count is for people who are temporarily working in a different city or town. Their usual work may be near to their usual address, but their work in the last week may be in a totally different place.

To address this second limitation, we enforced a threshold commuting distance above which a flow would be excluded from the dataset. The aim of this was primarily to exclude flows where it was obvious a person was not carrying out a daily commute. For example, for a person with their usual place of residence in Sydney who indicated they worked in Melbourne in the previous week, while possible, it is unlikely this would be their regular commute. We decided that a reasonable watershed, allowing for people who do make reasonably long commutes, would be 300km. Any commutes that were longer than 300km we excluded from the analysis, concluding these data were the result of the limitations in the survey design.

There were a variety of ways we could define our 300km threshold distance for commuting flows. For areas such as SA2s, the common practice in Geographic Information Systems (GIS) is to establish an appropriate centre point, from which distances can be measured. These centre points are commonly referred to as centroids, which indicate "the geometric centre of the polygon" (Deakin *et al.*, 2002: 2). Deakin *et al.* (2002) set out many ways to define a centroid.

In our case we are concerned with the commuting of the working population, so we want our centre point to be representative of where the population is located in each basic spatial unit, for example, SA2. That is, we want to locate a centre of population for each SA2, not simply a geometric centre. Our data consists of an origin SA2 and a destination SA2 for each commute, but has no more detail about where in the respective SA2s these journeys start and end. SA2s are often large areas that are irregularly shaped. As a result, the geometric centre location of an SA2 won't necessarily be an indication of the centre of population in the SA2.

The population-weighted centroid is calculated by incorporating the population distribution of the SA2. We do this by using the populations of the Statistical Areas Level 1 (SA1s) that comprise each of the SA2s. SA1s are the smallest spatial unit in the ASGC and aggregate to form SA2s. Our process involves calculating a centroid[1] for each of the SA1s in an SA2, and then finding the mean centre of the SA1 centroids weighted by their population. The result gives a more meaningful centroid representative of the population of an SA2. By capturing where the population of an SA2 live, we have more effectively estimated the distance between the population of two SA2s.

Once we established our population weighted centroids, we removed flows that were in excess of 300km. This removed Lord Howe Island and two of the three Other Territories: the Territory of Christmas Island and the Territory of Cocos (Keeling) Islands. In addition we removed the third of the Other Territories, Jervis Bay Territory.

In using the Flowmap software to run the Intramax procedure, there is a requirement that all areas in the calculation be interactive. Interactivity is defined as an SA2 requiring 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. There were 25 SA2s with no flows and 11 SA2s with only an intrazonal flow. In addition there were 38 SA2s that had inflows but no outflows and two SA2s with outflows but no inflows.

Consideration was given to how best we treat the states and territories throughout Australia. There were many cross-border commutes between New South Wales and Queensland, New South Wales and the Australian Capital Territory, New South Wales and Victoria, and Victoria and South Australia. Hence we treated these five states/territories as one area on which we would run our Intramax procedure. Hence we ran the Intramax procedure on four separate large areas: East Coast/South Australia, Western Australia, Tasmania, Northern Territory.

4. Results

The maps that are shown on the mapping tool are the aggregated regions that result after running the Intramax algorithm for each of the four large areas of Australia. For all four areas we stopped the Intramax procedure around the mark where 75% of all flows were intrazonal.

The number of regions produced by the Intramax procedure is listed in Table 2 with a comparison to the different regions the ABS uses. As can be seen across the five states/territories of the East Coast plus South Australia, we defined 79 CFERs with 5 non-interactive SA2s. For Western Australia, there were 18 CFERs with 4 SCLMs; 12 CFERs for Tasmania and 14 CFERs for the Northern Territory with 2 SCLMs. The comparatively larger number of regions in the states that were treated as individual areas reflects the existence of smaller labour markets in these sparse areas.

The SA2s that only had inflows or outflows were added to regions with which they had the most interaction after the process completed. The SA2s that were removed because they were non-interactive are shown in Table 2 in parentheses. We call these Self Contained Labour Markets. Further, the SA2s with no inflows or outflows we term Nonsense SA2s and are not included in Tables 2 or 3. When using the CFER data the user must decide how to use these extra areas. It is thought the Nonsense SA2s would not add anything to an analysis, while the

[1] We find the Moment Centroid of the CDs (Deakin *et al.*, 2002) using the ArcGIS software from ESRI

Self Contained Labour Markets are indeed labour markets themselves and may make a valuable contribution.

