Do motorways shape urban growth?

Analysis of growth patterns with micro-level data - before and after road openings in two Danish motorway corridors

Nielsen, Thomas Alexander Sick; Hovgesen, Henrik Harder

Published in:
Book of Abstracts

Publication date:
2005

Document Version
Publisher's PDF, also known as Version of record

Paper presented at the 45th congress of the European Regional Science Association, 23-27 August 2005, Amsterdam

Do motorways shape urban growth? Analysis of growth patterns with micro-level data – before and after road openings in two Danish motorway corridors.

Thomas S. Nielsen, Email: tsn@plan.aau.dk, Tel: +45 26 200 360
Henrik Harder Hovgesen, Email: hhh@plan.aau.dk, Tel: +45 96 35 84 30

Aalborg University, Department of Development and Planning
Fibigerstraede 11, DK-9220 Aalborg East, Denmark

Abstract

The paper is an offspring from the Research project Town, Road and Landscape that aims to assess the effect of the Danish motorway network (specifically the last 20 years) on urban growth and interaction patterns. As one of the main interests of the project is the changing urban form and the changing character of the roadscape, the impact of the motorway is in part analysed with micro level data, spatial statistics and GIS – allowing mapping of changing development trends in motorway corridors. The paper presents analysis of the impact of motorway openings on urban form in two Danish motorway corridors. The analysis is based on a before and after perspective – where the building activity and its location (building register with address coordinates) after the opening of the motorway is compared to building activity in the years before the construction of the motorway. Preliminary results suggest that the motorway most markedly influences the location of non-residential building activities within the city – in favour of locations near the entrance points to/from the motorway network. The development can be explained in part by municipal planning, which in some instances has opened up the new locations for development far ahead of market demand – and in part by an increasing demand for exposed and accessible sites for business development which still seems to be in its beginning.

Keywords: motorways, ex-post, building, mapping, GIS

1. Background

This paper is an offspring from the research project Town, Road and Landscape carried out by Aalborg University in corporation with the The Royal Veterinary and Agricultural University in Copenhagen and the Danish Road Directorate (see: www.bvl.aau.dk/english). The overall aim has been to analyse urban development and land-use changes along the Danish motorway network and to point towards future strategies for the management of land-uses along the Danish motorway network. The length of the Danish motorways has almost doubled within the last 20 years and has within recent years reached 1000 km in total length. The expansion of the network continues and at the same time land-use changes and changes to urban form following the opening of the motorways is immediately visible in different parts of the country. Numerous "motorway sites" with business areas has appeared – in some instances as a "leap frog" development in urban form where the new businesses is located in an area next to the motorway – but separated from the existing urban areas by non-urbanised land. The development of new business and commercial areas on motorway sites has been debated by planners and is deemed undesirable be many. From the perspective of the traditional urban planners it is incompatible with urban containment and makes it difficult to maintain a clear distinction between urban areas and open landscape. From the perspective of road-planners and traffic engineers it causes a disturbance to the carefully planned interplay between road and landscape (as seen from and windshield as well as from the neighbours perspective) and endangers traffic safety as developments along side the roads may cause the drivers to shift their attention away from the road environment. However apart from a few thematic representations of the problem-areas no systematic analysis of land-use changes and the location of urban growth following motorway openings have been carried out. The aim of this paper is to analyse the changes in the location of business related building activities following the opening of two recent Danish motorways sections. The questions asked is whether the opening of a new motorway is associated with the establishment of new "motorway sites " for business development – and – to what a degree the new motorways appears to influence the location of the new business development – and through this urban form within the road corridor. The general hypothesis is that the opening of a motorway will be associated with development in new sites directly connected to the network and that the changes to the geographical distribution of accessibility in the motorway corridor after the opening of the motorway is likely to cause urban development to shift in favour of locations closer to the new road. The paper is however also an attempt to exploit the new possibilities offered by

micro-level geodata and geographical information systems to construct cartographic representations of the changes in urban development ("scientific visualisations" – Woudsma and Jensen, 2003) and through this to open up for an explorative approach to the assessment of the changes that, given differences in context and prerequisites, is associated with new road infrastructure.

