

Understanding urban networks through accessibility

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Abstract: The question to be investigated in the paper is how to characterize urban networks, taking both place-bound activities and (quality of) transport networks into account. The description should help formulate planning questions about the development of urban networks. Urban networks can morphologically be characterized as major nodes or concentrations of land uses in a geographical area. Beyond this morphological description, places in the area can also be characterized by the amount and diversity of activities to be accessed by means of a physical transport network. So, each place can be valued in terms of opportunities within reach, depending on its links to the transport network, the attractiveness of activities within given travel time or costs. The changes of activities at one place (e.g. amount of workers or jobs) can thus, in combination with changes in the transport network (e.g. travel speeds), influence the position of places elsewhere because of competition between places. The process of influence will be spatially diffused further. It indicates that spatial competition is a hidden determinant of an urban network.

The paper will illustrate these different views of the urban network for the northern part of the Randstad Holland conurbation (the greater Amsterdam area) by means of different spatial representation. The comparisons between the patterns of three urban networks (morphological and opportunity based, or ‘virtual’) can help explore the changing urban network, giving rise to planning questions such as: - what should be the planning aim for urban networks: making places more homogenous, more diverse or rather make them subject to (controlled) competitive developments? - improvements in the transport system may have more or less exogenous impacts on the competitive position of urban places. How should these impacts be acknowledged in transport planning? - are comprehensive planned (and controlled) interventions thinkable in urban networks, or are urban networks rather the outcome of adaptively evolving, and necessarily partial planning interventions, as those responding to traffic congestion, the need for urban expansion, changes in location preferences, etc.? Answers to these questions will be tentatively addressed to formulate a planning research agenda for urban networks.

Key words: urban network, understanding, accessibility, morphology, and function

1. Introduction

The idea of networks has become fashionable once again since the mid-1990s, with the rapid pace of globalization and the increased role of information technology in many everyday lives (Smith, 2003). Numerous examples of network can be listed from various fields, such as social networks, entrepreneurial networks, biological networks, ecological networks, (public) transport networks, policy networks and others. In urban planning, thinking based on the concept of ‘network city’ or ‘urban network’ has become central. Network cities are defined as emerging, functionally connected sets of urban centres at the regional scale, such as in the Randstad Great Amsterdam, Mid-Utrecht and the South Wing (Rotterdam–The Hague) (Bertolini and Dijst, 2003). Urban networks consist of a number of compact larger and smaller cities that have good links with each other, separated by non-urbanized areas. Urban networks differ from each other with regard to both size and composition (Mayer et al., 2004).

Bertolini and Salet (2003) summarized three perspectives on network city and urban networks: a *morphologic–descriptive*, a *normative–strategic*, and an *analytic*. Following the morphologic-descriptive perspective the terms are equivalent to ‘polycentric/multinodal urban regions’, and identify one of two situations: functionally integrating, both competing and complementary constellations of mostly mid-sized cities (these are “urban networks”, see e.g. Ascher, 1995; Dieleman en Priemus 1996; Dieleman en Faludi, 1998), or the emergence of sub centres next to historic urban centres in metropolitan areas (these are “network cities”, see e.g. Anas et al., 1997). Those adopting a normative-strategic perspective, see the polycentric urban region as the most socially and/or economic and/or environmentally sustainable urban form, a belief increasingly popular among urban planners and designers (see among others Batten, 1995; Rogers, 1997; Hall & Ward, 1998). The analytic perspective on urban networks and network cities rather sees cities as overlapping sets of physically connected (by transportation systems) and virtually connected (by telecommunication systems) activity places (e.g. Webber, 1964; Alexander, 1965; Castells, 1989, 1996; Dupuy, 1991; Dijst, 1995).

In this paper, building upon these discussions, we propose three methods to understand and compare network cities and urban networks: node-based, density-based and accessibility-based, the former two are more morphology oriented and the latter is more function oriented. Their differences will be compared using the case study of Amsterdam urban region. In the conclusions, implications of the analysis for urban planning will be pointed at.

2. A node--based view

The Amsterdam region (figure 1) consists of the ‘mother’ city of Amsterdam and other smaller cities around it. The region is undergoing a transition from an agglomeration strongly oriented towards the core towards an urban regional network of multiple centres and shifting hierarchies (Bertolini and Salet, 2003). This has far-reaching planning implications. For instance, the central transport planning challenges of the last 150 years have been to develop adequate heavy rail linkages between

secondary centers and Amsterdam, and later to connect the regional into the national motorway grid. Today, with increasing specialization and the expansion of activities in the intermediate zones, the challenge is rather the development of a regional transit system and the introduction of hierarchies in the motorway system allowing that different cities, towns and major ex-urban activity concentrations function as complementary centers in a more horizontal fashion.

