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THE DELINEATION OF 21ST CENTURY LOCAL LABOUR MARKET AREAS: A CRITICAL REVIEW AND A RESEARCH AGENDA

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ABSTRACT

The paper reviews international scientific research on the delineation of local labour market areas (LLMAs) used in a range of contrasting countries for administrative and statistical purposes. The concept of LLMA is discussed, emphasising the spatial 'clustering' of interaction between labour supply and demand. The paper develops a taxonomy of methods and suggests that identifying best practice has so far been held back by a lack of clear criteria for objectively evaluating different methods. The paper then outlines a research agenda for further development of LLMA delineation methods, including the suggestion of more cross-national research.

Keywords: local labour market areas, functional areas, regionalisation, commuting, travel-to-work.

RESUMEN

En el artículo se revisan los procedimientos utilizados en diversos países para la delimitación de mercados locales de trabajo (MLTs) con fines administrativos y estadísticos. Tras discutir el concepto de MLT como ámbito en el que se concentra la interacción entre oferta y demanda de trabajo, se desarrolla una clasificación de métodos y se sugiere que la identificación de buenas prácticas en este campo se ha visto lastrada por la ausencia de

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criterios claros que permitan la evaluación objetiva de los diversos métodos. En el artículo se esbozan algunas de las prioridades de la investigación sobre MLTs, entre las que destaca la necesidad de potenciar la investigación transnacional.

Palabras clave: mercados locales de trabajo, áreas funcionales, regionalización, movilidad residencia-trabajo, movilidad obligada.

I. THE CHALLENGE OF DEFINING LLMAS

This paper addresses the theoretical and empirical issues involved in giving a territorial dimension to the abstract concept of the labour market. Once the labour market is defined with the same norms that apply to any market definition — that is, the area where the demand and the supply for a certain good or service (labour in this case) meet to fix the price and quantity of the exchange of the commodity — it is clear that national markets are fragmented into different regional or local labour markets. Administrative boundaries do not very frequently fit the functional reality of these (sub-) regional labour market areas. Even in those cases where social or economic factors informed the original delineation of administrative units, these boundaries usually remain unchanged for decades and so become unrelated to fast-changing functional realities[1]. Moreover most administrative boundaries are the product of tradition and topography, their diversity of size and their characteristics making them unsuitable as units for labour market statistics and policymaking.

Numerous alternative approaches to the definition of local labour market areas (LLMAs) have been developed by a wide range of researchers in recent decades. A sample of the earlier definitions can illustrate the principles which underlie most LLMA definitions. The first systematic attempt to define LLMAs was in the USA in the 1940s, with the primary objective to identify areas «in which workers can change their jobs without changing their residences» by the *War Manpower Commission*[2]. This is still the logical basis for the delineation of labour market areas in the USA by the US Department of Labor (2003) – who refer to «an economically integrated geographic area within which individuals can reside and find employment within a reasonable distance or can readily change employment without changing their place of residence» – and also by Tolbert and Sizer (1987) who defined the «market area as a locale that encompasses both the place of residence and place of work of a

1 These aggregate changes are the result of complex and sometimes contradictory forces, that can be exemplified in patterns of commuting, a variable that is crucial when dealing with the *functional* relationships between places: Whilst there is a general tendency towards more diffused and distended journeys to work, commuting distances remain short for some groups such as the growing numbers of part-time workers, alongside the potentially important new work patterns created by telecommuting (although this is sometimes associated with people making one or two long distance journeys most weeks). These complex working arrangements are often found among dual career households, one aspect of a growing divergence between 'work rich' and 'work poor' household (where the latter category includes people who rely on low paid, perhaps temporary and often part-time work).

2 Quoted in Smart (1974).

local population»[3]. Wilcock and Sobel (1958)[4] stated that «the place in which jobs are sought and job decisions are made and the local market area, in terms of ability to commute to and from jobs, are one and the same». Bunting (1962)[5] proposed the delineation of boundaries «around the smallest possible areas which simultaneously (a) put most of the potential labour supply of the enclosed firms within the same boundaries as those firms, and (b) include most of the firms that the enclosed workers think of as excellent substitutes within the same boundaries as those workers». Finally, Goodman (1970) identifies these two essential requirements when delineating local labour market areas in practice: (a) the boundary of the area is rarely crossed in daily journeys to work – what he calls *external perfection* – and (b) a high degree of intra-market movement exists so that the defined market is internally active and so as unified as possible. These two key concerns provide the basis for much of the following research.

Three decades ago Smart (1974) stated that «there have been surprisingly few attempts to produce a systematic definition of areas by which the main relationships between homes and workplaces could be indicated, and a common framework of reference established for the study of planning and labour market issues». The first part of that sentence now scarcely reflects reality, because the delineation of LLMAs became much less infrequent towards the end of the last century, at least in industrialised countries. The OECD (2002) reported a survey of the practice of Member States in defining LLMAs: only five of the twenty two responding countries did not define labour market areas. Yet there remains a lack of consensus among practitioners and academics about best practice, and not even agreement on how to evaluate different methods.

The delineation of LLMAs in practice has to be based on data reflecting the matching of labour supply and demand in an area. No country has suitable data on the *preferences* of people, or employers, so it is not possible to examine *potential* behaviour in the labour market (eg. as job search). The available data only covers successfully matched labour supply and demand, and in practice data on commuting flows takes centre stage in this field of research (Goodman, 1970; Smart, 1974). Unfortunately this leaves out of the analyses substantial groups, most especially unemployed workers. Commuting datasets have been systematically used since the 1950s when they served as the basis for the delineation of the first metropolitan areas in the USA: they have remained a constant in this form of regionalisation exercise, even though its central concern is not strictly with the labour market (Arbuckle, 1998). These datasets' availability and guaranteed periodicity (at least every ten years in most countries), and the centrality of labour relationships to social and economic life, has continued to foster the use of commuting datasets in many regionalisations, as if these flows can be taken as indicative of many other local linkages (Coombes *et al*. 1982).

3 As pointed out by ISTAT (1997) such definitions involve the capability of a territory for containing within its boundaries both economic production (concentration of jobs) and social reproduction (concentration of residences).

4 Wilcock, R.C., Sobel, I. (1958): *Small City Job Markets: The Labor Market Behavior of Firms and Workers*. Urbana, IL, Institute of Labor and Industrial Relations, University of Illinois, quoted in Tolbert and Sizer (1987).

5 Bunting, R.L. (1962): *Employer Orientation in Local Labour Markets*. Chapel Hall, University of Carolina Press, quoted in Goodman (1970).

This focus of labour market area definitions on physical flows may seem old-fashioned in a world where flows of information have become the distinct feature of new social and economic relationships. In practice, despite the predictions that new means of communication would allow many jobs to be done without the need for people to travel to a traditional type of workplace, there has been a sustained rise in commuting distances throughout Europe, with *teleworking* much less common than was expected a decade ago. As pointed out by Arbuckle (1998:70534) «the spatial patterns of commuting are more complex today than in previous decades, but no less important».

