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**Developments in the relationship between large cities - the suburban zone and the rural/urban hinterland. Analysis of commute patterns around large European and American cities.**

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**Abstract**

Many countries collect data on commuting that allows the analysis of how commuting develops over time - and - through the availability of origin-destination data.- also the analysis of functional interdependencies between sub-areas and the patterning of interaction more generally. In the case of the US, O-D data on commuting has been used to delimit metropolitan areas for statistical purposes for more than 50 years - based on the interdependencies between suburbs and a central city that is revealed by the commute pattern. Despite the debates on the multifaceted nature of functional interdependency between areas - and despite the rising importance of other transport purposes than commuting - commute data continues to be widely used as the prime indicator of functional integration between areas: The lack of other suitable geographically representative O-D data is probably the most important reason for this. The commute question is relatively simple and unambiguous and can therefore easily be included in a census - or the information can be extracted from public registers as in the Scandinavian countries. In recent years, commute data has become available with more geographical details (small zones) and the ability to treat this data in new ways has been greatly improved through the availability of geographical information systems (GIS).

This paper aims to take advantage of the availability of comparable data on commuting in European urban regions and to take a broader look at the developments in the relationship between the urban core, its suburban areas and the rural/urban hinterland. The analysis uses data on commuting between small geographical zones to perform the analysis as "realistically" as possible. The paper combines a GIS-based approach (with maps of commuter-flows) and inventories highlighting the relationship between centrality, directionality and commute-distances.

## **1. Background**

The increasing availability of spatial data from Europe and the US - as well as the improved ability to handle and in a spatial context to analyse disaggregate data-sets opens new possibilities for the research in interaction systems as well as urban systems more generally (Horner, 2004). The Danish register-based commute statistics was used in the recently completed project *Town, Road and Landscape* to map and analyse the developments in commuting over time in Denmark. The (almost) full count of origins and destinations for the working population's home and work addresses and the availability of time-series provided an opportunity to analyse the spatial distribution of commuting and development trends over a 20-year period as well. As the origin-destination statistics from the British census 2001 recently became available, free of charge, the authors were encouraged to

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<sup>1</sup> The research was initiated when the author was employed at Aalborg University, Dept. of Development and Planning

engage in international comparisons of commute-patterns and metropolitan development. Thus, British as well as US data and a more limited Spanish data-set for the region of Catalüna - has been analysed as part of the research presented in this paper.

Commute data, and especially commute data for the development over time, is especially well suited to assess the consequences of the changing urban form, such as de-concentration and sub-centring. An interesting aspect is here the combined effect of de-concentration and extended commuting or developments towards the formation of urban fields. For instance, an evaluation of the effect of sub-centring on commute-distances should take the ongoing outward expanding influence of the largest urban areas into consideration. This type of inquiry will be dependent on "borderless" OD-data over time, such as the commute statistics, in order to allow analysis of the changing sphere of influence of cities.

There is also a special case for cross-national comparisons of how commuting develops over time. Most studies of for instance how urban form affects commuting are carried out as cross sectional studies within a national context. This means that it is difficult to reveal the importance of the conditions that is common to all today – but which may change in the future. Examples would be travel costs and regulations and norms related to the labour market. Despite the difficulties that are associated with the controlling of relevant factors across national contexts, cross country and cross city comparisons are important to gain knowledge of the impact of changing urban forms on commuting. Comparisons between countries and cities with respect to transportation has been conducted on a number of occasions (see for instance: Cameron et. al., 2004; Giuliano and Narayan, 2003; Newman and Kenworthy, 1999) often, however, is it carried out at the most aggregate level ("one city one number"). It is suggested that more detailed and sensitive comparisons between countries and cities within these countries could be a highly valuable tool for strategic reflection on the long-term impacts of urban structure on commute patterns and the significance of differences in other structural factors that affects the commute pattern.

Studies of commuting offers insight into the functional interdependencies irrespective of administrative borders and, hence, a proper perspective for responding to the future demands and problems of urban-regional development. Further, commuting studies offer important inputs to long-term policies on urban form and transport systems revealing information about the sensitivity of the commuters response to changing contextual and structural factors and inputs for planning within a shorter time-horizon where trends in commuting may change the need for transport services or the like.

This paper analyses the expanding scale of functional integration with GIS-based mapping of commuter flows in Denmark, England and Wales and selected parts of the US and Spain. This is followed by analysis of the relationship between centrality and commuting in selected urban regions. The paper focuses on the commute data and the methodology and indicators used, mappings of the development in commuting in England and Wales, the development trend in commute distances - and finally, a comparison of urban areas in Denmark, England and US are presented as a number of "city profiles" that focus on the relationship between centrality and commuting in 2001. Especially, this last section should be seen as a first step towards a comparative case study that should focus on the developments in urban form and commuting over time in cities in different countries.

## 2. Data and methodology

The main data source used in this paper is the commute statistics from Denmark, England and Wales, the US and the region of Catalūna in Spain containing information on place of residence as well as place of work – for either the entire working population or a sample hereof.

### English data

The analysis draws on the origin-destination statistics and special workplace statistics released from census 1991 and census 2001. In the census principally all households and household members are surveyed in their home. The survey includes the question: “What is the address of the place where you work in your *main* job?” (National statistics, 2001, p. 8). Together with the home address this allows for creation of the origin-destination datasets to be created (including information on the number of persons that work from home). The way origins and destinations are registered changed for students in employment from 1991 to 2002 (Office for National statistics et. al., 2001). What is more a matter of concern for the comparability of commute patterns over time is for one thing the use of a 10% sample to construct the 1991 OD data – and the changes in survey methodology that was introduced from 1991 to 2001. The changes took place to increase the reliability of the census, but was not very successful in doing so (see: Boyle and Dorling, 2004; Simpson, 2003) and the consequences on the reliability of commute data is unknown. Thus comparisons between 1991 and 2001 commute data must be done cautiously. For the purpose of analysis, a dyadic origin-destination matrice (Berry, 1968; Marble et. al., 1997), with number of commuters in 1991 and 2001, has been generated based on wards (though the data is also available for the very small output areas in 2001).

### Danish data

The analysis draws on Statistics Denmark’s commuter statistics (workforce statistics) where home and place of work is registered for the employed population at the end of each year (in 2002: 2, 6 mill.). The database has been kept since 1981 and therefore allows analysis of some 20 years of change in commute patterns. The handling of the data has developed over time especially with respect to the identification of workplaces for the individual employees. However in the latest ten year period no changes with a likely significant impact on the proper detection of origins and destinations have occurred. For persons with more than one job, all jobs are registered in the statistics and sorted on the basis of the relative contribution to total income (in November). The primary occupation is the one that contributed the most. For the purpose of analysis a dyadic origin-destination matrice, with number of commuters from homes to primary occupations, in 1992 and 2002, has been generated based on parishes. Denmark is divided into parishes that today only have minor administrative responsibilities but are used as a geostatistical unit below the municipalities.