The important question for the future of the city, then, is how its scattered areas of urbanity can remain *connected* within the networks of urban interaction, the focus of which is partly

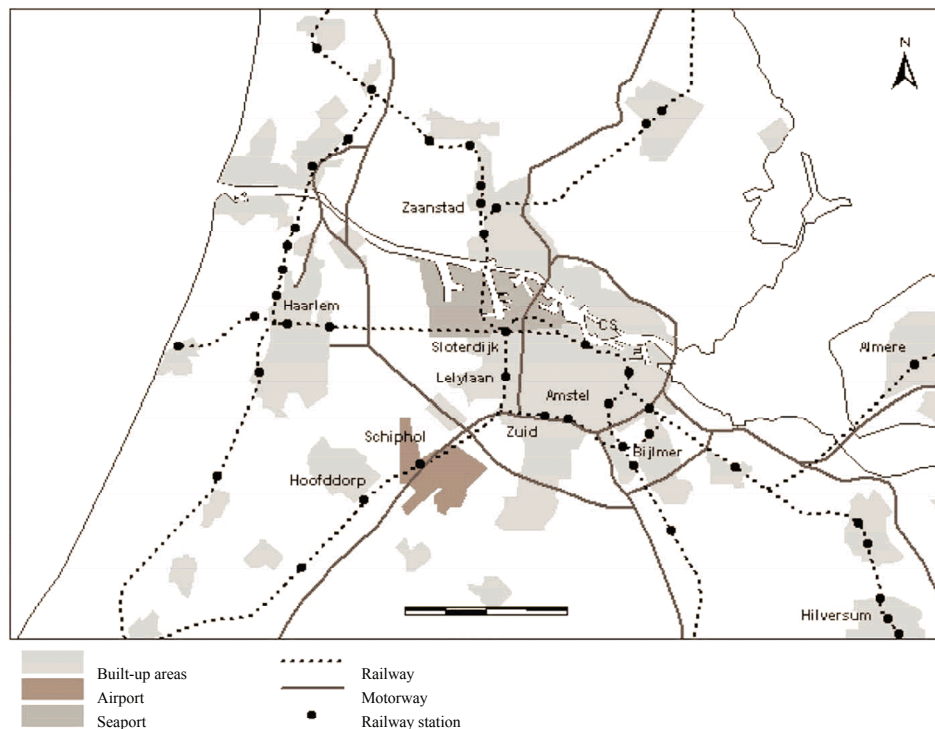


Figure 1. Amsterdam urban region, with main infrastructure and (sub) centers

outside the traditional municipal boundaries. This gives rise to a new situation, where Amsterdam will have to exchange its traditional ‘inside-out’ policy (planning its expansion) for an ‘outside-in’ approach, where the focus shifts to positioning itself in the networks of multiple centres in a broader spatial field (Bertolini and Salet, 2003).

The network that can be detected in figure 1 is built upon the historic pattern of the city of Amsterdam and other old cities such as Haarlem, Zaanstad, and Hilversum, which have become specialized centres in the region. More recently, these have been supplemented by planned growth centres such as Hoofddorp near Schiphol airport and, most importantly, Almere, which is located on land that was reclaimed as recently as the 1960s and is presently the fastest expanding city in the Netherlands.

At the core of the region, next to Amsterdam’s historic city center (around Central Station, or CS in figure 1), several sub-centres, or ‘nodes’ have emerged which typically combine excellent accessibility both by public and by private transport. The most important of these new nodes is the international airport of Schiphol, which

provides a unique combination of intercontinental air links and direct connection to the regional and national motorway and railway networks. The airport area has become the focus of a rich and diverse concentration of activities (including office, conference, hotel, retail, and logistics). Other older and newer nodes are also increasingly the focus of specific concentrations. Large-scale office complexes, and financial and business services in particular, have been clustering around the railway stations of Sloterdijk (for example, Teleport), Lelylaan (World Fashion Centre), Amstel (Philips, Worldcom), Zuid (World Trade Center, the ABN-AMRO and ING banks). The area between Bijlmer station and the A2 motorway appears to be a preferred location for combined warehouse and office complexes, including an extremely dynamic information and communication technology (ICT) sector (with, among others, the European headquarters of Cisco). In these locations firms enjoy, as well as the availability of space, excellent access both to the regional labor market and to metropolitan facilities including the airport. Urban centers elsewhere in the region, such the previously mentioned Almere or Zaanstad, are also experiencing growth as business locations, particularly as far as back offices are concerned. Many specialized small-scale professional services have, on the other hand, remained faithful to the walking and cycling environment of the historic city center, which is also proving an ideal breeding ground for up and coming Internet and multimedia businesses.

A similar differentiation may be also observed in the distribution of urban facilities; most noticeably: new hospitals along the A10 motorway ring; the RAI congress and exhibition center, the Insurance Exchange, the District Tribunal and the Free University around Zuid station; and a giant retail and leisure complex at Bijlmer station. At the same time, more finely grained shopping, entertainment, and cultural activities have continued to thrive in the old city. Reinforcing this trend, after an unfortunate attempt at downtown-style office development between the 1980s and 1990s, a number of large cultural facilities have recently been or will shortly be opened along the southern IJ-river banks, east and west of Central Station.

In addition, and although the dynamism is somewhat more limited, residential choices (at least, of those who can choose!) also appear to be increasingly influenced by the differences between, in addition to other factors, more and less accessible, more and less intensely used, urban areas. Furthermore, there are signs of an emerging demand for high-quality apartments in the direct surroundings of the main multimodal nodes.

While interesting, the picture of the network sketched above is still highly qualitative and dependent on users' perceptions. The method provides a conceptual understanding of the evolving morphology of the network and a language for planners to discuss its change. However, it does not explicit the factors that are behind such evolution, and is thus of limited value for understanding the function of the network.