As well as the emphasis on commuting patterns, LLMA definitions frequently impose a measure of minimum size (expressed in terms of absolute population, employed resident population or number of jobs). The size criterion has often been introduced to improve the suitability of the areas for reporting statistical information – because more volatile trends are likely with small populations – or for planning and policy making.

The development of systematic procedures for the delineation of local labour market areas has been stimulated by the need for coherent and comparable territorial units for collecting and publishing labour statistics in several countries. Once defined, local labour market areas have been used for many different purposes in both public administration and academic research. One clear example of this sequence of developments was provided by the UK from the middle of the last century, leading to the definition of Travel-to-Work Areas (TTWAs) for the calculation of local unemployment rates; the Department of Trade and Industry then used TTWAs as building blocks for the construction of Assisted Area maps, and they were later used for the identification of EU Objective 2 regions. LLMAs have also been the official unit for identification of areas benefiting from national or/and EU support policies in Finland, France, Germany and Italy (OECD, 2002)[6]. This use fits the observation of Coombes and Openshaw (1982) that «realistic LLMAs definitions [are needed] so that the assistance to industry in any area is likely to benefit the unemployed of that area and not provide jobs that are largely filled by residents of neighbouring TTWAs with lower unemployment rates». The Australian *Bureau of Transport and Regional Economics* delineated a set of LLMAs for the analysis of regional industrial structure. The aim was that *for each labour market region, the majority of employed resident work in the same region in which they live, and so employment by industry data provides a reasonable guide to the industry structure of the region's economy*. (BTRE, 2003). In Italy LLMAs are the geography for the identification of *distretti industriali* (Sforzi, 1987 and 1995; ISTAT, 1997; ISTAT, 2005b). In Denmark they were deemed a relevant geography to the debate on the reorganisation of local government (Andersen, 2000): the rationale was that commuters into cities should contribute to the financial resources for those cities, and this requires that the boundaries of municipalities represent functional areas (thus ensuring that few people commute across these wider city boundaries). In academic research, studies such as the Papps and Newell (2002) work on New Zealand emphasise the use of LLMAs for the analysis of migration.

In addition, LLMAs have a possible *normative* usage as a tool for planning. Taking the functional reality displayed in the boundaries as a starting point, new objectives can be

6 Tolbert and Sizer (1996) and Coombes (2002) provide further evidence of the use of LLMAs in the US and UK respectively.

established to, for example, mitigate congestion problems or the personal and social costs associated with very long journeys to work. Examples of this use of LLMAs can be found implicitly or explicitly in the territorial and strategic plans of certain European and American cities and regions[7].

Yet for all the increasing ubiquity of LLMAs, their empirical delineation faces a series of challenges (as noted, for example, by Schubert *et al*. 1987). Above all, there is no consensus on best practice among definition methods. One reason for the wide range of methods is the considerable variation between different periods and places in available commuting data. This issue sets the context for the rest of this paper.

II. OVERVIEW OF METHODS

The definition of LLMAs is a form of *functional regionalisation* because it is a grouping of areas with respect to the interaction between them (Spence and Taylor, 1970). With interaction datasets scarce in almost all countries, most functional regionalisations use commuting patterns and so are forms of LLMA delimitation. This leads to the first task here which is to identify the basis for an evaluation of alternative approaches to LLMA definition.

1. Principles for LLMA definitions

Table 1 is taken from Eurostat and Coombes (1992), where nine principles which LLMA definitions should meet were established. The two over-riding objectives which establish what makes a set of LLMA boundaries fit for purpose is that they should be the product of a rigorous method of definition and, as a result, reflect the reality[8] of labour market geography. It should be recognised that, in practice, analyses to delimit LLMAs usually observe a tenth principle «Detail» viz. that the number of separable LLMAs should be maximised. Thus if there are two sets of LLMA definitions, the set with more LLMAs *which all conform to the other pre-defined criteria* is usually preferred.

As is inevitable with as many as ten different guiding principles, there is room for much debate over the extent to which any one principle should over-ride another, or to which one can be 'traded-off' against the other. Table 1 does indicate that there are 5 criteria — together with the general need for Detail and Flexibility — which are a lower priority than the primary objectives and constraints. As a result, this paper's assessment of different approaches to LLMA definition tends to focus attention on the first four principles (together with the preference for the maximum Detail possible).

There are many methods of numerical taxonomy (Sokal and Sneath 1963) which might potentially be used to, for example, group together areas where the workforce has similar

7 Some references can be found in Cervero (1995) and Van der Laan and Schalke (2001). A recent example of this use is METREX (2010), where promoting intra-metropolitan polycentrism is seen as a tool to keep urban settlements more efficient and sustainable helping to combat urban sprawl and fostering labour divisions between centres.

8 The emphasis on the reality of existing labour market behaviour means that this paper does not consider *normative* forms of LLMA definition, such as the partitioning of a territory in such a way as to ensure no-one need travel more than 40 kms to reach an employment centre.

Table 1
PRINCIPLES TO GUIDE LOCAL LABOUR MARKET AREA DEFINITIONS

Principle	Practice
OBJECTIVES 1. Purpose 2. Relevance	 to be statistically-defined areas appropriate for policy each area to be an identifiable labour market
CONSTRAINTS 3. Partition 4. Contiguity	 every building block to be allocated to 1 and only 1 area each LLMA to be a single contiguous territory
CRITERIA *in descending priority* 5. Autonomy 6. Homogeneity	 self-containment of flows to be maximised LLMAs' size range to be minimised (eg. within fixed limits)
7. Coherence	boundaries to be reasonably recognisable
8. Conformity	alignment with administrative boundaries is preferable
SUMMARY 9. Flexibility	 method must perform well in very different regions

characteristics. Methods of non-functional regionalisation include the graph theoretic method of Nystuen and Dacey (1961), most forms of «redistricting» (eg. Horn, 1995) and variants of location-allocation analysis (eg. Lolonis and Armstrong, 1993), plus the automatic zoning program of Openshaw and Rao (1995). A key challenge to these methods' applicability for defining LLMAs is the requirement for Contiguity (Table 1). For example, cluster analyses have rarely, if ever, included an explicit contiguity constraint. The fact that contiguity has to be imposed as an additional constraint shows that contiguous groupings must be *sub-optimal* with respect to the primary criteria for selecting the strongest link, otherwise they would emerge without that constraint. To illustrate: the city centre of Manchester is likely to be more similar to the centres of other cities than it is to the other parts of its own city, hence a contiguity constraint is required to ensure that the city centre is grouped with its own suburbs because a cluster analysis alone may not consider that the optimal grouping.

A more general point here is that any method which uses an explicit contiguity constraint faces several disadvantages. Contiguity constraints' influence on the results of the analysis includes being shaped by the effects of «irregular base areas» (Spence and Taylor, 1970:30). There are very often rather bizarre boundaries among the base areas for which commuting data can be obtained, and these boundaries will restrict the area groupings at every step of an analysis constrained by contiguity. Such a constraint does vastly speed up analysis by restricting to a handful the number of options considered for grouping, but this is no longer important because modern computers allow vast numbers of permutations to be evaluated

quickly. Hence there is no reason now to impose a contiguity constraint throughout the analysis when this will inevitably produce sub-optimal boundary definitions.