1.1 Motorways and urban development

Theoretically the increased accessibility offered by a new high speed road connection will affect land-values and later on the location of urban development, land uses and development intensities. Several – primarily American – studies have concluded that access to motorways is associated with increased rent or increased land values (Ryan, 2005; Eyerly, 1966; Boarnet and Chalermpong, 2001; Palmquist, 1986; Huang, 1994; Siethoff and Kockelman, 2002). Other studies address the effects of motorways on location and urban development patterns over time. At the beginning of the freeway era Berry (1959) reviewed a number of before and after studies generally pointing towards changes in the land use pattern following freeway construction. Later deLeon and Enns (1973) found that the increased accessibility resulting from highway construction in St. Louis, USA was followed by increased employment densities. Their interpretation was that the improved accessibility to/from suburban sites allowed businesses to relocate to suburban sites without increasing transportation costs. Khasnabis and Babcock (1977) found that urban arteries and beltways in North Carolina, USA caused urban development to shift and centre around the new facility. Analysing a number of urban areas in the US, Frost and Ludwig (1978) found that the largest proportion of new office locations occurred in interstate radial corridors. Through detailed mappings of phases of changing land-uses in freeway corridors Baerwald (1978; 1982) and Erickson and Gentry (1985) found urban nucleation's (new business complexes) around freeway interchanges and a corresponding concentric pattern of land use as these sharply increases land values. In the Chicago area, Kawamura (2001) found that businesses moved closer to the freeway ramps between 1981 and 1999. In a comprehensive study of urban beltways in the US, Payne-Maxie consultants and Blayney-Dyett, Urban and regional planners (1980) concluded that the urban beltway can increase development opportunities in its corridor and reinforce prevailing urbanisation patterns. Thus there is a considerable amount of evidence that the opening of new motorways influences location patterns and urban form – but also that this effect is conditioned by a number of other factors. The beltway-study by Payne-Maxie consultants and Blayney-Dyett, Urban and regional planners (1980) addresses this directly and concludes that a beltway will not be sufficient to counterbalance a poor image or to create a market where none historically existed. Industrial and

office park developers are willing to pay a premium for corridor and interchange area sites with accessibility to and visibility from the beltway – but the presence of the beltway is less important than the availability of developable land and the accessibility to a skilled labour force (Payne-Maxie consultants and Blayney-Dyett, Urban and regional planners, 1980). Similarly Moon (1988) finds that the land use around non-urban freeway interchanges is dependent on the existing "latent demand" in the area.

Other studies has focussed on the effect of the construction process (stage versus non-stage construction – see Buffington et. al., 1985), the shape/type of interchanges (see fore instance Moon, 1988) and lastly the effect of capacity increasing projects. Sanchez et. al. (1999) and Sanchez (2004) fore instance found that capacity increasing projects produced a significant gradient of land-use change around the project.

Few studies has employed the new possibilities that disaggregated geodata provides. Boarnet and Chalermpong is an exception as they use sales prices on individual buildings to assess the development in sales prices from before till after the new toll road. But on the other hand they are not concerned with cartographic representations and visualization of the trends. Other studies has bee more interested in the cartography and the resulting geographical pattern, but have fore instance relied on orto-photo in order to derive urban development patterns (fore instance Sanchez et. al., 1999; Sanchez, 2004). This can be seen as a rather crude approach that has a very geographically expansive form of urban development as its prerequisite. In the Danish case where urban areas have not expanded much geographically since the 1970´s the changes in the location of activities within existing urban areas would have to be taken into account in order to detect the changes in growth patterns.

2. Data and methodology

This paper attempts to analyse shifts in location of business-related building activities using a before and after methodology. The overall idea is to map the location of building activities before the motorway and after the motorway and describe the changes in location patterns. The result will be "scientific visualizations" of actual growth patterns (all things unequal) and a number of inventories that will highlight how the location of building activities has changed vis-à-vis the new

motorway and the largest urban nodes in the selected corridors. The question of causality is a difficult one – partly because of the road planning process, that generally aims to place the roads where they are thought to be most needed – and partly because of urban planning (zoning) that is a prerequisite for urban expansion and which may – more or less independently – shape urban form based on planners or politicians beliefs regarding what types of locations that is preferred by the businesses they are trying to attract. However the maps and the associated inventories will provide evidence on the actual development and thus provide valuable input for the discussion on the effects of motorways and its preconditions.

2.1 Case-corridors

The analysis focuses on two case-corridors that opened in 1990s. The first case is the motorway between the city of Kolding and the city of Esbjerg that opened between June 1996 and September 1998. 65 km of new motorway connected the city of Esbjerg in west Jutland with the north-south going motorway. The road planning process was officially initiated by the Danish parliament in 1986 and the final location and layout of the road was decided upon in 1989. For the purpose of the analysis the period from 1989 till 1998 is considered to be the time where the location of the road is known and under construction. Thus building activities before 1989 (1984-1989 – both included) will be compared to building activities after 1998 (1999-2003 – both included).