3. A density-based view

Cities can be seen as places of concentration of social and economic activities connected by transport networks (see figure 2 and 3, based on the density of employment and population in the Amsterdam urban region). Figure 2 shows the spatial concentration of jobs, which are located in Amsterdam city centre and other smaller city centres. Figure 3 displays the spatial concentration of inhabitants, which

is globally similar but more continuous than that in figure 2. Or rather, jobs are spatially more segregated than inhabitants. Compared with figure 1, figure 2 and 3 provide more accurate and detailed information for identifying centers and their spatial relationships with the transport network, thus providing a more objective support to the morphological description of the previous section. However, it still does not capture the functioning of the network as such, because the actual interaction between places of activity is not considered. Furthermore and related to this, density-based representations of networks are not sensitive to changes in human activity and spatial strategies, that is, they are of a static nature and as such not sufficient to reflect the dynamic changes in spatial and social interactions.

To illustrate both the potentials and the limits of a density-based representation of the network, let us consider the example of the relationship between the demand and supply of jobs, a crucial aspect of the functioning of urban networks. To do this, we can calculate the ratio of employment to inhabitants as in figure 4a. This ratio can help understand the spatial mismatch between inhabitants and employment from a location point of view, as it reflects the functional mixture at any fixed residential location. However, this information does not take the role of the transport network in determining access to jobs and workers, into account, or the interaction between transport and land use. As a consequence, on the basis of such representation, it is impossible to assess how good a residential location is in terms of access to jobs, or business locations in terms of access to workers.

4. An accessibility-based view

It is a well-known common place that city is a complex system, meaning numerous components in spatial and temporal interactions. The pre-requisite to any reasonable planning is the scientific understanding of the complexity inherent in the objects to be studied. The complexity of a network is its interaction and the effects from the interactions as a dynamic component. Interaction-based analysis should be theoretically better to understand the functions of a network. Building upon the discussion in the previous section, here we take the issue of job accessibility as an example to illustrate its advantages.

Job accessibility is influenced by the complex social and spatial interactions between land-use structure, transportation (e.g. availability of vehicles, existing road network, congestion in high-density areas), and the functional aspects of jobs and workers (e.g. employment type, gender, age, education, their household roles and income). As a result, job accessibility can be a window to understand the functioning of urban networks based on the complex and dynamic interactions.

Extensive academic literature on accessibility measures suggests many ways to define and measure accessibility. However, uses of accessibility measures in planning practice are still relatively scarce (Handy and Clifton, 2001). One of many reasons is the capacity of interpretation to users, which has not received enough attention.

In this paper the modelling strategy as such is not at stake, but the implications which can be learned from it for planning. This can be best explained by an example: Supposing that accessibility to jobs from a residential location is measured in the traditional way, by only calculating the number of jobs within access of, say, half an

hour travel time. If the same calculation is made when incorporating distance or travel time decay, the difference between both results indicate whether it is necessary to include travel distance as a discriminating planning element in thinking about urban networks or, if no severe differences occur, it is just sufficient to stick to the locational pattern of jobs to inhabitants. The example can be extended to the incorporation of other components, which might affect job opportunity, such as competition for the same jobs executed by other inhabitants (competition in demand). If this is overwhelming the distance effect, it might be more important from a planning perspective to carefully plan the spreading of jobs to inhabitants then worrying about travel distances in the urban network.

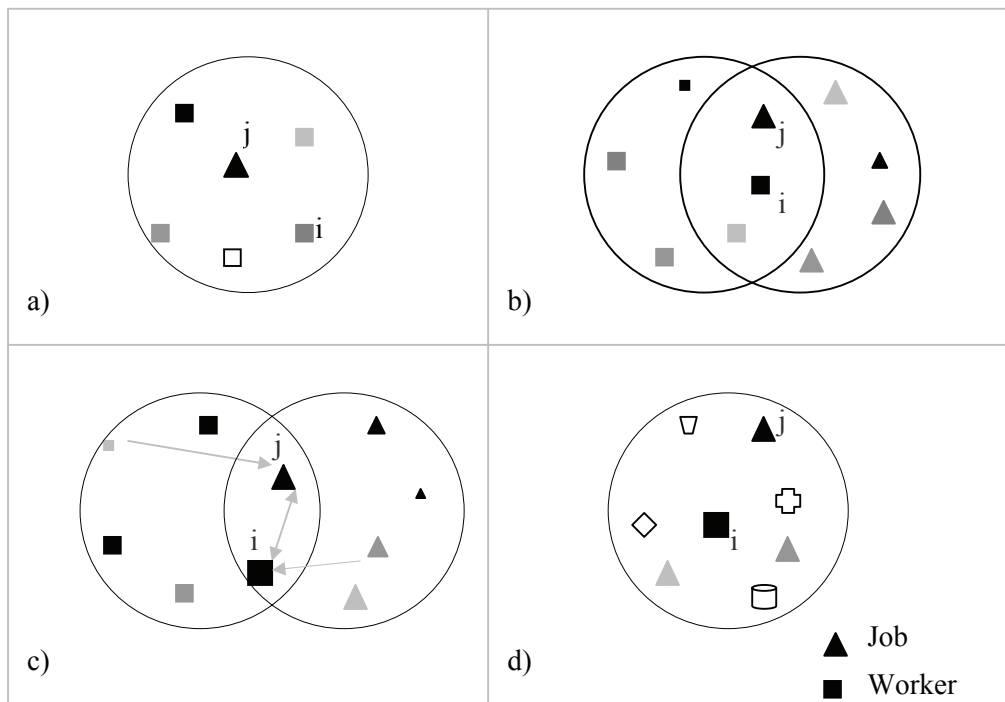


Figure 5. Illustration of components for job opportunity measure: [a): competition in demand, by amount of workers; b): competitions in supply, by amount of workers; c): distance decay in demand and supply; d): diversity of jobs]