In fact one crucial advantage of commuting data as the basis for definitions of LLMAs is that the 'friction of distance' which restricts people's patterns of movement causes most of the strongest interactions to be between nearby areas. The consequence is that contiguous groupings of areas are *inherently* more likely to be produced from the analysis of interaction data than they are from analysing other types of data. Analyses can thus avoid using an explicit contiguity constraint – and so avoid sub-optimal results they produce – whilst still generating LLMA boundaries in which almost all areas meet the administrative requirement of Contiguity (Table 1).

2. Typologies of LLMA definition

Several past studies have examined different approaches to LLMA definitions, developing classifications within which particular methods can be grouped. Most notably, Van der Laan and Schalke (2001) developed a multi-level taxonomy. The highest level of their classification distinguished between methods allowing for heterogeneity among LLMAs, as against those which assume homogeneity. In their accompanying discussion, Van der Laan and Schalke made it clear that the value of a heterogeneous set of LLMAs in more fully reflecting the complexity of modern commuting patterns effectively requires the identification of *over-lapping* LLMAs: this would be in direct contradiction to the principle of Partition (Table 1) which demands that each part of the territory should be in one, and only one, of the defined LLMAs. As a result, attention here turns to the further break-down by Van der Laan and Schalke (2001) of the homogenous category into ***deductive*** and ***inductive*** approaches to LLMA definition. In practice, deductive methods begin by identifying urban centres around which the LLMAs are constructed, whilst inductive methods do not have such a pre-conceived structure to their definitions.

The distinction between the deductive and inductive approaches highlights many of the key issues in LLMA definition. With its requirement that every LLMA has a significantly sized urban centre to which surrounding areas' residents travel for work, the deductive approach is readily understood by non-experts and is also reflecting the long-established pattern of rural-to-urban commuting. Yet this imposes a geographical model which has been undermined by the growth of polynuclear urban systems and the decentralisation of employment, and which already struggled to find a place for remoter rural areas, as shown by many versions of the inductive approach simply excluding more remote areas from their results (e.g. Cheshire and Gornostaeva, 2002). The inductive approach, not surprisingly, has the converse strengths and weaknesses: it is able to adapt flexibly to the different commuting patterns in different times and places, but this same flexibility means that it does not have a simple form which is easily recognisable. That said, it builds upon a more sophisticated conception of LLMAs as clusters of commuter flows within a wider 'space of flows' (cf. Castells, 1989). Even so, the intuitive appeal of the deductive approach's urban-centred structure tends to have only been outweighed when and where its mono-centric model can no longer provide adequate LLMA definitions due to increasingly complex and diffused commuting patterns. Thus it is this increasing 'real world' complexity of commuting patterns

which has shifted research interest away from the deductive methods' rigid mono-centric model towards the inductive methods' greater flexibility.

Just as the complexity of commuting patterns has increased in recent decades, so the capacity for analysing this complexity grew through rapid advances in computer functionality. As in other social science fields, new opportunities for computerisation led to new challenges to earlier methods rooted in traditional disciplinary approaches. In the case of regionalisation, and in the USA more specifically, one very well-established approach to LLMA definitions has continued in use while at the same time many new alternatives were being developed with antecedents in such disciplines as information science. The established approach can be summarised as applying a series of definitional rules, each of which had been separately devised to help reveal the patterns which the labour market analyst expected to predominate among the commuting flows. The most familiar of these ***rules-based*** methods, in its latest form, defines the Metropolitan Statistical Areas in the USA (Spotila, 1999). The alternative approach replaces this series of different rules with a one single rule which is applied over and over again within a ***hierarchical*** method which builds up the LLMAs iteratively. Hierarchical methods tend to be rooted in abstract principles of statistics or quantitative methods, rather than empirical research on the spatial structure of labour market geography, or on cities and their hinterlands.

The really crucial distinction between hierarchical and rules-based methods is that hierarchical methods use the same 'rule' from start to finish, whereas the rules-based methods use different rules at different stages of the process. A procedure is *hierarchical* because the process builds up so that finally all the areas satisfy the single rule which determines when the procedure stops. Hierarchical methods developed rapidly in the 1970s as computerised matrices began to be available (e.g. Slater and Winchester 1978), although Smart (1974) led the way with an algorithm which was in fact applied manually. The hierarchical methods' grouping of areas step-by-step progressively raises the areas' statistical characteristics (e.g. the population size of the smallest remaining region). As a result, these methods allow the objectives for the analysis to be set in terms of *either* the required number of regions *or* the statistical properties which the defined regions must possess. It is the latter option which is relevant here due to the principle of Detail viz. the preference for identifying as many LLMAs as possible which all meet the specified objectives. For rules-based approaches, the number of regions is not known at the start of the analysis.

Hierarchical procedures tend to provide sub-optimal results at larger scales, because the area groupings made at the early stages of the analysis severely restrict the options available at the later stages. For example, a grouping of European countries might be expected to link Luxembourg with Belgium and then with the Netherlands in its early stages; in a hierarchical procedure, these early groupings would then prevent the later stages creating what may be the optimal broader groupings in which, for example, the Netherlands could be linked with other northern countries which speak Germanic languages, whilst Belgium and Luxembourg were grouped with France and other more southern countries. The most appropriate set of results at one scale of resolution often prioritise one sub-set of the data, whilst a different scale calls for a focus on a different sub-set of the data. Thus hierarchical methods tend to be sub-optimal because early groupings of areas remain preserved throughout the rest of the procedure — and thus shape all the

subsequent groupings — when the criteria on which they were based are unlikely to be very relevant at the broader scale of analysis.

The early rules-based methods were also hierarchical, because they proceeded sequentially and so their early groupings were preserved in the later results. Frey and Speare (1995) recognised that more recent European analyses had advance beyond existing practice in the USA by devising rules-based methods which 'escape' from being hierarchical through procedures which liberate later groupings from the constraint of keeping intact all the groupings produced by earlier stages of the analysis. For example, Coombes *et al*. (1986) developed the earlier CURDS Functional Regionalisation rules-based method's re-allocation procedure into the form of self-optimisation which is central to the method which defines TTWAs.

3. Illustration of the typology

The discussion here has identified two critical distinctions in the typology of methods to define LLMAs:

- between inductive and deductive approaches, and
- between rules-based and hierarchical methods.

It is possible to combine these two distinctions into four categories (Table 2). There are methods of defining LLMAs which fall into each of the four categories which shows that, for example, adopting a deductive approach does not automatically mean using a rules-based method.