### US data

The analysis of commuting in the US is based on the registration of commutes to work in Census 1990 and 2000. From both censuses a “special tabulation” containing data on census tract of work by census tract of residence is available (Census 1990, STP154, and Census 2000, STP 64). Origins and destinations are identified based on the 67.000 census tracts (62.000 in 1990). The census tracts within metropolitan areas are a geographically fine grained unit of analysis well suited for the purpose of this research. The data contains information on 127 Mill. commutes using 6,7 Mill. different combinations of OD census tract pairs (117 Mill. commutes and 5,2 Mill. combinations in 1990).

## **Spanish data**

The analysis of commuting in Spain is limited to a subset of the Spanish commuter survey covering commuting within Catal una where the city of Barcelona is located. A matrix of commuting between Catal nas 946 municipalities in 2001 and 1996 has been the basis of the analysis. The Spanish data contained information on 2,6 Mill. commutes in 2001 distributed on 44.000 different combinations of origin and destination municipalities (1,8 Mill. commutes in 1996).

There are of course methodological differences between the datasets. Most are survey based but the Danish statistic rely on public registers. Survey methodologies and job definitions differs somewhat. Comparisons should therefore be done cautiously and focus on development trends and patterns within the case areas.

## **Mapping functional integration**

Limited by the availability of data most studies of urban patterns and systems has relied on urban morphology and data on population or jobs within statistical zones. Analysis of functional integration focuses on the interactions between zones as a measure of functional dependence and inclusion into a functional urban area. As an important part of the analysis, maps of commuter-flows in selected regions have been drawn. In this case, commuter-flow is understood as a characteristic of a given area and is derived from the number of commuters passing through, originating or ending in a given area unit (for a similar conception see: Matthiessen and Andersson, 1993). Maps of commuter-flows in Denmark and England and Wales have previously been presented by the authors (Nielsen and Hovgesen, 2005; Nielsen et. al. 2005).

The flow maps were created in ArcGis/ArcView through a number of steps. First, the origin-destination data were represented as desire lines. Second, the desire lines were intersected with a superimposed 5x5 km grid. Third and last, the flows were summarised for each individual grid-cell. The result is a series of maps using colour codes to show the differences and growth in commuter-flows in 1991 and 2001. Thus, the maps visualises the state and development of functional integration in its geographical context. The result can be compared to the delimitation of commuter-regions (see for example Berry 1968; Nielsen, 2001; Andersen, 2002). The main difference is that the flow-maps identify functional regions by the intensities of flows whereas the commuter-regions identify functional areas by discrete boundaries.

## **City profiles**

Two main indicators are used to analyse the changes in commute patterns around 7 selected large European and American cities. The first indicator is the directionality of commuting. The second indicator is the commute distances. The analysis focuses the relationship between distances to the centre of the urban areas and the two indicators. The indicators reveal the changing importance of location vis- -vis the urban area in shaping the commute pattern – and thus the changing sphere of influence of urban areas (Nielsen and Hovgesen, 2005).

A measure of directionality vis- -vis the centre has been used in a number of studies (see: Christopher et. al., 1995; Vandersmissen et. al., 2003; Van der Laan, 1998). The commute-directionality indicator reflects the dominance of the core of the urban area but it is also likely to reflect the range of the city’s labour market. If the broad interpretation of the monocentric model is taken for granted (see for instance Anas et.al. 1998) the assumption would be that workplaces generally are more centrally located than residences and that commuting is generally oriented towards the centre. Therefore, the movement over distance from one labour market sphere towards another should leave an imprint on commuting directionality. Rain’s (1999) concept of directionality - where the average commute direction is represented as a vector - could be seen as an attempt to rely on such an “imprint” to delimit functional regions. In this paper, commute-

directionality is plotted as a function of distance to the centre of the urban area (equals the historical core or the CBD). Commute-directionality is measured as the proportion of the resident employed population that commutes more than 5 km closer to – or further away from – the centre than their place of residence.

The second indicator is the commute-distance and its correlation with the distance to the centre. From the literature on transportation and land use it should be expected that the commute-distance for the resident population in a given area will rise with increasing distance to the centre of an urban area and then level off and possibly fall as the interaction with the urban area decreases and the areas of residence become more independent (see for instance Næss, 2005; Næss and Johannsen, 2003; Christensen, 2001).

Commute-distance as well as the directionality of commuting is calculated from the origin-destination datasets on the basis of airline distances between zone centroids. The main reason for using airline distances is the lack of access to adequate road networks for all the case study areas. As a point of departure, all commutes included in the databases are included in the calculations of directionality and commute-distances. Thus, whether the actual travel between home and workplace is undertaken daily, weekly or at some other frequency is not taken into account. A comparison between US and European cases does, however, pose a problem in this respect. The European statistics stops at the national boundary, since commuting across national borders are not included in the data. This is of course also the case with the US data but the size of the country implies that the American data contains commutes that would/could never be registered in a European statistic. To avoid the “noise” associated with the extreme commutes between mainland US, Alaska, Hawaii, Virgin islands etc. it was decided only to include commuter relations less than 1000 km.

### **3. Commuter-flows**

The commuter-flows in the six “case regions”: Denmark, England and Wales, the north-eastern seaboard of the US, California and Nevada, the south eastern US, as well as the region of Catalüna in Spain are mapped in figure 1- 4. The number of commuters starting, ending or passing through each 5x5 km cell is summarised based on the censuses and shown as standard deviations above the mean each year (calculated on the basis of the cells that had any flow in 2000/2001/2002). The means and standard deviations have been used as the basis for the cut off values on the maps in order to reduce the problems associated with variations in census methodologies over time. Status quo, followed by the development in commuter-flow over the preceding decade is shown for each region.