Table 2 Regions for various aggregations ASGS 2011

	NSW	Vic	QLD	SA	ACT	WA	Tas	NT	Aus*
States/Territories	1	1	1	1	1	1	1	1	8
Greater Capital City Statistical Area	2	2	2	2	1	2	2	2	15
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			79 (5)			18 (4)	12	14 (2)	123 (11)

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

Of particular interest in is the comparison between the number of CFERs and the regions at which the Labour Force Survey results are disseminated. Previously, under the ASGC, this was Labour Force Regions (LFRs), while since the introduction of the ASGS, this is now SA4s. As can be seen in Table 2, there are many more CFERs than there are SA4s, due in part to the constraints the ABS place on their regions as well as the nature of the SA4s. SA4s must be large enough to accommodate the ABS sample sizes for surveys without giving results with standard errors that are too large to make the data meaningful. Hence, particularly in rural areas, SA4s are quite large and represent areas much too large to be considered a labour market. In addition, these regions must adhere to capital city and state/territory boundaries, which in many cases prevents existing labour market areas as being part of the same region; for example along the Murray River where there are labour markets that are comprised of areas in NSW and Victoria.

5. Specialised Functional Economic Regions

One of the criticisms of delineating regions based on economic behaviour is that all commuting behaviour is considered, irrespective of the individual characteristics of the workers (Morrison, 2005). The argument is that there is an assumption that labour is homogeneous, where in reality there is a need to recognise a differentiated labour force. Indeed, many studies will benefit from a discrete set of local labour market delineations based on different behavioural assumptions. To this end we have delineated additional functional economic regions based on gender, occupation type and mode of transport.

5.1 Gender-based CFERs

The commuting behaviour of males and females presents a contrast where males generally commute longer distances to work than do females. This would then translate into labour markets for males covering a larger area than for females, which is indeed the case when comparing the Male CFERs to the Female CFERs. The Male CFERs consist of fewer regions than the Female CFERs reflecting this differentiation in commuting behaviour.

5.2 Occupation-based CFERs

Green and Owen (1998) note that low-skilled workers are less spatially mobile (through both migration and commuting) and require spatially proximate jobs, with the alternative being likely unemployment. The spatial reach of local labour markets for high skill workers is broader than it is for low-skill workers. Our occupational-based CFERs more closely fit the actual behavioural boundaries linking labour supply and demand for each of the occupational sub-groups, and thus permit more robust statistical analysis of issues arising, which require an occupational focus.

The occupation-based CFERs utilise the Australian and New Zealand Standard Classification of Occupations (ANZSCO), which divides workers into eight occupational groups. We have grouped these into three, being skilled workers, less skilled workers and tradespersons. The skilled group comprises of the ANZSCO groups Managers and Professionals. The less skilled group is comprised of Community and Personal Service Workers, Clerical and Administrative Workers, Sales Workers, Machinery Operators and Drivers and Labourers. Finally, the Technicians and Trades Workers group make up their own group due to the transient nature of their day-to-day workplaces

5.3 Mode of Commuting CFERs

These regions are experimental in nature, with their aim being to help researchers interested in the impact of transport infrastructure (new roads, rail lines, cycle paths etc) on labour market and related social outcomes.

We define four different functional regions based on mode of commuting. The Rail CFERs use the commuting flows of those who commute by train, the Road CFERs use the commuting flows of those who commute by a form of road vehicle, these include by car as a driver, car as a passenger, bus, motorbike, taxi, tram and truck. The Bicycle CFERs employs the commuting flows of workers who commute by bicycle. Our final group is those who use more than one of the above-mentioned modes of commuting or one of the above combined with another mode classified as “Other”.

6. Data Conventions

Table 3 lists the number of regions corresponding to each of the CFER aggregations. We began by removing the Other Territories and Lord Howe Island, which left us with 2192 SA2s across Australia. The tables show the number of regions broken down across the four large areas. The first number in parentheses is the number of SA2s that are non-interactive, which we call Self-Contained Labour Markets. The second number in the parentheses is the number of SA2s that have no flows at all for that particular gender, occupation class or mode of commuting.