Table 2
ILLUSTRATION OF THE FOUR-WAY TYPOLOGY

	Examples of analyses in situations *without* commuting flow data	
	Inductive approach	**Deductive approach**
Rules-based method	Bus service hinterlands (Green, 1950)	Road network accessibility analysis (eg. Hugo, 2001)
Hierarchical method	'Waste-less commuting' (Coombes 2004)	'Gravity' models (eg. Glover and Openshaw, 1995)

One way to illustrate this point is to briefly review ways in which LLMAs can be identified in cases where *no* flow data at all is available. How could there then be evidence of the patterns of linkages which should be represented in the form of LLMA boundaries? There are, in fact, a number of analysis techniques which can estimate patterns of linkages given other, admittedly indirectly relevant, information. A fairly simple yet plausible example can be outlined by estimating the pattern of commuting where no flow data is available *but* the distribution of both jobs and employed residents is known. For some time now, spatial interaction models have been able to estimate the pattern of flows which may link where the workforce live with where the jobs are located: for example, Glover and Openshaw (1995) provide a web-based version of the well-established gravity models, whilst a simpler option

— which also assumes there is no «wasteful commuting» (Small and Song, 1992) – has been illustrated by Coombes (2004). A different form of modelling is needed if the data available is limited to the resident population together with evidence (eg. from maps) of transport infrastructure or services. Some types of network – whether fixed networks like roads or service networks like bus services – may be useful as a 'proxy' for data on actual patterns of interaction. Hugo (2001) uses road networks to measure the relative ease with which more rural areas can access urban centres. Green (1950) analysed bus service information to identify urban centers and sketch their hinterlands: this approach may still be highly relevant in those countries where public transport continues to dominate mobility patterns and where Census information does not include information on the pattern of commuting.

4. Specific examples of LLMA delineation methods

Although academic debates are of some relevance, there is less interest here in very sophisticated procedures which do not have clear value for administrative or policy purposes. Table 3 summarises the methods used by a selection of countries' public bodies to define LLMAs or metropolitan areas.

Metropolitan areas do not correspond exactly to LLMAs, because their aim to identify the extent of the influence of large towns and cities means that metropolitan area definitions usually leave some areas unallocated and so they do not meet the administrative need for LLMA definitions to achieve a complete Partition (Table1). Even so, in the USA and Canada it is the metropolitan area which is the most frequently used definition of the labour market of more urbanised areas, notably after the 1971 Census, when hinterlands started to be seen as labour market constructs (Puderer, 2008): 'a metropolitan area contains both the supply and the demand components that determine factor incomes, and it possesses a high degree of labor mobility within its boundaries'[9].

Table 3 summarises some of the main features of the latest US metropolitan area definitions (Spotila, 2000)[10], and it is noteworthy that there is no criterion which sets a minimum degree of closure. Bearing in mind that they are not in fact designed to be LLMAs, it is not really surprising that the metropolitan area definitions' interaction measures and conditions are quite unlike those of the other methods considered here (Table 3). In a similar way to the majority of European countries, LLMAs are defined in the USA so as to exhaust the national territory (in fact the set of definitions by the US Department of Labor has a history that goes back to 1950). The boundaries delineated by the *Bureau of Labor Statistics' Division of Local Area Unemployment Statistics* are formed by *small labor market areas* in nonmetropolitan zones (U.S. Department of Labor, 2003 and 2011) and depend entirely upon the analysis of commuting flows. This approach yields a heterogeneous national map of LLMAs – because of the different process followed in metropolitan areas – and this inconsistency has been increased with the recent changes to the metropolitan area definitions

9 Hirsch (1978): «Predicting Earnings Distributions Across Cities: The Human Capital Model Versus National Distribution Hypothesis». *Journal of Human Resources* 13, 366-384 (quoted in Tolbert, 1989).

10 The latest update until the data from the new census of population are available is OMB (2009), and was conducted using Census 2000 data and Census Bureau population estimates for 2007 and 2008. Variations of these procedures have been adapted to other countries like Spain (Feria, 2008).

in which the criterion based on commuting flows has been raised from 15 to 25 per cent (Spotila, 2000).

Examples of hierarchical and inductive methods on the two sides of the Atlantic are *commuting zones* (CZs) in the USA and the French *zones d'emploi*. The delineation of Commuting Zones was developed under the auspices of the Economic Research Service, U.S. Department of Agriculture to solve the 'urban bias' that characterises other US regionalisation exercises, like that of the *Bureau of Economic Analysis*[11] or the map of metropolitan areas that treats all counties outside a metropolitan/micropolitan area as one large residual area (Sizer and Tolbert, 1993). Commuting Zones were first defined with 1980 data (Tolbert and Sizer, 1987) and the exercise was replicated with the 1990 (Tolbert and Sizer, 1996) and 2000 (US Department of Agriculture, 2004) Census of Population using a hierarchical algorithm that groups counties with strong commuting ties, and without imposing a population minimum until later in the process[12]. To measure the relevance of specific commuting flows, the original non-symmetrical origin-destination matrices were transformed using the expression in Table 3. The method used in France[13] (INSEE, 1998) shares some characteristics with that of CZs. An employment zone is a geographical space defined with the stated aim of producing an area within with the bulk of its workforce lives and works. The procedure groups communes to reach a minimum of 25,000 working residents (a threshold which is not always respected). One of the differences between the methods is the function used to measure the relative strength of commuting flows (Table 3). In contrast with the metropolitan area procedure, the CZ regionalisation aims to reduce urban bias *since the two-way flow treats the relationship between counties as one of reciprocity rather than dependence* (Sizer and Tolbert, 1993). This aim is further supported by the choice of the denominator in the interaction measure: the authors concluded after empirical testing[14] that using the size of the labour force in the smaller area under consideration avoided excessive dominance of large counties in the analysis.

One characteristic of hierarchical approaches such as those just reviewed is that they rely less on the numerous, and arguably arbitrary, thresholds which typify rules-based methods. This does not mean however that no arbitrary decisions are substantially embedded in these procedures. A clear example of this is the need to choose critical values in the decision rules that guide the iterative process (e.g. the between-cluster distance in the American case, and minimum size in the French one).

One of the more widely applied methods for the delineation of LLMAs has been that of Coombes *et al*. (1986). It was used for the delineation of TTWAs in the UK based on 1981 and 1991 (see ONS and Coombes, 1998) Census of Population, served as inspiration for

11 See Johnson and Kort (2004) for a summary of the latest definition of BEA *economic areas*.

12 CZs were then aggregated into Labor Market Areas (LMAs) with resident population over 100,000 in the delineations based on 1980 and 1990 Census of Population.

13 *Zones d'emploi* have been defined there in 1983-1984 and 1993-1994 using the same procedure after they were first delineated in 1970: INSEE (1970): *Les zones de peuplement industriel et urbain. Délimitation 1968. Evolutions démographiques, 1962-68 et 1954-1962*. Paris. INSEE (quoted in O'Connor, 1980).

14 The use of (a) the size of the larger county or (b) the addition of both areas' resident labour forces was found to reproduce the central place model of social and economic counties whose avoidance was searched for with this exercise.