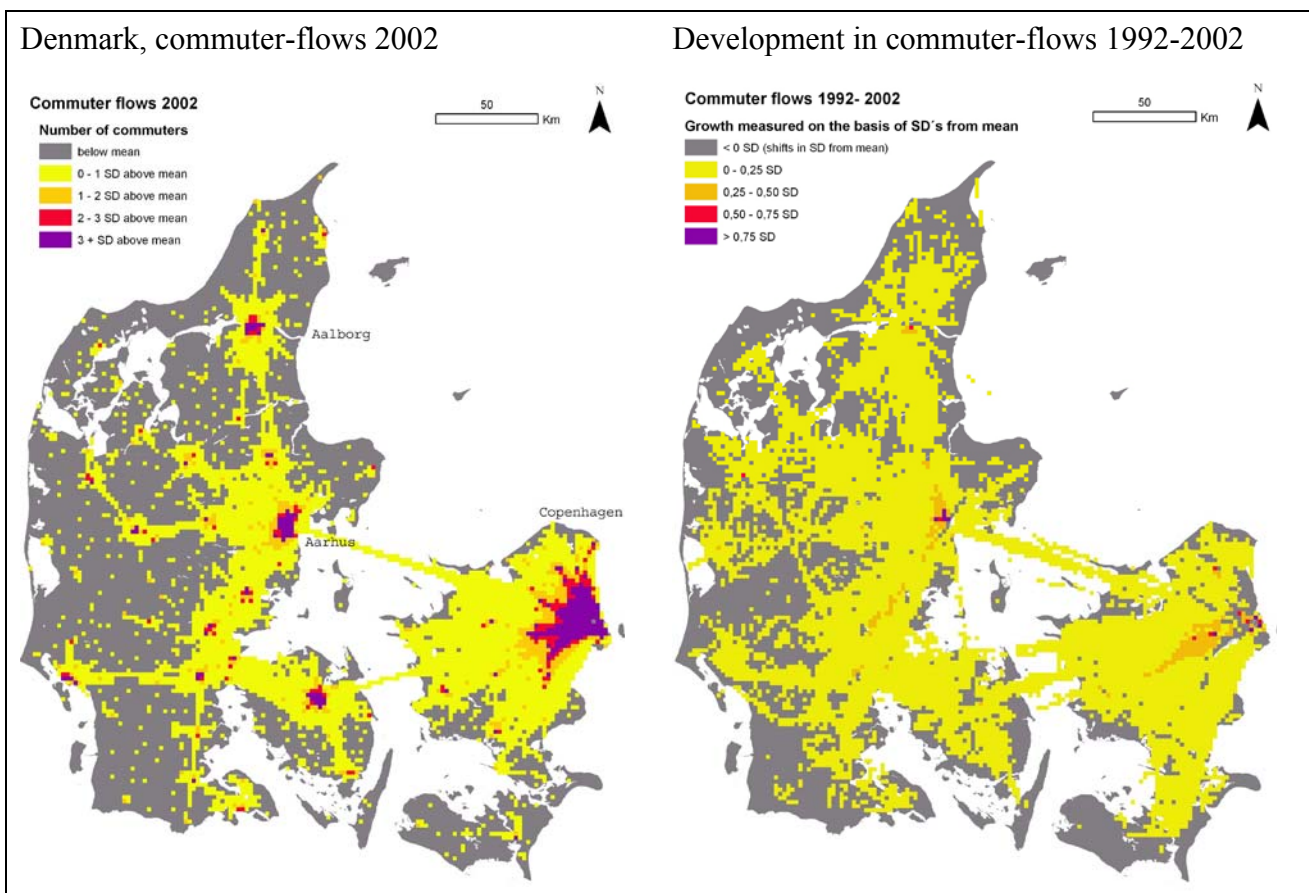
The geography of flows in Denmark, England and Wales have been commented in detail in Nielsen and Hovgesen, 2005 and Nielsen et. al., 2005. In what follows the comments will focus on common denominators and main differences in the development of commuter-flows in metropolitan regions and the implications for the relationships between urban regions, their suburbs and the hinterland.

The geography of flows in the two North-European case regions: England and Wales and Denmark (figure 1 and 2) has a lot in common in spite of the differences in scale between the two countries. Both countries contain a main axis, a spinal of commuter flows resting upon a relatively dense network of cities. The development trends in the distribution of commuter-flows also follow a largely similar path in that growth avoids the largest centres and tends to widen the characteristic corridor of interaction within the countries. This implies larger functional commuter regions as well as a tendency for the large centres to increase their catchment-areas and, hence, impose urbanisation pressures on former rural areas on the edges on the spinal corridor.

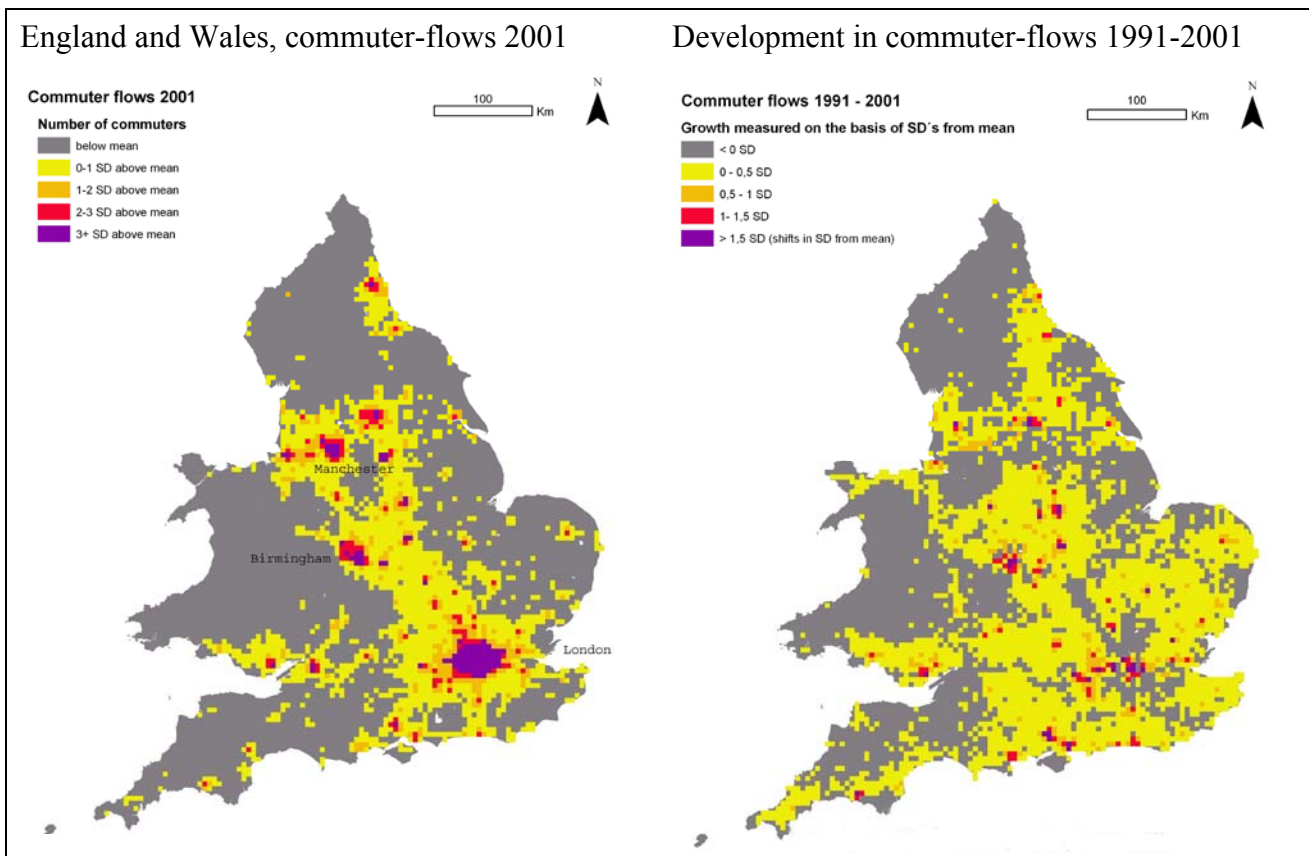
This is likely to be a European pattern – i.e. urban functional regions developing from the historical urban pattern. However, it is not possible on the basis of the present data to conclude if this is also the case in the region of Catalüna in Spain. Interactions with other Spanish regions would have to be included in the data to make such considerations possible.