The second case-corridor is the motorway between the city of Århus and the city of Aalborg that opened in 1992 and 1994. It is an expansion of the north-south motorway to the north of the city of Århus. Bypasses had been constructed at the city of Aalborg and the city of Randers (on the road) around 1970 and the 100 km of new motorway that was added in 1992/1994 connected these approximately 25 km of bypasses to the national network. The road planning process is more difficult to delimit in time as the Danish parliament took a number of principal decisions on the location of the north-south motorway in the area in the mid sixties. Later debates questioned whether this road should be build, but the first section on the road was eventually initiated in 1985 and subsequent sections was initiated by the Danish parliament in 1986 and 1988. The final placement of the road was very close to the 1965 proposal but because of the long time periods and the uncertainty involved, the 1985 decision by the parliament is used to delimit the period before the road from the period of construction (1985-1994 – both included). Thus building activities before 1985 (1976-1984 – both included) will be compared to building activities after 1994 (1995-2003 – both included).

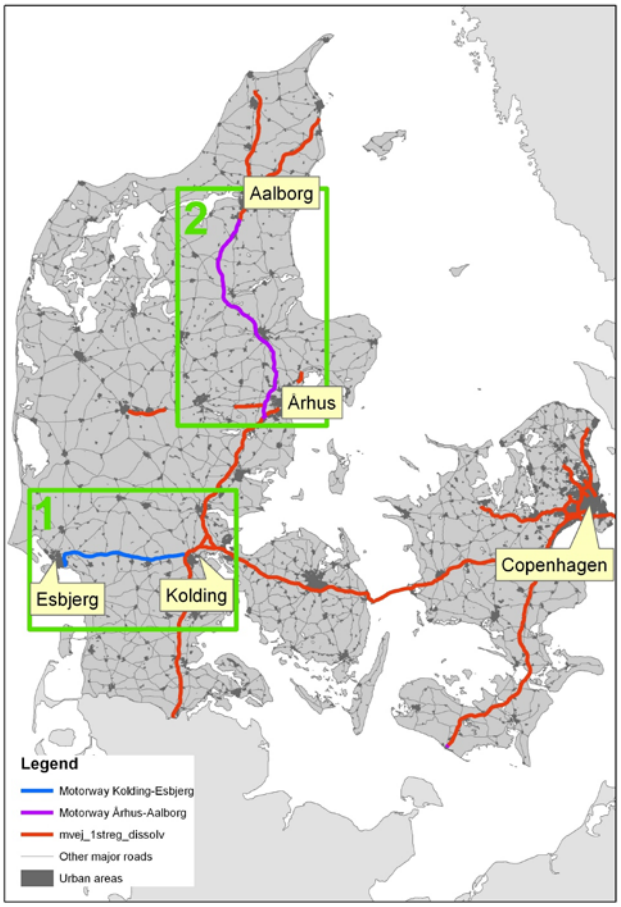


Figure 1: The selected case-corridors (green frames)

2.2 Data

The main data input for the analysis were the Danish building register (BBR – see www.ois.dk). The register is maintained by the Danish municipalities and contains information on the individual units (apartments, dwellings), buildings and properties. Due to a recent arrangement access to the data has been greatly improved and at the same time most of the buildings has been located geographically allowing a fairly exact analysis of the buildings present at a given location, when they were build etc. The database used in this analysis is the building register that has the individual buildings as data-units with their attributes such as floor-space, business floor-space, residential floor-space, year of completion and address coordinates. In total a little over 4 million Danish buildings is included in the register. In this study the buildings is geocoded based on address coordinates. The buildings constructed before and after the motorway in the respective case-corridors was identified based on their year of completion.

2.3 Mapping the data

Because of the number of scale of analysis and the number of buildings involved the building register information has to be aggregated in order to arrive at a "readable" representation of growth patterns. A data grid – where the building volumes is summarised on grid-cells of fore instance 1x1 km is one option and the maps would thus resemble the ones presented by Sanchez (2004). Other options are neighbourhood statistics where the building volumes within given buffer distances is calculated or kernel densities where the individual buildings and their floor-space is given a distribution in space before the densities is summarised on a superimposed grid. A kernel density function was chosen in this case – partly because it makes good use of the disaggregate information in the dataset – and partly because the result is visually appealing and intuitively easier to associate with actual growth patterns compared to the grid that contrasts the often more organic form of actual urban forms and patterns. The maps were drawn to represent the volume of business floor-space added by area. Experiments were made with the kerneldensity function to find a suitable level of aggregation. Based on inspection of mappings derived from different levels of aggregation – it was chosen to assign the individual buildings a normal distribution with a standard deviation on 500 meter – and a summary of the resulting densities by area on a 100x100 meter grid (see figure 2). The main concern in choosing the kerneldensity function was that it should not be too aggregate – as this would make it difficult to detect development on smaller sites. However the level of aggregation should also allow a reasonable visual inspection of location trends across the 60-70 and 125 km long corridors chosen for the study.