Table 3
EXAMPLES OF OFFICIALLY DELINEATED LOCAL LABOUR MARKET AREAS[a]

Method and name of area	**Country** **Comments**	**A priori identification of (potential) centres**	**Type**	**Rule for consideration of relationships between areas/regions (if *rules-based*)** **Rule for transformation of matrices (if *hierarchical*)**	**Self-containment / minimum size/ contiguity constraints**
Core Based Statistical Areas (CBSAs), Office of Management and Budget (OMB)	USA Method aimed at the delineation of metropolitan areas (not urban labour markets). CBSAs are however an input for the delineation of US Department of Labor LMAs.	County/ies associated with Urbanised area ≥50,000 inhabitants (metropolitan statistical areas) or Urban cluster ≥ 10,000 inhabitants (micropolitan statistical areas) (Also considerations on continuous residential developments and population density)	Rules-based	To assign outlying counties (i) to central county/ies (j): (a) $\left(\frac{T_{ji}}{\sum_{k=1}^{n} T_{jk}}\right) \geq 0{,}25$ or (b) $\left(\frac{T_{ij}}{\sum_{k=1}^{n} T_{kj}}\right) \geq 0{,}25$ Adjacent CBSAs merge if their central county/ies meet (a) or (b) *Employment interchange measure* to guide potential combinations of adjacent CBSAs into Combined Statistical Areas (≥25%: automatic; between 15 and 25%: depends on local opinion): $\left(\frac{T_{ji}}{\sum_{k=1}^{n} T_{jk}}\right) \times 100 + \left(\frac{T_{ij}}{\sum_{k=1}^{n} T_{kj}}\right) \times 100$	No testing of final level of self-containment Contiguity is a rigid constraint in every step (an outlying county will not fall within a CBSA if it is not contiguous with other counties in the CBSA) Counties that do not fall within CBSAs represent «Outside Core Based Statistical Areas».
Labor Market Areas (LMAs), US Department of Labor	USA LMAs consist on two sets of areas: *CBSAs* and *small LMAs* in no metropolitan zones		Rules-based*	*CBSAs:* taken from the procedure above Small LMAs: counties outside CBSAs are combined if they meet (a) or (b) above.	No testing of final level of self-containment Contiguity introduced ex-post: single-county non-contiguous parts of a small LMAs are considered as separate small LMAs

Commuting Zones and *Labor Market Areas*, US Department of Agriculture	USA		Hierarchical	$\frac{T_{ij}+T_{ji}}{\min(LF_i, LF_j)}$ value set to 0 for cells in the main diagonal; merging of zones prevented when a normalized average distance between zones of 0.98 is reached.	No testing of final level of self-containment other than that indirectly included in the decision rule. No indication of contiguity constraints. Minimum size: CZs aggregated into LMAs with number of inhabitants ≥ 100,000 based on the single strongest commuting relationship when possible (when it was not the case other criteria among which topographic considerations apply). Not done after Census 2000
Zones d'emploi, Ministère du Travail - INSEE	France		Hierarchical	Two alternative measures: $\frac{T_{ij}}{\sum_k T_{ik}}$ and $\frac{T_{ij}+T_{ji}}{\sum_k T_{ik}}$	Minimum size of 25,000 workforce (threshold not always respected)
Sistemi locali del lavoro, Italian National Institute of Statistics, *ISTAT*	Italy Method very similar to the TTWAs one (Census 1991). Most relevant differences are reported here.	Areas are ranked in two lists according to: $\left(\frac{T_{ii}}{\sum_{k=1}^{n} T_{ik}}\right)$ and $\left(\frac{\sum_{k=1}^{n} T_{ki} - T_{ii}}{\sum_{k=1}^{n} T_{ik} - T_{ii}}\right)$ Inductive selection of foci strongly relaxed in successive steps	Rules-based	$D = \frac{T_{ij}^2}{\sum_{i\neq k} T_{ik} \times \sum_{j\neq k} T_{kj}} + \frac{T_{ji}^2}{\sum_{j\neq k} T_{jk} \times \sum_{i\neq k} T_{ki}}$ Potential merging considered only if : $\left(\frac{T_{ji}}{\sum_{k=1}^{n} T_{jk}}\right) \geq 0{,}10$ and $\left(\frac{T_{ij}}{\sum_{k=1}^{n} T_{ik}}\right) \geq 0{,}01$ and D>0.002	Minimum self-containment: 0.75; minimum size: 1,000 jobs; provisional zones are repeatedly ranked during the process according to function C: $C = \min\left[\frac{\min(\frac{T_{ii}}{\sum_k T_{ik}}, \frac{T_{ii}}{\sum_k T_{ki}})}{0.75}, 1\right] \times \min\left[\frac{\sum_k T_{ki}}{1{,}000}, 1\right]$ No trade off considered No contiguity constraints; manual adjustment in the last stage (provided statistical criteria are respected)

[a] T_{ij} is the number of commuters from area i to area j. LF_i is labour force in area i.

Table 3
EXAMPLES OF OFFICIALLY DELINEATED LOCAL LABOUR MARKET AREAS (CONTINUED)

Travel-to-Work Areas, UK Department of Labour (Census 1991)	UK Function A measures linkage and function B accomplishment of self-containment and size minima.	Areas are ranked in two lists according to: $\left(\frac{T_{ii}}{\sum_{k=1}^{n} T_{ik}}\right)$ and $\left(\frac{\sum_{k=1}^{n} T_{ki}}{\sum_{k=1}^{n} T_{ik}}\right)$ Top 20% in both lists are considered as potential centres Potential centres are combined if a close linkage exists (combined centres considered as a single one)	Rules-based	$A = \frac{T_{ij}^{\,2}}{\sum_{k=1}^{n} T_{ik} \times \sum_{k=1}^{n} T_{kj}} + \frac{T_{ji}^{\,2}}{\sum_{k=1}^{n} T_{jk} \times \sum_{K=1}^{n} T_{ki}}$ Potential merging considered only if $\left(\frac{T_{ji}}{\sum_{k=1}^{n} T_{jk}}\right) \geq 0{,}10$ and $\left(\frac{T_{ij}}{\sum_{k=1}^{n} T_{ik}}\right) \geq 0{,}01$ and A>0.002	$B = \min\left[1; \frac{c1 \times \sum_{k=1}^{n} T_{ik}}{\alpha}; \frac{\left(c2 \times \sum_{k=1}^{n} T_{ik}\right) + c3}{\alpha}\right] \times \min\left[1; \frac{T_{ij}}{\max\left(\sum_{k=1}^{n} T_{ij}; \sum_{k=1}^{n} T_{jk}\right) \times \beta}\right]$ Where α is target size (20,000 active) and β is target self-containment (0.75). An arch-shaped trade-off between both requisites is allowed (minimum size is in fact 3,500 for areas reaching target self-containment, and minimum self-containment is 70% for areas reaching target size) A value of 0.625 later increased to 0.9267 is needed to be considered as a viable grouping. No contiguity constraints; manual adjustment in the last stage (provided statistical criteria are respected)
Travel-to-Work Areas, UK Department of Labour (Census 2001)	UK Function A measures linkage and function B accomplishment of statistical requirements (self-containment and size minima).		Rules-based	$A = \frac{T_i^{\,2}}{\sum_{k=1}^{n} T_{ik} \times \sum_{k=1}^{n} T_{kj}} + \frac{T_j^{\,2}}{\sum_{k=1}^{n} T_{jk} \times \sum_{K=1}^{n} T_{ki}}$	Statistical requisites' target levels are 25,000 and 75% respectively. A new function (X) substitutes B; it allows a linear trade-off between both requisites (minimum level of size and self-containment). Therefore minimum size is in fact 3,500 for areas reaching target self-containment, and minimum self-containment is 66.67% for areas reaching target size. Proto-TTWAs are ranked according to X; if the lowest-ranked meets the requirements the process stops; if not it is dissolved and its components are assigned according to function A.