The systems of commuter-flows in the eastern US show some resemblance with the European flows. This is especially the case on the North-eastern seaboard where the axis of Boston, New York, Philadelphia, Baltimore, and Washington D.C. form a spinal of interaction throughout the regions. In this part of the US, the development in commuter-flows also has a strong resemblance with the European cases as it avoids the largest urban centres and generally widens and extends the corridor.

It is however, also noticeable that the American urban system differs from the European with a less dense urban network and a larger proportion of interactions occurring within large metropolitan areas relatively separated from each other. This is evident in California and Nevada that in terms of commuter-flow mainly consists of the San Francisco Bay – Sacramento area and the Los Angeles – San Diego area. These two integrated areas are largely unconnected by commuter-flows – and Bakersfield and Las Vegas exists as small nodes of interaction outside these two large Metropolitan areas. The developments in commuter-flows do not point to the formation of corridors of interaction with a regional coverage. Rather the commuter-flows tend to expand the build-up of commuting in the two separate metropolitan regions outwards from the metropolitan cores.



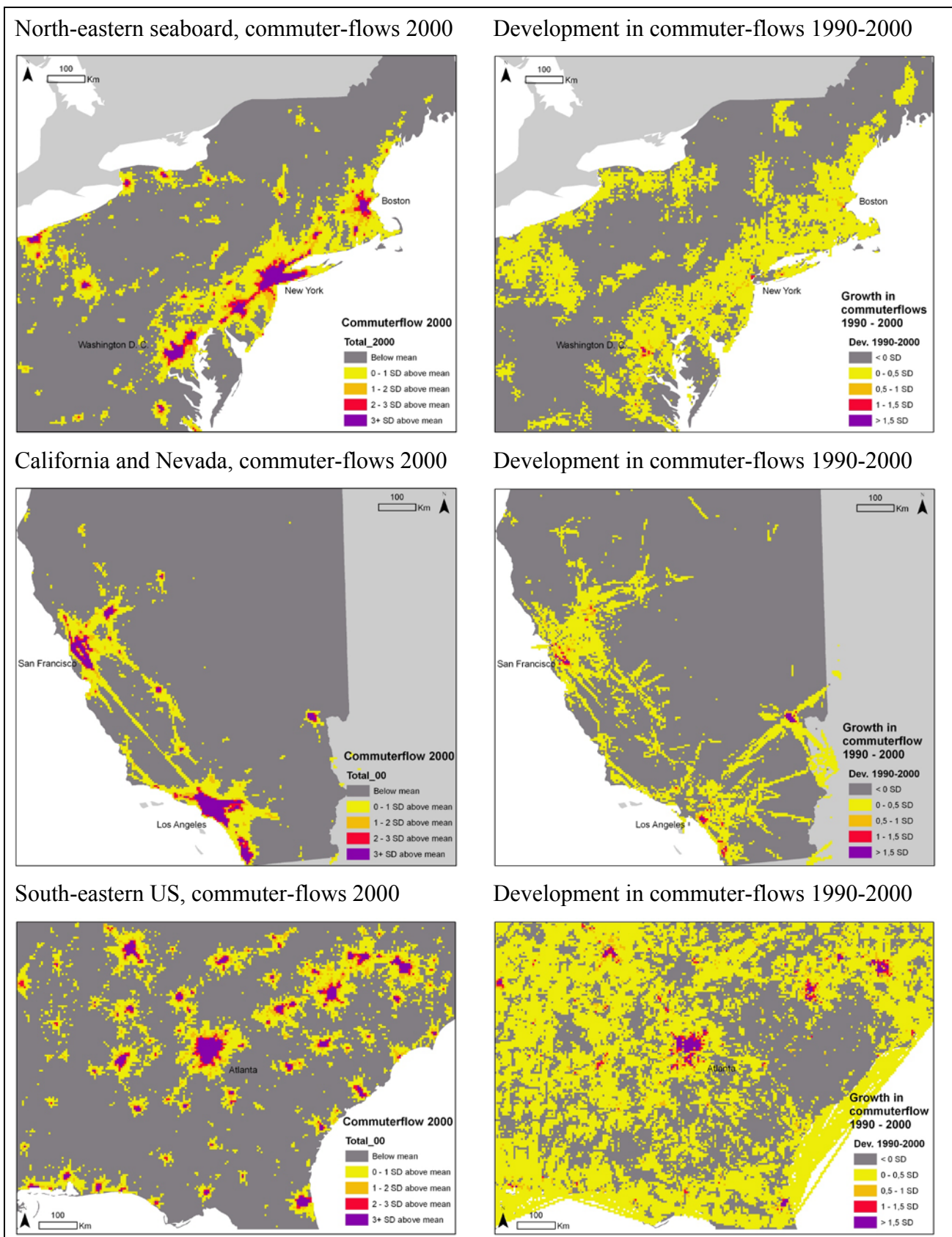
**Figure 1.** The flow of commuters in Denmark in 2002 summarised on 5x5 km grid cells (left) and the development in commuter-flows between 1992 and 2002 (right). The development in commuter-flows is measured as the change in standard deviations from the mean between the 1992 and 2002 commuter-flows.



**Figure 2.** The flow of commuters in England and Wales in 2001 summarised on 5x5 km grid cells (left) and the development in commuter-flows between 1991 and 2001 (right). The development is measured as the change in standard deviations from the mean between the 1991 and 2001 commuter-flows.