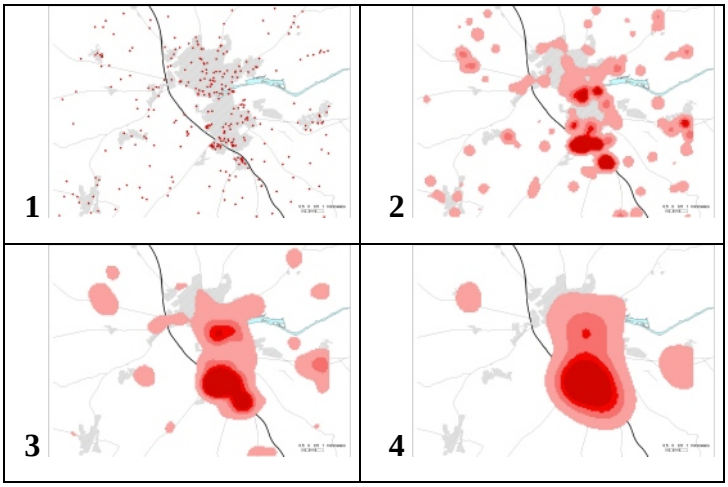


Figure 2: Mapping the added business floor-space in the city of Randers. The data input is buildings located by address coordinates (picture 1). Pictures 2-4 shows the effect of different specifications of the kerneldensity function. Picture 2, SD=250 m, picture 3, SD=500 meter, picture 4, SD=1000 meter.

3. First case: The Kolding-Esbjerg motorway

3.1 Timing

The first case-study is the motorway between the city of Kolding and Esbjerg on the peninsula of Jutland. The approximately 65 km of new motorway was opened between 1996 and 1998. Prior to this the Danish parliament had decided to build the road in 1989 after a couple of years of preliminary inquiries into different routes, types of roads etc. It was not decided from the beginning of the process that the new road should be a motorway and this decision was taken by the Danish parliament against the recommendations put forward by the Danish road directorate. Therefore the year 1989 where the final route and type of road is decided upon can be considered as a fairly good distinction of the time before the motorway from later points in time. As land use changes in the corridor is thought to be associated with the municipal planning for the location of new business areas around the motorway – a process that may begin as soon as the exact location of the road is known – and the accessibility benefits generated by the opening of the new road, - the "after" period is placed from the year after the opening of the last section of the road and onwards (see figure 3).

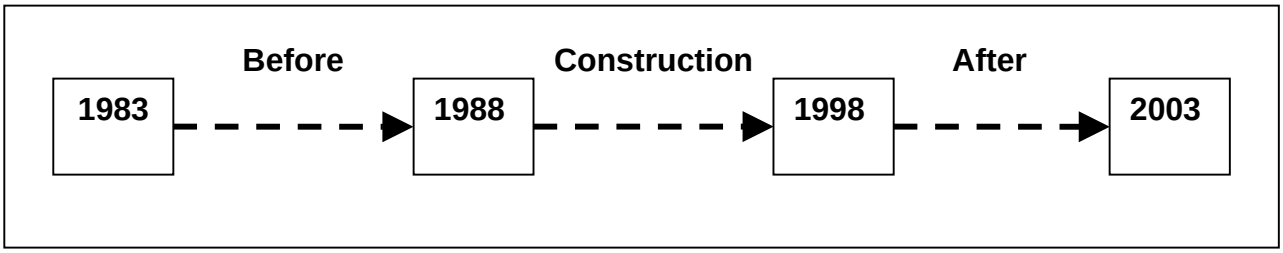


Figure 3: The timing used to delimit the period before the motorway from the period after the motorway in the Kolding-Esbjerg corridor.

It should be kept in mind that the Kolding-Esbjerg corridor - as most Danish motorway corridors has a long history as a transportation corridor. The motorway runs parallel to the old highway and improvements within the corridor has been part of several previous plans.