the official Italian procedure[15] (ISTAT-IRPET, 1989; ISTAT, 1997; ISTAT, 2005a) and has also been applied in New Zealand (Papps and Newell, 2002; Newell and Perry, 2005) and Australia (Watts, 2004), and with minor modifications[16] in Spain[17] (Casado-Díaz, 2000). The method is a clear example of the rules-based category of methods described before. The complex set of steps constituting this method is summarised in table 3. The procedure creates TTWAs whose *supply-side self-containment* (the percentage of an area's employed residents who also work there) and *demand-side self-containment* (the percentage of jobs in the area filled by residents in that zone) pass a threshold which is fixed in advance. It is a key feature, compared to most other methods, of the TTWA procedure that it explicitly defines these characteristics which each LLMA must have in order to be deemed a 'separate' region. These characteristics are not the only parameters that need to be fixed at the beginning of the process. The procedure includes numerous thresholds at different stages of a process of gradual integration[18] and, because the parameter values were set during an analysis of British 1981 data, they are unlikely to be ideal for the many other applications of the method. One reason why the method is still found to be useful, despite these parameters, is that each of the steps in the process only makes a small contribution to the final result. For example, one step allows multinodal regions to emerge, but this is found not to be relevant in many areas. One particularly innovative feature was the inclusion of a trade-off between critical self-containment and size levels, so as to allow more populous areas to score lower in self-containment and vice versa.[19] In contrast to the methods used to identify CZs and *zones d'emploi*, the TTWAs procedure is not rigidly hierarchical, in that two areas which are grouped together at an early stage may then later be disassembled and grouped into separate areas. The method has proved that even in very diverse territories, the grouping procedure should not be constrained by contiguity but guided by the integration function A (see table 3).

15 There are a number of differences between the TTWA method and the Italian one (although these are not of direct relevance to the concerns of this paper).

16 These were in fact a simplification of the model where the arch-shape trade off between self-containment and size was substituted by a spline function based on a strictly linear relationship between the two extremes. Similarly to the Italian case function B was substituted by function C (see table 3) with the aim of ranking the diverse areas in several parts of the process.

17 Where also a method very close to that of Smart (1974) was previously used for the delineation of LLMAs in the regions (*comunidades autónomas*) of Catalonia (Castañer et al., 1995; Clusa and Rodríguez-Bachiller, 1995) and Valencia (Salom et al., 1997). Roca and Moix (2005) proposed using the interaction measure in Coombes et al. (1986) to weight the commuting flows between pairs of areas and then apply an inductive hierarchical procedure in a similar fashion to that of the US *Commuting Zones* or French *Zones d'Emploi* in Catalonia. Other references can be found in Módenes (2007). Duque (2004) proposed a substantially different approach based on the identification of homogeneous units. More recently Salom and Casado-Díaz (2007) and Susino et al. (2007) used 1991 and 2001 Census data to analise the evolution of LLMAs in the Spanish regions of Valencia and Andalusia respectively using the method proposed by Coombes et al. (1986), a variation of which (which included commuting time) was applied by Alonso et al. (2008) to define the map of LLMAs in Aragón. Royuela et al. (2009) used commuting data and quality of life indicators to define functional areas in Catalonia. Godenau and Arteaga (2003) and Barrios et al. (2009) applied a substantially different method but equally based on commuting flows for the delineation of LLMAs in the Canary Islands based on 2001 Census data. Finally, this database was also used by Casado-Díaz et al. (2010) to identify the Spanish LLMAs through the new TTWAs' procedure of delineation (Coombes and ONS, 2008). The same authors proposed (and tested using 2001 Census Spanish commuting data) a method based on genetic algorithms fitted for the delineation of LLMAs and other functional areas (Flórez et al., 2008 and 2009).

18 See column 5 in table 3.

19 See column 6 in table 3.

In fact only 0.5% of basic territorial units were eventually attached to non-adjacent TTWAs in the British case (Coombes *et al*., 1986), a number very closely matched in the Italian case (ISTAT-IRPET, 1989) and similar to the 0.9% for the New Zealand analyses by Papps and Newell (2002).

The 2007 definition of TTWAs based on 2001 Census data (Coombes and Bond, 2008)[20] included a major simplification of the method so that, in effect, it was simply the repeated iteration of the last step of the previous multiple step procedure (nb. the initial steps of the earlier method had owed their existence to the need to limit the computational burden of the procedure). The 'self-optimising' potential of the method is retained by allowing initial groupings of areas to be modified in the subsequent iterations, allowing the method to avoid the determinism that characterises hierarchical procedures. It is thus a multi-step procedure in principle, even though it depends on a single process which is repeated a vast number of times.

As stated before, table 3 is far from being exhaustive. Among others, Sweden, Denmark, the Netherlands, and Australia are countries where commuting flows have also been used for the delineation of LLMAs[21]. The Swedish method (Carlsson *et al*., 1993; SCB, 2010) is a deductive one in which *local centres* are identified as municipalities whose supply-side self-containment exceeds 80% and whose single largest flow of commuters to a specific municipality accounts for less than 7.5% of working residents. Successive steps add other municipalities to those centres to form labour markets according to their largest flow in relative terms. Polynodal regions are considered through the allowance of *dual local centres* where these are strongly linked. Statistics Denmark has applied the Swedish method for the delineation of LMAs in that country, although this is not the only official map of functional areas based on commuting data[22]. Deductive approaches have frequently been seen to be more restrictive than inductive ones (especially in highly integrated urban systems). The use of specific rules allowing the formation of combined nodes as is the case of the Swedish example lessens the relevance of this concern, although this is effect is likely to be more than compensated by the use of the single largest commuting flow as the guiding principle for the assignation of remaining areas to nodes (a practice this review has found to be frequent). This use clearly imposes a bias toward large centres whilst paying less attention to secondary

20 In Casado-Díaz et al. (2010) this procedure is tested in the Spanish case using data from Census of Population 2001, and several alternative measures of the goodness of the regionalisation are proposed. An automatic procedure to solve the potential absence of contiguity in a part of the resulting LLMAs is also specified and tested in that work. In Persyn and Torfs (2010) the procedure is applied to the Belgian case.