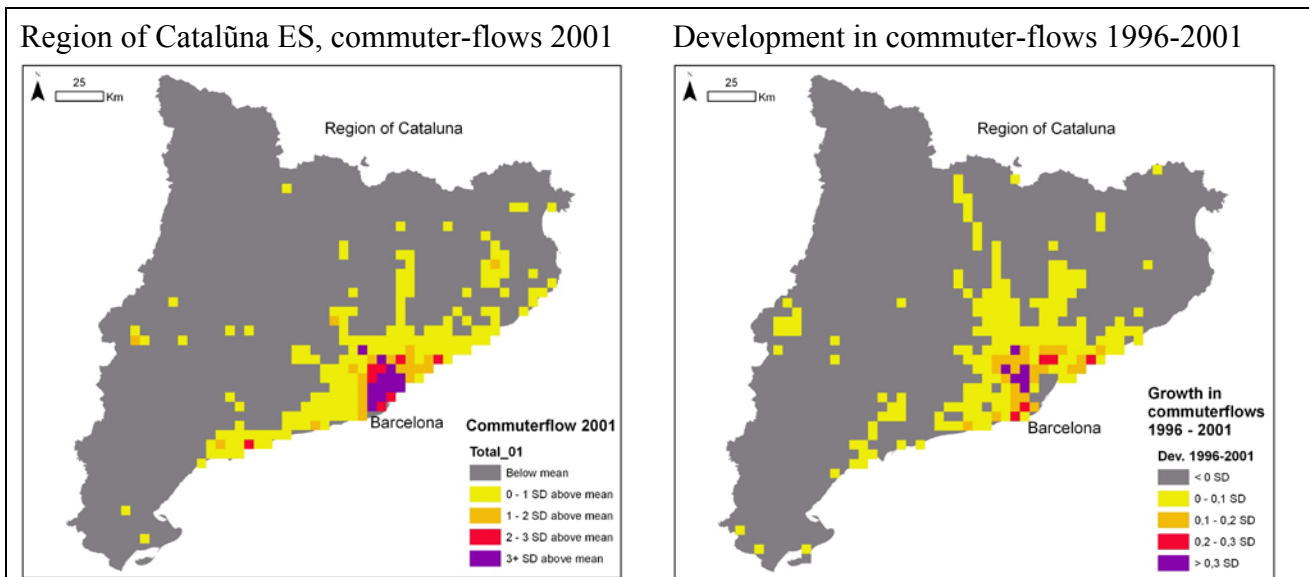
The south-eastern part of the US – focussed on Atlanta – lies somewhere in between California and the European system. It's a relatively dense urban network that tends to be bridged by commuting in some parts – and consists of large “stand alone” metropolitan areas in other parts. The development in commuter-flows in this part of the US seems in part to expand the area covered by the build-up of flows surrounding a large metropolitan area such as Atlanta. The map of the development of commuter-flows, however, also reveals an impressive unfocussed growth in commuter-flows bridging areas outside the larger urban areas. This coverage of the development in the criss-cross of relations that this implies is unique to the south-eastern US – among the regions studied.

The geography of commuter-flows within the region of Catalüna in Spain (figure 4) is dominated by the build-up of flows around the city of Barcelona. The development in flows tends to geographically expand the build-up of flows around Barcelona. This development especially points inland – into areas previously not affected by large volumes of commuters – residing or passing through.



**Figure 3.** The flow of commuters in selected parts of the US in 2000 summarised on 5x5 km grid cells (left alignment) and the development in commuter-flows between 1990 and 2000 (right). The development is measured as the change in standard deviations from the mean between the 1990 and 2000 commuter-flows.





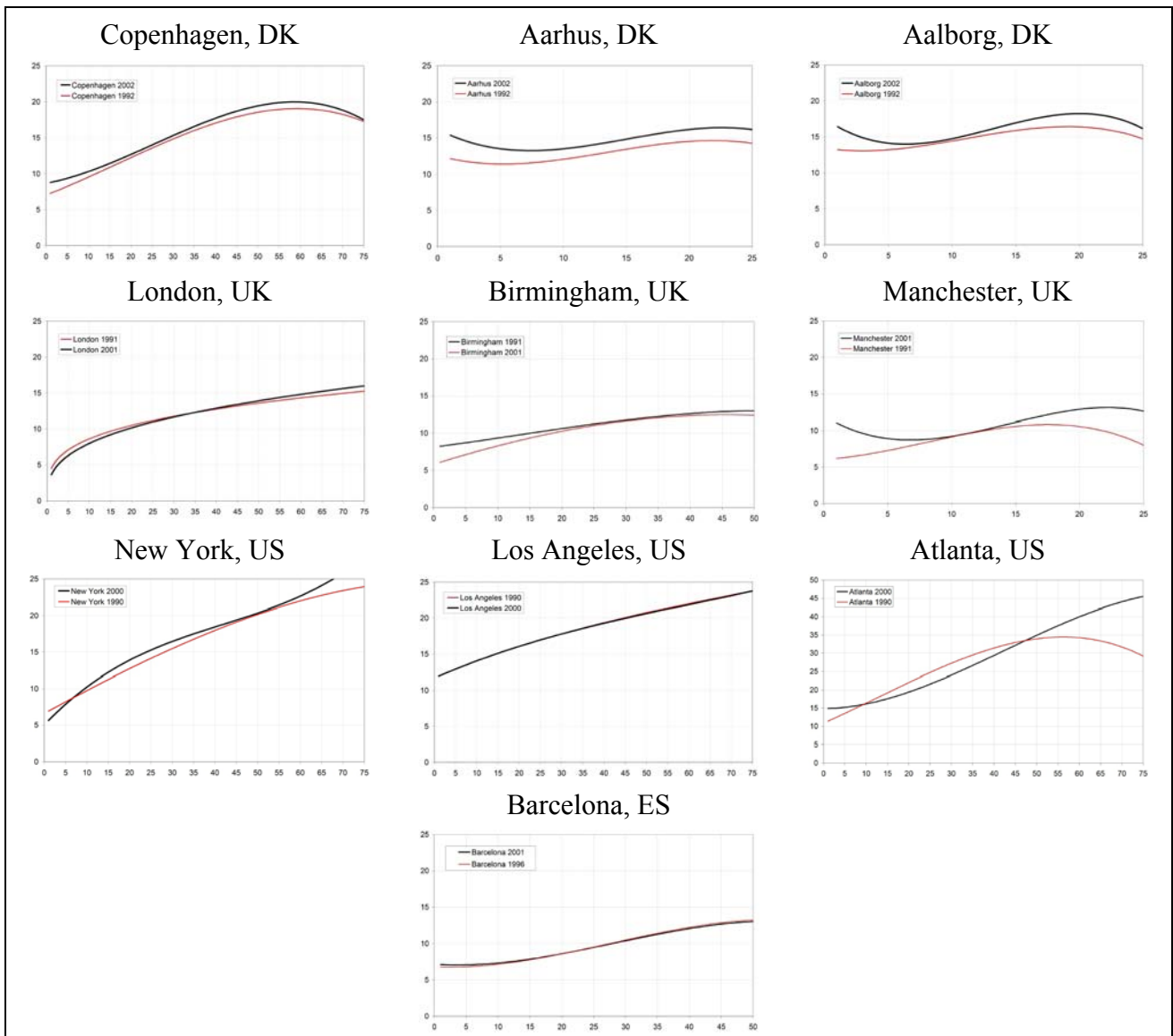
**Figure 4.** The flow of commuters in the region of Catalüna, Spain 2001 summarised on 5x5 km grid cells (left) and the development in commuter-flows between 1996 and 2001 (right). The development is measured as the change in standard deviations from the mean between the 1991 and 2001 commuter-flows.