In this project, we adopt the strategy to model accessibility in particular job accessibility by quantifying or measuring it in a more communicative and interpretable way with an aim to link with planning practice. The strategy incorporates different components of job accessibility (*opportunities* within reach, the *competition* for those opportunities, and the impact of *distance* and *diversity* on the value attributed to opportunities) into the measure, step by step as illustrated in figure 5 and more extensively discussed in (Cheng et al., 2005)).

More specifically, in this study, the interaction between transport and land use is measured from four components: competition on demand (i.e. workers), competition on supply (i.e. jobs), distance decay (i.e. travel time) and job structure (i.e. diversity). The step-wise results are displayed in figure 8, which shows the change of job opportunity under the different combination of job accessibility components. Each of

these components shows some aspect of the complex interactions within the network. Figure 6 and 7 show the difference in spatial patterns of job opportunity after application of the strategy of modelling. For example, the job access in the city Almere (right side in figure 6 and 7) is enhanced after incorporating all the components of job accessibility, the same situation is also for the city of Hoofddorp, Zaanstad. By contrast, the job access in the northern part of Amsterdam city, and the peripheral areas of other smaller cities is reduced and worse totally.

In contrast to the previous section, we can now adequately address the issue of the spatial relationship between job demand and supply in the network. In order to illustrate this, let us calculate the ratio of job opportunity (taking account of all the accessibility components) to the number of inhabitants as (b) in figure 4. This accessibility-based ratio shows a remarkably different pattern with that of density-based in (a) of figure 4. In figure 4, when using the same classification, the accessibility-based ratio implies a much stronger spatial match between job opportunity and inhabitants, which are expanded to the peripheral areas. This is mainly because of the fact that job accessibility measure considered the interaction of transport and land use (employment, workers, and transport network).

The impacts of the different components of job accessibility can be compared and evaluated from figure 8. Comparing a, b, c and d in figure 8, the most remarkable change comes from the competitions on both demand and supply (i.e. competition for jobs among workers and also competition for employees between employers). This change in job opportunity is characterized by the increase in the suburban areas of Amsterdam city. The latter three maps (b, c and d) are globally similar with slight changes in their spatial patterns. To identify the spatial (and planning) impacts of each component, we calculate the ratio of job opportunity between any two components of job accessibility as figure 9, assuming other set of conditions unchanged. The ratio with a value greater than 1 means an increase of job opportunity and a ratio smaller than 1, conversely, means a decrease of job opportunity. The spatial patterns of the ratio values could indicate different policy implications.

In the case of map *a*, the increase of job opportunity is clustered in city (Amsterdam and smaller) centers, this results from the spatial concentration of jobs in these areas, or the density of jobs, which strengthens the competitive position on the side of demand (competition for jobs among workers).

In the case of map *b*, the change of job opportunity is largely dominated by its increase (93%), with a greater intensity in the fringe where the density of inhabitants is higher, than in the city center. It implies that the density of inhabitants affects the competition on the side of supply (competition for employees among employers).

In the case of map *c*, both the increase and decrease of job opportunity are symmetric and evenly distributed in terms of amount and spatial pattern. Distance decay is strongly related to the functional mixture of jobs and workers at a location level. This case implies that, on the one hand, the improvement of functional mixture can stimulate the increase of job opportunity, on the other hand, the functional mixture in the study area is not spatially homogeneous in city center or fringe. For instance, the low functional mixture of city Almere (compare figure 4-a) produces its dominant decrease of job opportunity.

In the case of map *d*, the change of job opportunity is dominated by its slight increase, spatially distributed relatively more in the fringe than in the city center. This case implies that, on the one hand, job diversity contributes less than other three components, on the other hand, the job structure in Amsterdam city center is not significantly more diverse, compared with those in the fringe. Probably this job structure resulted from the local policy of old-city preservation.

Linking figure 8 and 9, we can summarize that land use densification, functional mixture and job diversification can affect the level of job opportunity in locations of the network, and thus the functioning of the network as a whole. Consequently, they can be utilized as policy instruments within the framework of a network planning strategy.

By taking Almere as example, the job opportunity there is limited and also spatially heterogeneous (figure 7). Two reasons may contribute to this: one is the relatively low density of jobs, another is the relatively low functional mixture of jobs and workers. Further elaborating the argument, figure 10-a illustrates what the impact would be of a relocation of jobs from Amsterdam city center to Almere. Totally 24800 jobs are relocated in this example. The corresponding change of job opportunity is displayed in figure 10-b (where the impact of the change on all four components of job accessibility is accounted for). This change results from the complex social and spatial interactions between various land uses, as linked by a transport network. Similar examples could be made for the impacts of other land use and transport policies.