21 Commuting flows were also central in the delineation of *Economic Regions* in Norway (Statistics Norway, 2001), but the process was also informed by sales data, number of inhabitants, newspaper areas, the pattern of internal migration and *local knowledge*. In the German case labour market regions (LMR) are defined following a deductive procedure in which not only functional but also other conditions related to distance and accessibility are included (Coombes and Eurostat, 1992; OECD, 2002). Although reviewing them is out of the scope of this paper, among recent academic definition of LLMAs/functional areas of different nature in diverse countries stand: Karlsson and Olsson (2006); Reggiani et al (2010) and Eckey et al. (2006) in Germany; Flórez et al. (2008 and 2009) in Spain; Casado-Izquierdo (2007) in Mexico; Prodromídis (2008) in Greece; Halás et al. (2010) in Czech Republic, and Drobne et al. (2010) in Slovenia.

22 Also the Danish Ministry of Environment and Energy defined in 1994 a map of 46 *Commuter Catchment Basins* built around centres *i* accomplishing the following condition: $T_{ii} > 2 \times (\Sigma T_{ij} + \Sigma T_{ji'})$ (OECD, 2002).

flows that considered more comprehensively could allow the identification of additional distinct LLMAs in favour of the principle of *Detail* stated before.

In the Netherlands, 1971 commuting data provided the basis for 40 official LLMAs — *COROP* — and these have not been substantially revised since (Vliegen, 2003). Several proposals have been made recently to update these classifications using other data sources: for example, the multi-step procedure proposed by Van der Laan and Schalke (2001) was an inductive method that allows the formation of *polynodal urban regions*. In this procedure all the criteria are expressed in terms of relative rather than absolute numbers, this making it more transferable according to the authors –the specific values for these relative thresholds remaining as arbitrary themselves as they are in the rest of the methods listed here. This concern about the arbitrary selection of parameters seems to have inspired another examples in that country, that of Hensen and Cörvers (2003) and, more recently, Cörvers et al. (2009), who applied hierarchical Ward's method to a matrix of commuting flows transformed into a MFPT matrix.

This review concludes with another Australian example: the Bureau of Transport and Regional Economics has defined *labour market regions*, based on commuting patterns revealed by the 2001 census (BTRE, 2003). A typical labour market region embraces the capital city statistical division, plus any adjoining statistical local area (SLA) whose supply-side self-containment falls under 70 per cent. Where there were a number of similarly sized towns in close proximity and commuting patterns were multi-directional, a broader labour market region was defined. This procedure is rare in that it does not consider the *direction* of the flows but the mere contiguity between 'open' areas and administrative centres; this could severely undermine the 'functional' character of the resulting map of areas (which may be one reason why the authors describe it as a *first attempt at developing a set of labour market regions*).

What conclusions can be extracted from this review regarding the principles listed in Table 1? In terms of principle 1, *Purpose*, all the methods collected here are defined through basically systematic procedures based on statistical data, notably commuting conditions. All produce areas which, rather unsurprisingly, are deemed appropriate for policy and so to constitute 'true' labour markets (principle 2), although the qualitative nature of this principle makes any testing extremely difficult. This becomes a central issue, since the assessment of how 'optimal' the resulting boundaries are heavily relies on local knowledge, not easily challenged by external scrutiny and subject to a high degree of subjectivity due to the complex nature of the phenomena analysed. Principles 3 and 4 are also respected by all the methods, although *contiguity* constraints are introduced in different ways. Thus they may limit every step of the process (as in the delineation of metropolitan areas in the USA) or they may be introduced *ex post* as part of the process of final calibration (e.g. by considering them as self-standing independent LMAs, as with US Department of Labor LMAs). The principle of *partition* is nevertheless only relevant for metropolitan areas definitions in relation to the avoidance of overlapping zones, because this type of area does not aim to exhaustively cover the territory, something that is central in the rest of methods reviewed here. Principle 5, *Autonomy*, is faced in different ways in the procedures described here. Some of them (e.g. TTWAs, *mercati locali del lavoro*, and to a lesser extent BEA *economic areas*) make it central in the procedure in a very explicit way: thus no LLMAs is accepted

if self-containment (defined both in terms of economically active resident population and places of work in the British and Italian case, and only from the supply side in the American example) does not reach a certain level. It must however be stated that the maximisation of overall closure is not an objective in any of these cases. Other exercises (e.g. *CZs*, *zones d'emploi*, and Swedish labour market areas) consider that by linking areas according to their different specific measures of commuting flows is sufficient to achieve the stated aim of identifying *autonomous* labour market areas. Although this is indeed a likely output of the process, it is not assured by the procedure itself (i.e. these algorithms do not guarantee that a certain level of self-containment is reached by *all* resulting regions).

Concerning principle 6, *Homogeneity*, many of the methods include a minimum size, which puts a lower limit to heterogeneity. Upper limits are very rare. Yet this principle no doubt contributed to the empirical feedback in the process of fixing specific values for the parameters in the various steps of the methods, despite it not being formally included. The same applies to *Coherence* (principle 7), which has not been explicitly highlighted in any of the methods reviewed here. Regarding principle 8, *alignment with administrative boundaries*, most methods rank the functional criteria higher and, as a result, upper tier administrative boundaries are frequently crossed by LLMAs (thus CZs in the USA and labour market regions in Australia cross state borders), although some like the *zones d'emploi* do respect regional boundaries. In almost all cases, basic local administrative areas (municipalities, *communi*, counties and similar) are the building blocks of the process. (An exception is the 2001-based st of TTWAs which were constructed from over 40,000 purely statistical areas.) Finally in terms of *Flexibility* (principle 9), all methods presented here have been applied to a diversity of regions *within* one country. In fact the difficulty of creating a single procedure able to perform well in different zones of the country is a common concern in most of them. It is notable that the TTWA method has also been applied in different countries with results that have been reported to be reasonable, despite expectations of a lack of 'transferability' between countries.

III. SOME KEY ISSUES IN THE DELINEATION OF LLMAs

The preceding selective review of LLMAs definition methods raises certain recurring issues. One central question in the debate about LLMAs is the measurement of the relative performance of the alternative methods. From section 2 it is clear that a wide diversity of methods exists, and the selection of variables and parameters used in the different algorithms is arbitrary to a greater or lesser extent. There is not a single *natural* procedure for the delineation of LLMAs, and there are not *natural* or equilibrium levels for the parameters (notably self-containment and size minimum levels). This section of the paper examines a broad selection of methods, prior to any systematic attempt to identify best practice in LLMA definitions.