3.2 Kolding-Esbjerg corridor - “before” and “after” maps

The maps showing intensities of completed business floor-space before and after the motorway can be seen in figure 4 and 5. The colours and cut-off values are exactly the same on both maps to allow a direct comparison. Figure 6 displays the difference between the areas promille of business floor-space in the after period compared to the before period (difference is in promille-points).

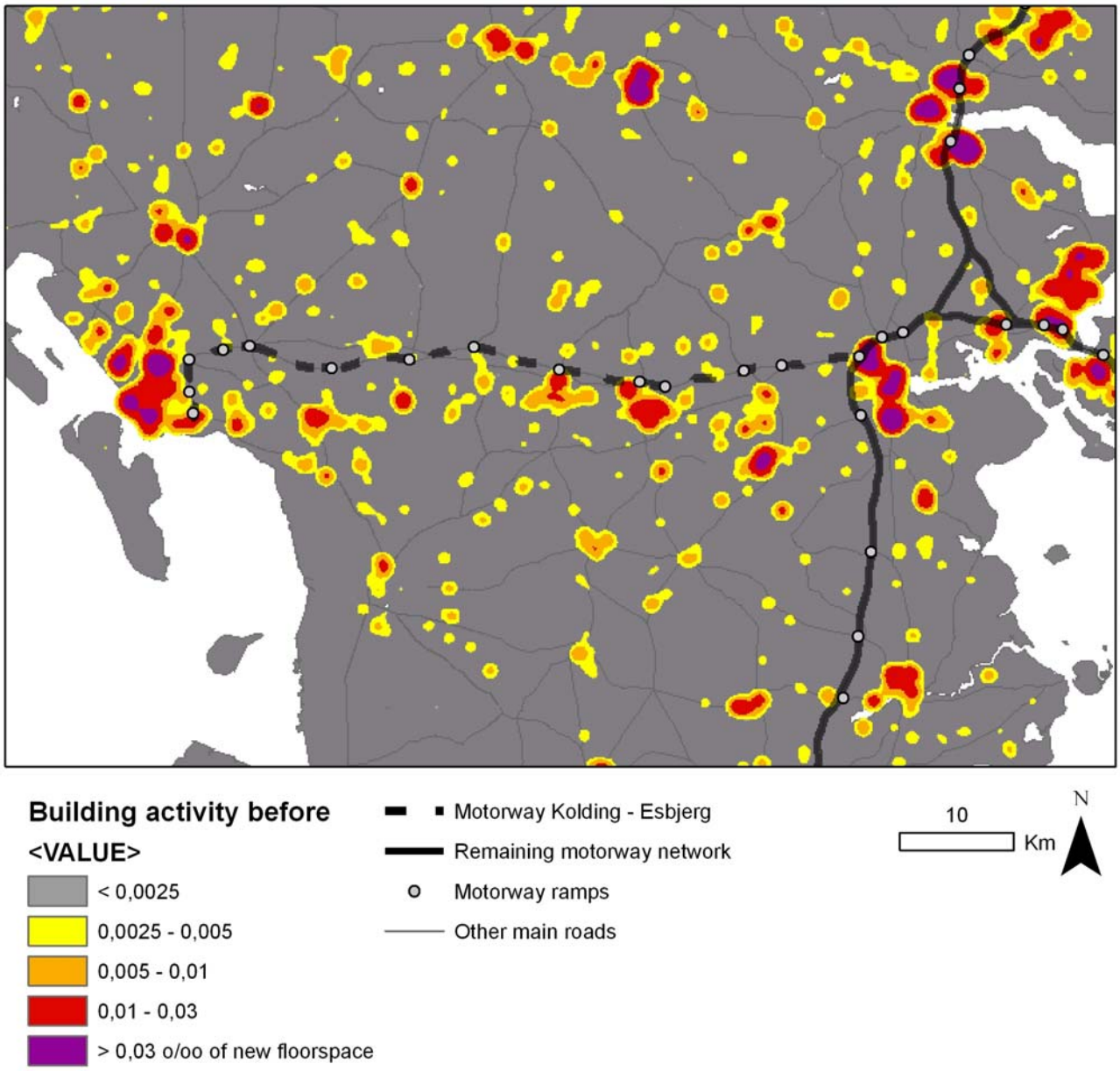


Figure 4: Business-related building activities in the Kolding-Esbjerg corridor in the 5-year period prior to the Danish parliament’s decision to build the road in 1989. Added business floor-space is mapped as kernel densities. Each building is represented with a normal distribution with 500 meter as standard deviation. The resulting floor-space densities is summarised on a 100x100 meter grid. The map shows each gridcells promille-share of added floor-space through the five-year period.