5. Implication for planning practice

It is well known that city is a complex system exhibited as a network, which is characterized with multiple actors, dynamic social interactions and emergent spatial patterns. Any policy-making must be based on the proper understanding of the network. The Dutch national urbanisation policy currently in force is often said to be inadequate and not a timely answer to societal changes (van der Burg and Dieleman, 2004). The illustration described above, by taking job accessibility as an example, shows the importance of understanding such network from the functional rather than just the morphological perspective. The latter is able to better reflect the dynamics of the network. In the example of access to jobs, it shows how a change of jobs or workers at a location affects the level of opportunity at another location, a change that is normally hard to be perceived. This new insight is possible because the traditional focus on direct physical proximity has been replaced by one on the functional interactions within the network.

To some extent, the three methods, i.e. node-based, density-based and accessibility-based, may represent the different languages or perspectives of urban development participants, i.e. residents, urban planners, and transport planners. They perceive the network according to the information they have at hands, with a trend to have more and more detailed and complete data. The reasoning above shows that density-based (density and mixture) network can be utilized to explain the reasons of network change or to stimulate the change of network. The change itself can however be better represented and understood by an accessibility-based analysis. The integration of both

can be helpful for the design of policy-making or strategy making. This understanding will bring a new perspective to make sustainability-oriented policy in planning practice. It is necessary to shift from physical sustainable to functionally sustainable, from an urban policy based on compactness to one considering the whole urban network. A functional, accessibility-based perspective on urban networks (and network cities) points to a series of interesting questions for planning practice, such as:

- What should be the planning aim for urban networks: making places more homogenous, more diverse or rather make them subject to (controlled) competitive developments?
- Improvements in the transport system may have more or less exogenous impacts on the competitive position of urban places. How should these impacts be acknowledged in transport planning?
- Are comprehensive planned (and controlled) interventions thinkable in urban networks, or are urban networks rather the outcome of adaptively evolving, and necessarily partial planning interventions, as those responding to traffic congestion, the need for urban expansion, changes in location preferences, etc.?

A discussion of these questions could help sketch a planning research agenda for urban networks. This set of questions stems from the consideration that the issues discussed above call for an integrated approach to land use and transport planning in urban networks. Better policy coordination is indeed needed. However, the limits to policy coordination in urban networks must be also recognized. Urban networks are invariably highly fragmented in terms of public power, while the growing need for coordinating government and private decisions makes matters even more complicated. The limits to policy coordination have also a temporal dimension. Urban networks show a wide range of paces of change: from the very long cycles of infrastructure development, to the much shorter cycles of land use transformations, to the continuous adaptations in individual activity and mobility behaviour. Furthermore, there are limits to just knowing what future developments will be. As a result, next to the need of improving coordination and reducing uncertainty, there is also a need to deal with the *impossibility* of coordination and the *irreducibility* of uncertainty. Accordingly, interventions that enhance the resilience and the adaptability of the land use and transport system are needed (Bertolini, 2005). In order to achieve this, there is a need to continuously assess the potential implications of changes in accessibility and its appreciation by individuals and organizations, and to identify ways of dealing with the ensuing development opportunities and threats. The accessibility-based perspective on the functioning of urban networks introduced in this paper could provide a tool for such an assessment.

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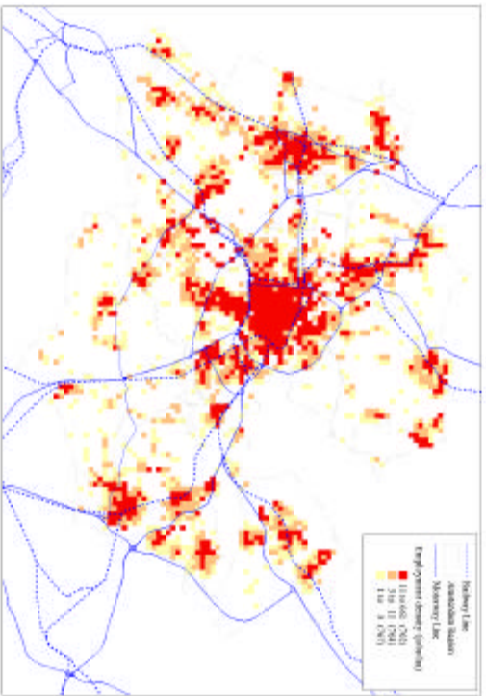