#### 4. City profiles

This section focuses on the relations between location vis-à-vis urban centres and commute distances and commuting directions in 6/7 case-cities. In England, Wales and Denmark three of the largest cities in each country have been selected for the analysis. From England: London (11 mill. inhabitants within larger urban zone, LUZ), Greater Manchester (2,5 mill. inhab. within LUZ) and Birmingham (2,3 mill. inhab. within LUZ). From Denmark: Greater Copenhagen (1,8 mill. inhabitants within the larger urban zone), Aarhus (600.000 inhab. within LUZ), and finally the city of Aalborg (220.000 inhab. within a larger urban zone that includes the neighbouring municipalities). From the US the iconic urban areas of New York (18,3 mill. in metropolitan area) and Los Angeles (12,4 mill. inhab. in metropolitan area) is included together with Atlanta (4.3 mill. inhab. in metropolitan area) that has experienced rapid growth and is the home of well-known edge-city developments such as Tyson's corner.

The analysis presented, gives an indication of how the dependencies in the urban areas are developing and being reshaped as a consequence of increasing interaction distances in combination with de-concentration. Admittedly, not all desirable information on the case areas is provided and treated in this paper. There is a trade-off between the treatment of many cases in a sufficiently rigid and comparable manner – and a fuller account of the trends structures within the single case area. Thus, the data material assembled for this paper still opens numerous options for future inquiries and analysis.

Within the present paper the commute-distances have been plotted for each city as a function of distance to the city centre. The regression line that explained the most variation in commute distances has been drawn (figure 5). Different mathematical functions were tested on the commuting from zones within different ranges of distance to the city centre: 0-25 km, 0-50 km, 0-75 km, 0-100 km and in the case of the US even longer distance intervals was applied. The regression results indicate the significance of the single urban areas upon commuting from the surrounding areas.

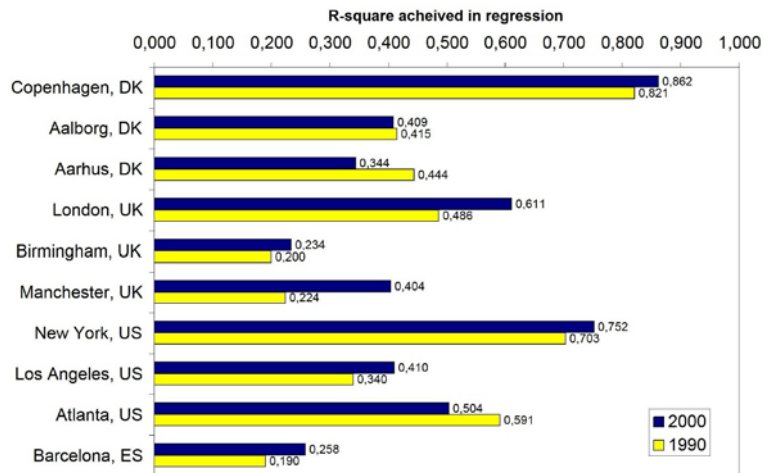


**Figure 5.** The relationship between centrality and commute-distances in seven urban areas, 1990 and 2000. The figures have been drawn on the basis of the regression line or curve that explained the highest proportion of variance in airline commute-distances in the statistical areas – weighted by their respective residential working population (night populations). Note that the first axis display the interval of distance to the centre where the proportion of variance in commute-distances explained by the regression was maximised (25, 50 or 75 km). The second axis has a fixed maximum of 25 km – except for Atlanta, US where the maximum is 50 km. The level of explanation achieved with the regression lines presented here can be seen in figure 6.

The common denominator for commuting in all the cities is some increase in commute distances as distance to the centre increases. As it can be seen in figure 5, it varies how steep this increase is and within what range there can be said to be an increase in commute distance as distance to the centre increases. For many of the large cities, distance to the centre has its biggest impact on commute distances within 75 km from the centre, with the exception of Los Angeles where about 41% of variation in commute distances within 125 km from the centre is explained by distance from the centre.

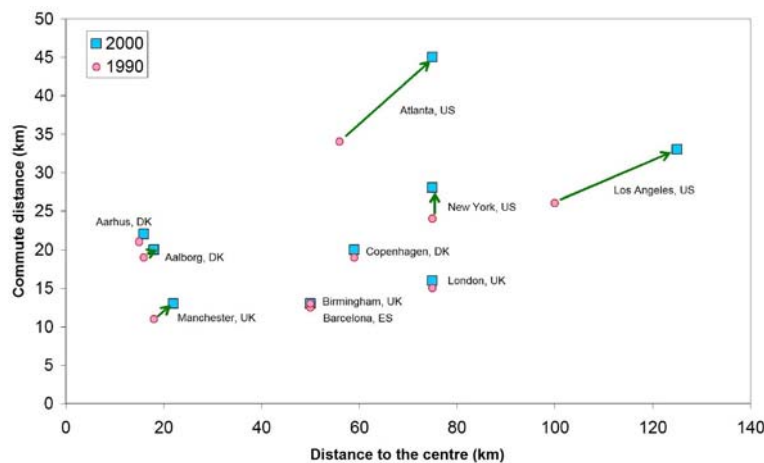
The level of explanation from distance to centre on commute-distances varies from 86% in Copenhagen to 23% in Birmingham and 26% in Barcelona (figure 6). The degree of explanation of commute-distances - offered by distance to the centre has increased in most urban areas between

1990 and 2000. This probably reflects increasing commute-distances and increasing in-bound commuting from the edges of the functional urban area (see comments on directionality of commuting). There are two cities that differ from this general trend, namely Aarhus, DK and Atlanta, US. The explanation for Aarhus is that the city is located in a polycentric region where other urban areas close by – counter balances the attraction of Aarhus (see: Nielsen and Hovgesen, 2005). A likely explanation for the city of Atlanta is that the de-concentration of workplaces has partially dissolved the dominance of the central parts.