There still needs to be systematic study of the 'performance' of different methods, evaluating their results against the sort of criteria listed in Table 1. However comparing the methods is especially complex when cross-country analyses are carried out. Some additional steps, such as the comparison between the selected map of LLMAs and other sets of functional areas defined by the use of different variables, as well as the comparison with

administrative sets of areas of similar average size, can be considered to test the coherence of the procedure for academic and administrative purposes. Regarding this issue ISTAT-IRPET (1989) proposed carrying out a number of regionalisation exercises through different procedures so as to identify the existence of regularities in the way LLMAs emerge and thus being able to assess which method performs better in identifying such regularities. Moreover the *ex post* use of a specific map of LLMAs by researchers and policy makers, and the successful replication of the procedures in different territories, could add evidence in favour of a method. Finally, a recurrent proposal is to carry out a sensitivity analysis of the volatility of the boundaries defined when small changes are introduced in the parameters involved in the procedure of regionalisation, a practice that has been recently demonstrated by Papps and Newell (2002) who document this part of their exercise in a very detailed manner.

As pointed out in section 1 the two essential requirements when delineating local labour market areas in practice are, according to Goodman (1970) *external perfection* and a high degree of intra-market movement. In terms of self-sufficiency, the optimality of the areas produced by different methods could be assessed by analysis of supply and demand-side self-containment as well asthe balance between working residents and located jobs, using the *job ratio* (Coombes *et al*., 1986) or its variation the *home-work ratio* (Van der Laan and Schalke, 2001). These are, however, of little use when the procedure itself aims to define self-contained areas and only those meeting this requisite are considered as an acceptable output of the algorithm. In the last step of the algorithm by Coombes *et al*., (1986) the sum of the values for function B in the diverse TTWAs is proposed as the objective function in a heuristic that was not finally used. A simplified version for this function is the one used in Italy, were the trade-off between size and self-containment is not considered (table 3).

The second condition proposed by Goodman (and implicitly or explicitly incorporated in almost all the methods) is that of a high level of interaction among the diverse constituent units within the labour markets. Table 1 includes this condition by implication, because its principle of Relevance sets the objective of identifying genuine labour markets and, as has been stated at the outset, the concept of a local labour market emphasises the need for a high degree of internal interaction. A kind of a trade-off relationship exists within the definition of a local labour market, because of «the danger of seeking external perfection at the expense of losing the essentially *local* character of the market must be guarded against» (Goodman, 1970). As self-containment increases due to the aggregation of areas, integration is likely to decrease in most cases, leading to the possible emergence of sub-markets (whose boundaries are frequently more permeable than those of the main market but do identify some clusters of commuting flows). The two last columns in Table 3 provide a number of functions that measure the interaction between pairs of areas. These indexes are part of the respective process of delineation, but could also be used to measure to what extent desirable integration occurs within the areas produced. Hence they could collectively assess the relative performance of one method versus others (or the relative performance of some of the technical parameters in any one process).

An alternative way for contrasting the goodness of the map of LLMAs proposed is the analysis of the association within LLMAs between the local units of which they are composed. Barkley *et al*. (1995), for example, compute the statistics known as *Moran's I coefficient* (a measure of spatial autocorrelation in a sample), $G_i(d)$ *statistic* (which provides

a measure of the concentration of a spatially distributed attribute variable) and *Anselin's local Moran statistic (I_i)*. Their analyses are carried out on a number of functional areas defined to be self-contained using data for the states of Georgia, North Carolina and South Carolina; economic association is analysed in terms of both population and per capita income change. This kind of exercise may however not be so relevant here because this paper's focus is on LLMAs which are not defined to be internally homogeneous but instead by reference to the intensity of flows within them.

IV. LLMA DEFINITIONS FOR THE 21ST CENTURY: A RESEARCH AGENDA

The fundamental basis for LLMA definitions is the pattern of commuting and this is a form of mobility. There can be little doubt that in the twenty-first century, and in modern western economies in particular, there is a very strong tendency for personal mobility to increase as a result of many different factors. These include rising average earnings and increased car use, which enables more diffused and distended commuting patterns and could result in the integration of previously separate local areas. To give just one example, the main towns of upper Saxony were each once highly distinct labour pools, but now they are seen as an emerging polycentric region (METREX 2010).

Labour supply responds and, in certain cases, can shape the pattern of labour demand. The increasing diversity of commuting patterns poses a considerable challenge to methods for delimiting LLMAs which were devised to represent the traditional pattern of largely discrete local areas, most of which were identifiable as the 'catchment area' of a single urban centre.

Recalling the 4-way typology of LLMA definition methods in section II, the evidence on changing patterns of commuting makes the rigid urban-centred basis of the deductive approach a much less plausible option. There are less clear lessons for the choice between a rules-based or hierarchical form of definition; here the research challenge might be to improve the efficacy of hierarchical methods so that they retain their greater simplicity whilst coming closer to matching the rules-based methods' arguably greater level of success in representing the peculiar detail of LLMAs in different times and places. One acutely difficult challenge for this sort of methodological development would be to seek a form of LLMA definition which produces acceptable results when applied consistently to many different countries' commuting datasets.

Section I of this paper has shown that the concept of local labour markets implies spatially 'clustered' interaction between labour supply and demand. There are two key issues that define a LLMA. One is what has been called *external perfection*, i.e. a relatively high level of self-containment of the area in terms of commuting flows. The second is internal integration, i.e. exchanges must be frequent among the diverse components of a LLMA; in particular, no basic unit should be relatively isolated within one LLMA. Of course some additional requirements, such as minimum size, internal contiguity and absence of overlapping among the areas, can be considered necessary in statistical or policy-making environments. That said, these additional constraints should not be introduced in ways which make them so influential that the LLMAs could lose the functional coherence which is their single most significant characteristic.

There is an emerging need for establishing systematic criteria allowing comparison among methods which are very different in nature but, at least at the level of stated guidelines, have similar goals. It may be very well the case that no one of these can be considered to be the best in all respects, but it is necessary to have an idea of the relative advantages of each of the procedures. Table 3 displays some integration indicators as an example. They have been extracted from the methods reviewed and are at the same time a proof of the diversity of the methods and a promising field for comparative analyses. These tools would then allow comparison (a) among methods, and (b) within methods, where different thresholds are used for various variables and parameters. Other evaluation procedures offered by spatial econometrics may also be of value here.

To conclude, it must be stated that this is a research agenda where international comparative exercises can be very fruitful. Some decades ago the main interest for a national administration was in creating a set of comparable areas suitable for the purposes of producing statistics and/or providing a basis for the country's public policies. At that time, methods able to deal with one country's different territorial specificities were all that were needed. However, European integration — and, in broader terms, globalisation of the economy and society — have led to the need for functionally coherent areas which are comparable *between* countries. Of course these exercises should be, so far as possible, based on comparable 'building blocks'. The challenge for regionalisation methods is now to deal with realities that not only vary nationally but also, and probably more significantly, internationally. This issue has practical consequences, such as the development of regional policies funded by national and international institutions like the OECD and the European Union (and for the latter it is even more acute after the accession of new member states). These genuine practical implications further increase the challenge to methods of LLMA delineation, a challenge which is already posed by the substantial changes to the patterns of urbanisation and location of economic activity, and to the evolving composition of the labour force. These challenges can only benefit from comparative international research.

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