Figure 2. Pattern of employment density

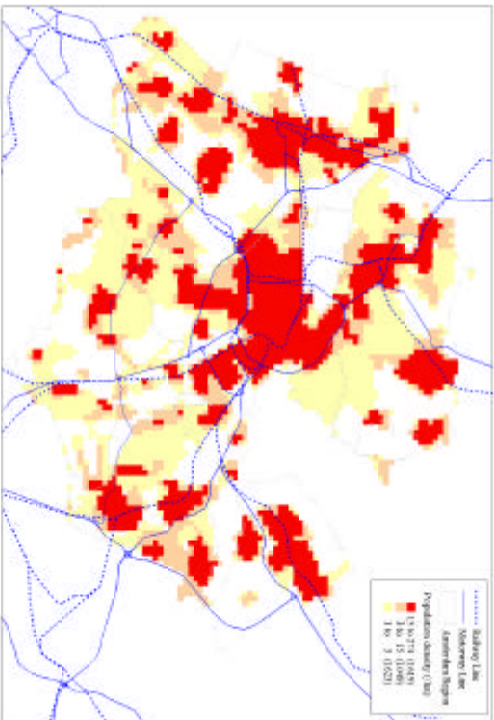


Figure 3. Pattern of population density

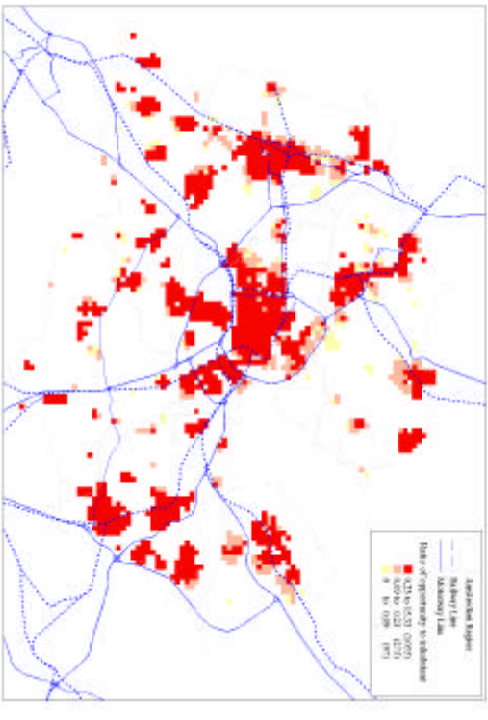
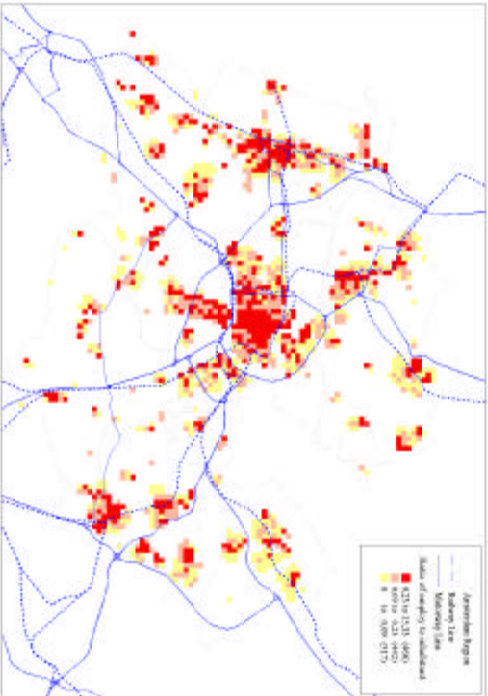