**Figure 6.** The degree of explanation achieved in regression models where the commute-distance is explained by distance to the centre of the urban area.

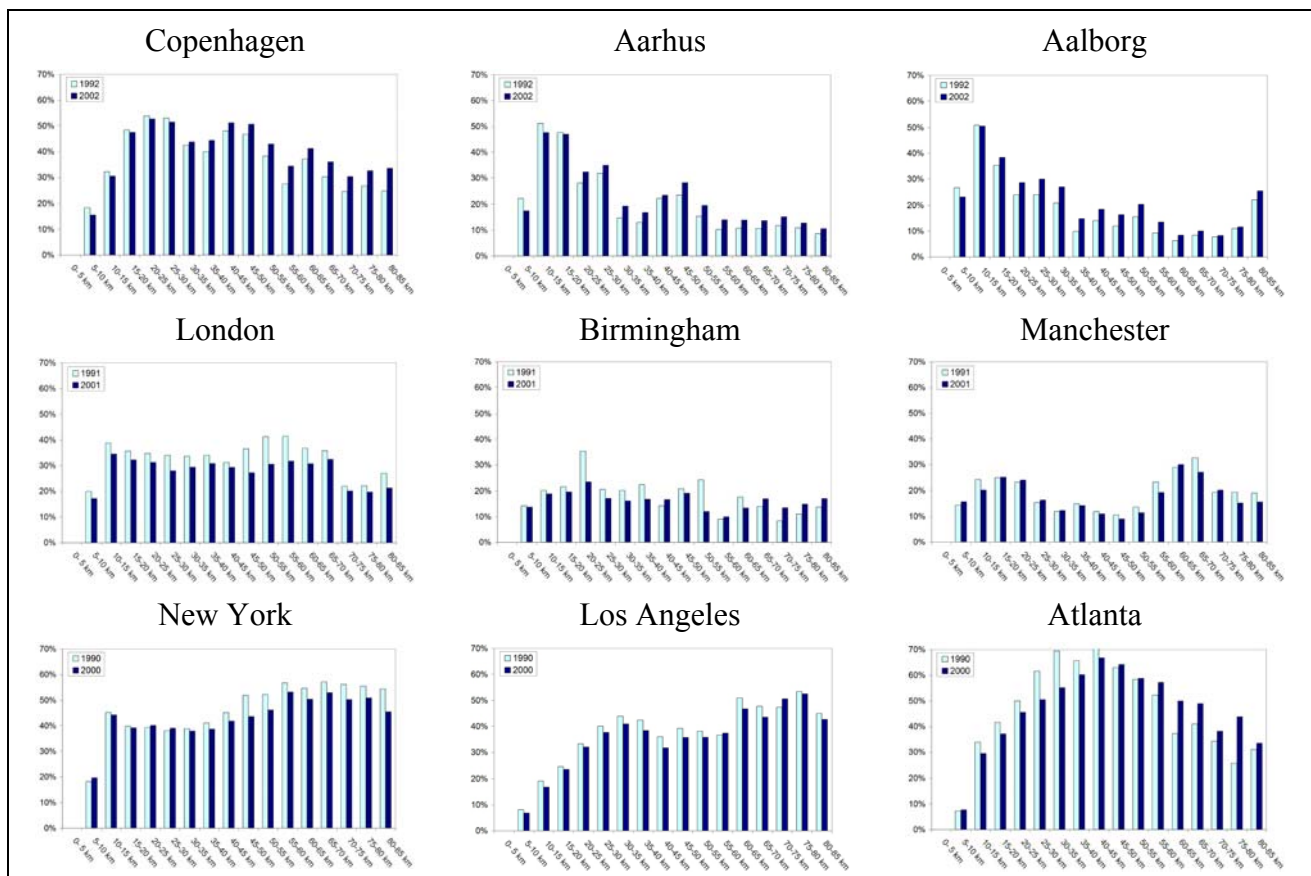
Another common trend is that commute-distances generally tend to increase across the cases. There is however, some variation as to where this increase occurs. There seem to be an increase in commute distances in the areas furthest away from the centre in all cities – reflecting the increasing size of the functional urban areas. Besides, there seem to be strong growth in commute distances in the central areas of the Danish cities as well as in Manchester and Birmingham. This reflects to some degree a reduced dominance of the core as an employment centre but also an increasing degree of what could be termed “functional polycentricity” in combination with a higher concentration of highly skilled employees in central areas that are willing to travel long distances to find a suitable job.



**Figure 7.** Summary of tendencies. Maximum commute distances in urban areas (2. axis) and the distance from the centre where this occurs (1. axis).

The general trends in commute-distances and the range of influence of urban areas can be summarised based on the maximum commute-distance and the distance from the centre where this

occurs (retrieved from regression results – see figure 7). As can be seen, the commute-distances have generally increased and wherever this peak has shifted geographically, it has moved outwards. Sunk costs in existing housing and infrastructure will, of course, cater for a slow development in this parameter. So, much more interesting it is to see the shifts that have occurred in Atlanta and Los Angeles. The large attraction and growth associated with these cities makes this radical development possible.

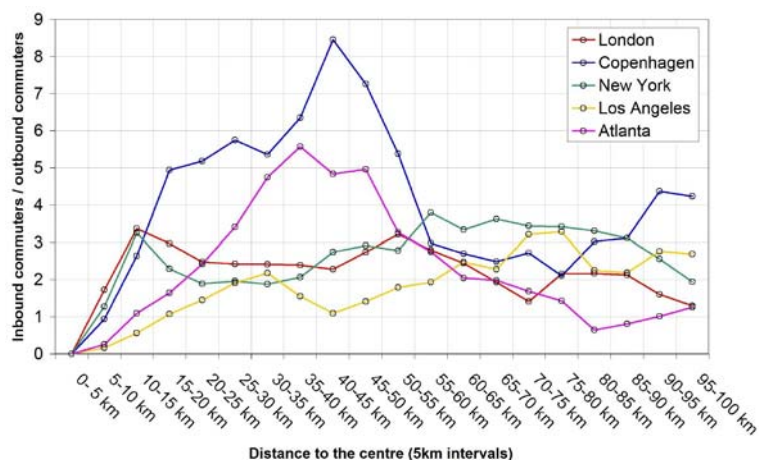


**Figure 8.** The directional bias of commuting in 6 urban areas in 1990 and 2000. The figures show the proportion of resident working population in each 5-km distance interval, measured from the centre of the urban area, that commute to a destination that is at least 5 km closer to the centre than their residential location. 1<sup>st</sup> and 2<sup>nd</sup> axes are the same on all the figures. The Spanish data has not been included in this part of the analysis.