As can be seen from the tables some of the aggregations have many Self Contained Labour Markets and also many SA2s with no flows. This reflects the type of commuting flow that is being used. In the case of the Bicycle CFERs for example, there are naturally many non-interactive regions as generally the distance someone would ride a bike would be less than using a motorised vehicle. Hence, it is quite likely that bike riders do not leave their SA2 of origin. In addition the Bicycle CFERs also have many SA2s with no flows, reflecting the lack of popularity of using a bike to commute to work in those areas.

The Rail CFERs only exist in and around the capital cities of Sydney, Melbourne, Brisbane, Adelaide and Perth. In some cases the CFERs do extend outside the ABS defined area of the capital cities, however, in general there were very few respondents 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 CFERs.

Table 3 Regions for the CFER aggregations 2011

	EC + SA	WA	TAS	NT	Australia
Original	79 (5,15)	18 (4,6)	12 (0,3)	14 (2,1)	123 (11,25)
Male	72 (7,18)	16 (4,6)	12 (0,3)	16 (3,2)	116 (14,29)
Female	95 (9,21)	19 (4,6)	12 (1,3)	15 (3,3)	141 (17,33)
Skilled	65 (7,23)	16 (4,10)	12 (1,3)	15 (3,4)	108 (15,40)
Less Skilled	95 (11,16)	20 (4,6)	13 (0,3)	16 (2,2)	144 (17,27)
Trades	95 (12,28)	19 (4,6)	13 (1,3)	13 (5,4)	140 (22,41)
Rail*	13	4	N/A	N/A	17
Road	87 (6,16)	17 (4,5)	11 (1,3)	14 (2,2)	129 (13,26)
Bicycle	131 (316,185)	18 (53,28)	8 (21,27)	5 (14,11)	162 (404,251)
Multiple	70 (68,52)	21 (18,13)	12 (7,5)	5 (14,6)	108 (107,76)

Source: authors' calculations
* Only SA2s that had sufficient rail commuting were included in any analysis

For each aggregation we followed the same naming conventions for the CFERs. Each unique area has an area name, whether it is a CFER, a Self Contained Labour Market or an SA2 without any flows. For those that were classified as CFERs their name attempts to explain where they are placed in Australia and the extent of the CFER. If a CFER crossed a state 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. Self Contained Labour Markets also took on the name of their SA2, as did those without flows.

Each area also has a corresponding area code, which are four-digits in length and convey information about the region. The first digit indicates the state/territory of the CFER, or the majority of the CFER. The second digit indicates the type of region it is. A 1 indicates the region is an interactive CFER, formed through the Intramax procedure. A 2 indicates the region is a single SA2 that only has an intrazonal flow (i.e. a SCLM). A 3 indicates the region is an SA2 that had no commuting flows and as such was excluded from the analysis (a Nonsense SA2). The final two digits then start at 01 for the region incorporating the capital city CBD, and increase as the regions fan out.

The SA2s that were not part of interactive Rail CFERs were once again combined and 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.

7. Conclusion

In exploring the best way to delineate regional labour markets such that the resulting geography has inherent economic meaning we have developed spatial demarcations (termed functional economic regions) based on a hierarchical aggregation technique known as Intramax. This technique is applied to Journey to Work data, which explicitly captures the economic interactions of firms and workers across space. The technique delivers very interesting results.

It establishes a new geography representing the space over which supply (workers) and demand (firms) are seeking to interact as shown by the maximisation of commuting flows. It also helps us to better understand the ways in which the regions are linked.

The Intramax technique emphasises labour force flows and optimises basic spatial unit groupings based on higher than expected interactions between neighbouring areas (regions), and appears to provide a much closer approximation of a local labour market. Mapping the functional regions provides an informative critique of the current labour force area designations. These functional regions generally collapse metropolitan and split non-metropolitan labour force regions (with the splits often centred around major regional towns).

These regions are presented as an alternative to the ABS SA4s. They are presented for policy makers and practitioners who are interested particularly in regional economics, to use as a basis for the demarcation of their data.

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