Figure 4. Ratio of employment (a) and opportunity (b) to inhabitants

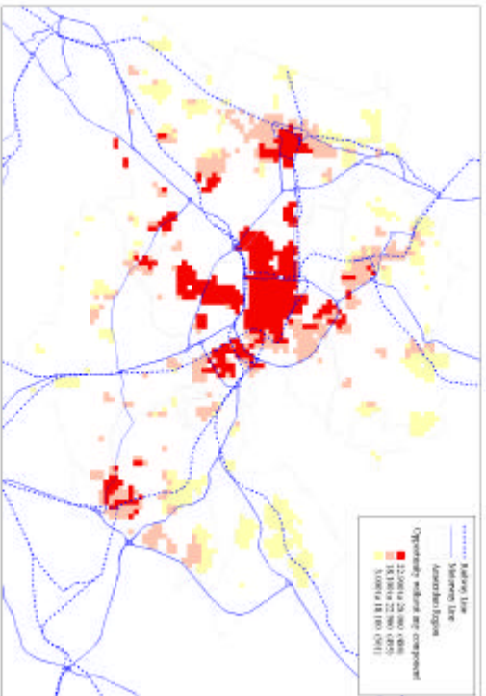


Figure 6. Opportunity without any component

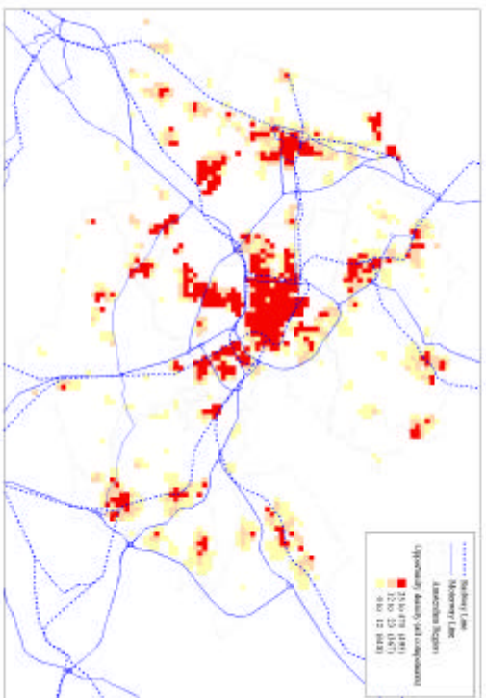


Figure 7. Opportunity with all components

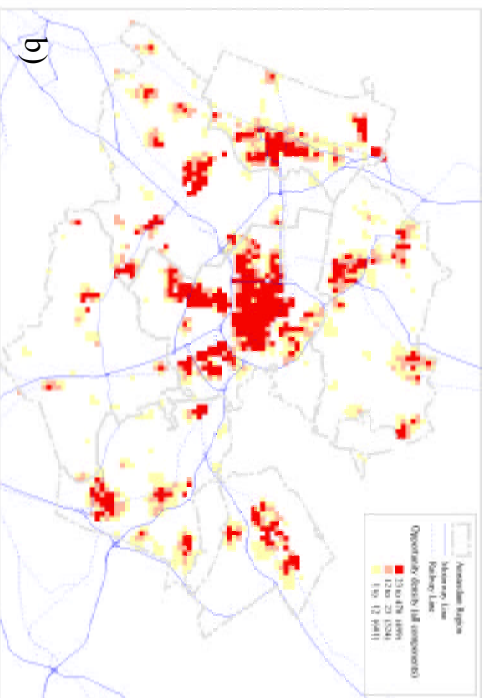
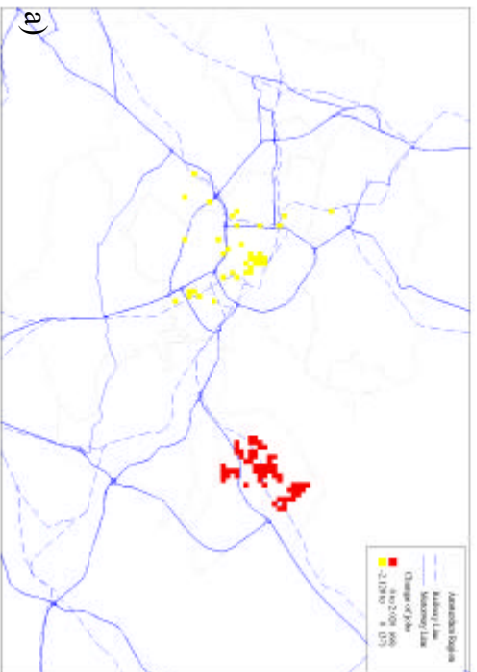


Figure 10. Change of jobs (a) and corresponding change of job opportunity (b)