The analysis of directions of commuting (figure 8) indicates that especially Copenhagen but also the other Danish cities have a high orientation towards the centre with more than 50% of commuters commuting inwards from the suburbs 20-30 km from the centre of Copenhagen. This level of inward-commuting and even more is also seen in US cities where the relative isolation and thus dominance of the metropolitan regions will tend to “push” the orientation towards the urban centre upwards as one moves towards the edges of the urban area. The high levels of inbound commuting in the areas surrounding the centre of Atlanta probably reflect the high growth that has occurred in the city and its attraction on workers far a field.

The English cities seem to be the ones where the commuting bias towards the core is the least pronounced. This is for a large part due to the fact that a large proportion of the working population works within a short distance from home or travel circumferentially. When we compare London with Copenhagen it is also characteristic that a larger proportion of the working residents of London commute outwards from the zones between 15 and 50 km from the centre. London appears to be more polycentric than Copenhagen. A direct comparison with the US cities is made difficult by the

differences in commuting range. A ratio between in-bound and out-bound commuters will allow a more direct comparison of the structuring of commuting within the metropolitan areas (figure 9).



**Figure 9.** Ratio between in-bound and out-bound commuters (local or circumferential commuters are left out) by distance interval in 5 urban areas, 2000/2001/2002.

The cities with “strong” and concentrated centres, Copenhagen, London and New York show a rapid build up in commuting bias. Copenhagen seems to be an exceptional case, however, as commuting bias continues until in-bound commuters out-number out-bound commuters by more than a factor of eight around 40 km from the centre. London only reaches a ratio of about three and this happens already around 10-15 km from the centre. London, New York and Los Angeles follow a pattern where commuting bias increases by distance to the centre and then declines as sub-centres take over – and then again increases as we move into the largely residential catchments areas on the edges of the functional urban area. In this aspect there is an interesting difference between the European and the US cases. The US cases (LA and NY) seems to continuously increase the level of commuting towards the centre orientedness of commuting after the first peak. The highest level is reached at very long distance from the centre (New York around 60 km – and Los Angeles around 75 km from the centre). This of course, reflects the long commute-distances and the attraction of these very large metropolitan areas. It also indicates that even though urban areas can be internally dispersed, the volumes of jobs and opportunities in these areas take the part as nodes of attraction at the regional level. Atlanta is a special case among the US cities. Looking at the pattern of out/in-bound commuting ratios it has more resemblance with the largely monocentric system of Greater Copenhagen. This probably reflects the growth of this area. Given the prevailing conditions in New York and Los Angeles, it seems highly unlikely that Atlanta will stabilise in this largely European interaction structure.

Turning to the developments in commuting directionality (figure 8) the common trend is that commuting towards the centre decreases in the areas closest to the centre in all cities. This reflects the increasing commute-distances and reduced dominance of the central parts. In many of the cities the opposite trend occurs at some distance from the central area reflecting the increased sphere of influence of the large urban areas. This is particularly evident in the Danish cities and seems to be the case in Birmingham and Manchester as well – though the trend is weaker here. In the US cities this increase in the orientation towards the centre occurs in areas as far as 90 km (New York) or 150 km (Los Angeles) from the centres of the urban areas. This indicates that de-concentration within the urban area to some extent occurs within confined boundaries and that there is a parallel process of increased dominance of the urban centre at the regional level. How these developments interact seems to have been insufficiently studied.

## 5. Summary and conclusion

This paper presents analysis of developments in commute patterns based on GIS-based mapping of commuter-flows from origin-destination data from Denmark, England and Wales, the region of Catalüna in Spain as well as from three regions in the US. Analysis of commute-distances and commuting directionality in six to seven urban areas was also presented.

Generally, the maps of commuter-flows can be used to delimit the areas characterised by high volumes of internal interactions (commutes) as well as the intensity of interaction going through any given area (flow). Broadly speaking, the European case areas seem to be characterised by a “backbone structure” where a national corridor of high internal interaction defines a functional core within each country. The largest urban areas are “hotspots” within this highly integrated area. Current developments in the geographical range of commuter-flows (approximately 1990-2000) are below average growth in these “hotspots” and above average growth across the wide surface of the larger, surrounding area which seem gradual widening and, hence integrating areas that were previously located at the margins of the national interaction corridor. The status-quo as well as growth patterns on the North-eastern seaboard of the US have a strong resemblance with the European pattern (even though the convergence of about 1 Mill. Commuter-flows on Manhattan can not be matched by the European cases). In the other US cases the large urban areas more or less “stand alone” as the centre of a concentric build-up of flows. The development in these areas is a “classic” outward expansion of the build-up of flows towards the urban area. Urban areas that experience strong growth – such as Las Vegas and Atlanta, US - have the strongest growth in commuter-flows in the centre.

Most of the urban areas studied with respect to commute-distances and commuting directionality experienced the following: increased commuting distances, a reduced dominance of the centre in central parts of the urban area, an increasing dependence on the larger urban areas in remote areas and an overall increase in the degree of determination of commute-distances from the centrality of location of residences in a larger urban area. Broadly speaking, this can be explained by the effects of de-concentration and continued growth on the dominance of the centre – combined with the effects of increasing specialisation/commute distances/attraction of urban areas. The increasing commute distances are probably the main reason why the location in the larger urban area is becoming more and more important determinant of commute-distances. There are exceptions from this overall picture, for instance where an urban area grows into a relatively balanced polycentric region (Aarhus, DK) as well as where rapid growth has markedly changed the distribution of population and jobs over the decade studied (Atlanta, US).

Among the city cases, Copenhagen stands out as the one where the location of residential areas vis-à-vis the centre is the most important in determining commute-distances and commuting direction. The distribution of jobs and population in the other European capital studied are significantly “flatter” with as far less dominant central area and thus the impact on commute-distances and commuting directionality seem to be less marked. In these respects, the large urban areas in the US have a different imprint on commuting. The highest commuting biases are in areas far way from the centre (Fx. In Los Angeles 75 km from the centre). Thus, even though a strong European type of central area is absent the location of jobs/opportunities, the urban area seems to create a functional centre in the region. The American urban system with “stand-alone” metropolitan areas is of course an important part of the explanation for this effect.

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Analysis of commuting in Denmark was based on an origin-destination matrix based on 1390 geographical zones (derived from parishes). The matrix was created from the Danish register-based workforce statistics (Registerbaseret arbejdsstyrkestatistik) by Statistics Denmark on request from Aalborg University.

US data has been delivered by the US Census bureau of statistics, Journey to work and migration branch. The following census products was used for the analysis: Census 2000 Special tabulation: Census tract of work by census tract of residence (STP64) – and – 1990 Census of population, Census tract of work by census tract of residence (STP 154).

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