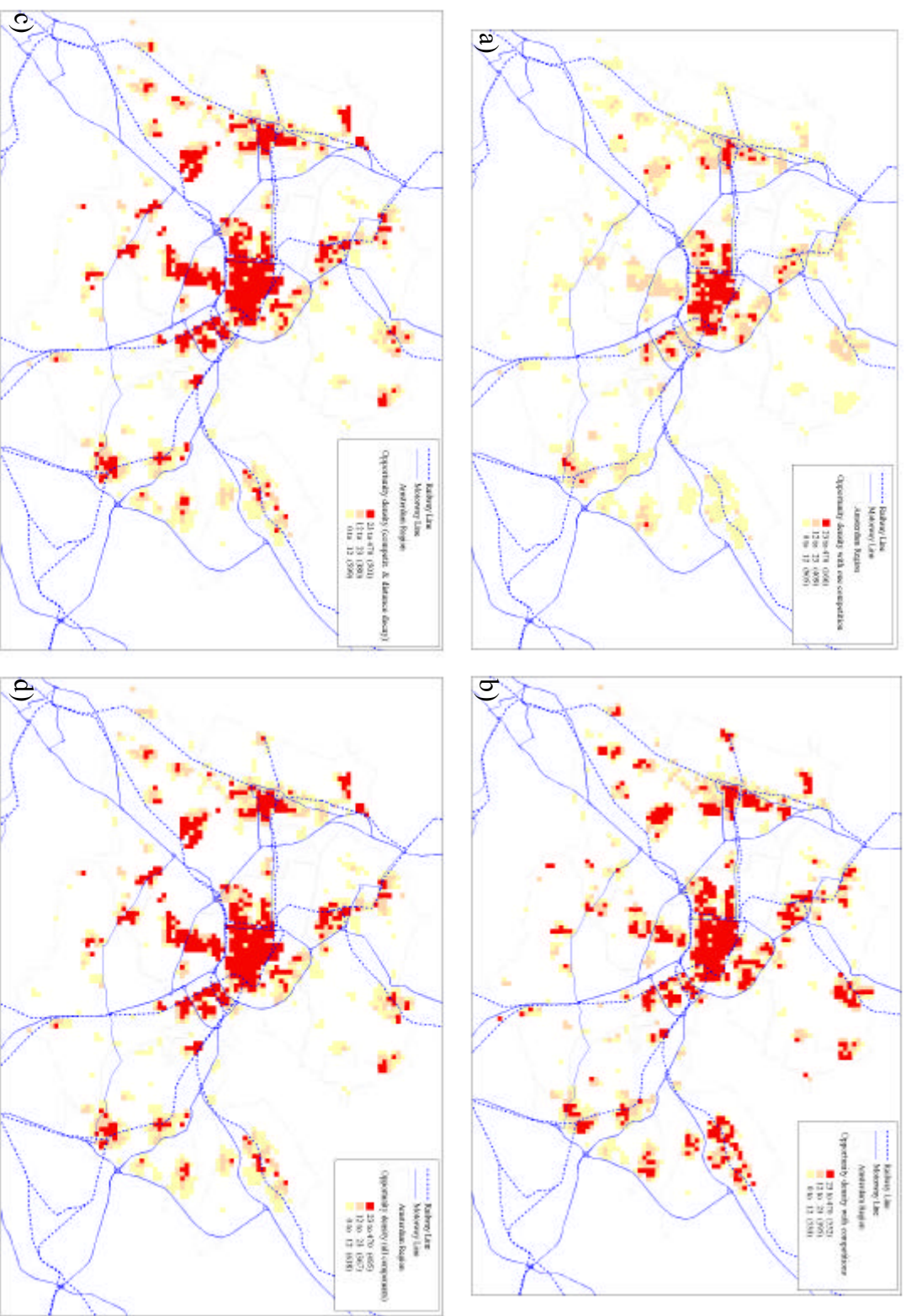


Figure 8. Opportunity, step by step (a): competition on demand; b) competitions on demand and supply; c): distance decay; d) job diversity

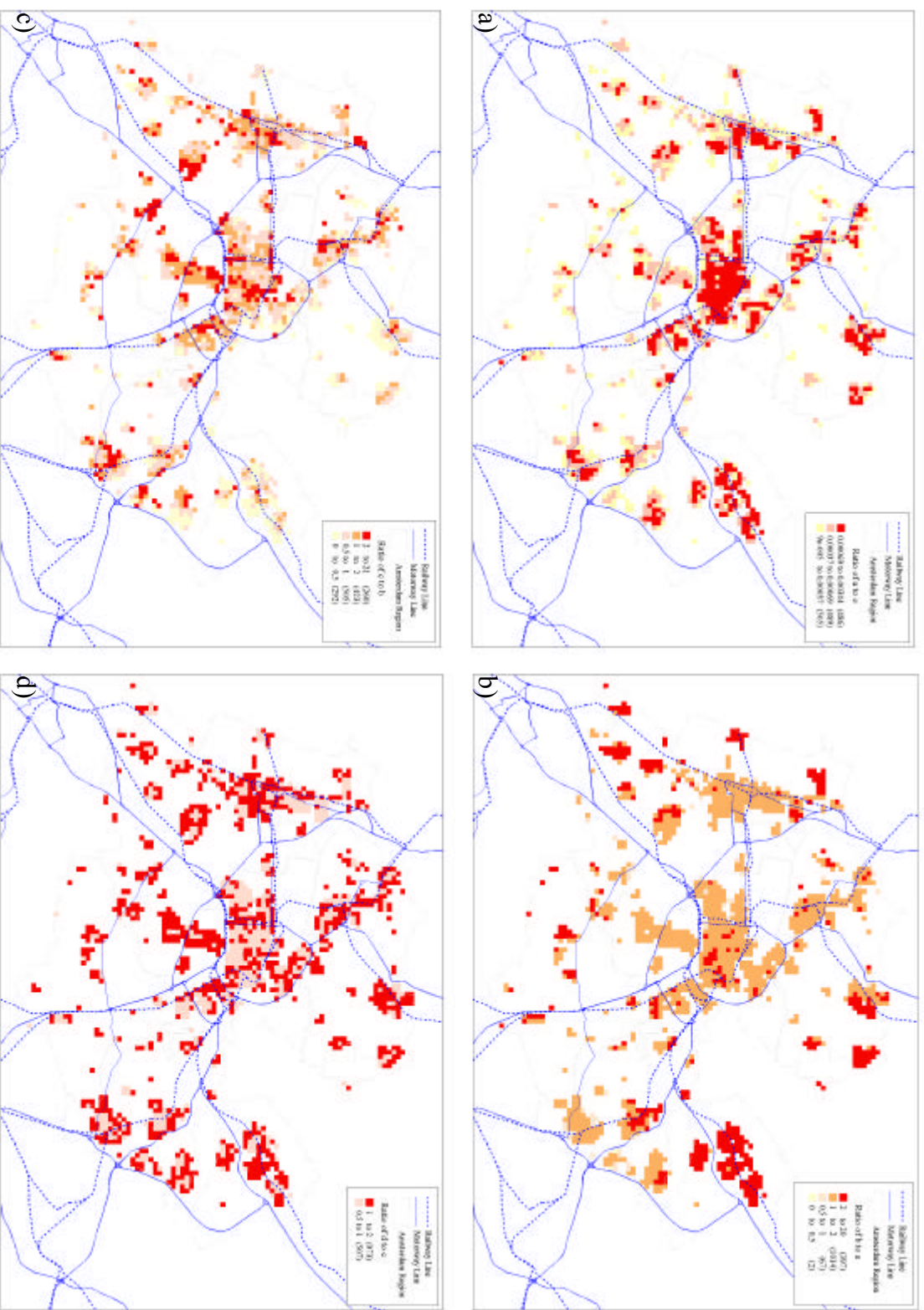


Figure 9. Ratio between the various components in job opportunity, step by step (a): a/b ; b) b/a ; c) c/b ; d) d/c