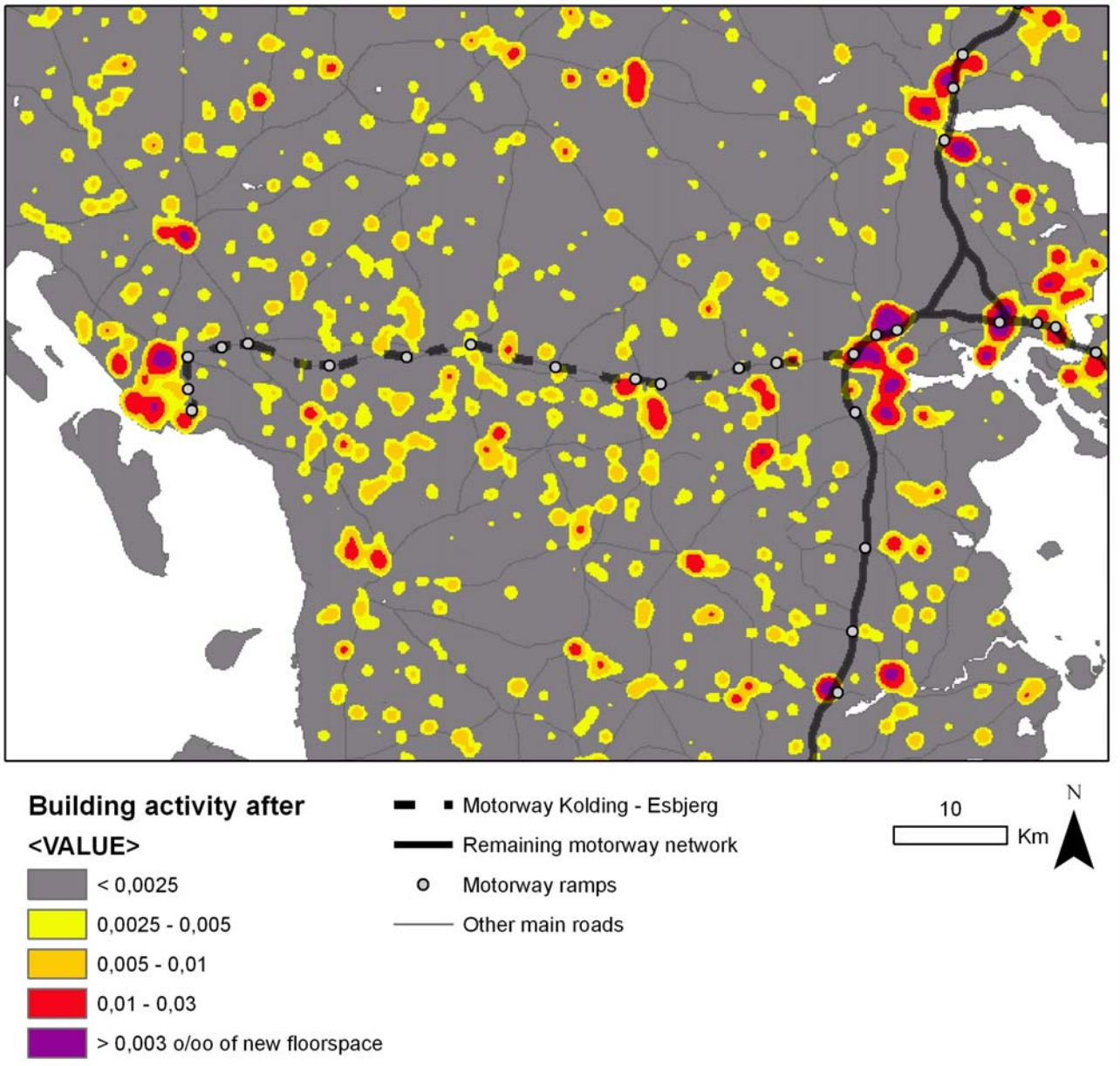


Figure 5: Business-related building activities in the Kolding-Esbjerg corridor in the 5-year following the opening of the last section of the motorway between Kolding and Esbjerg in 1998. Added business floor-space is mapped as kernel densities following exactly the same procedure that was used to map the "before" data. Each building is represented with a normal distribution with 500 meter as standard deviation. The resulting floor-space densities is summarised on a 100x100 meter grid. The map shows each gridcells promille-share of added floor-space through the five-year period.

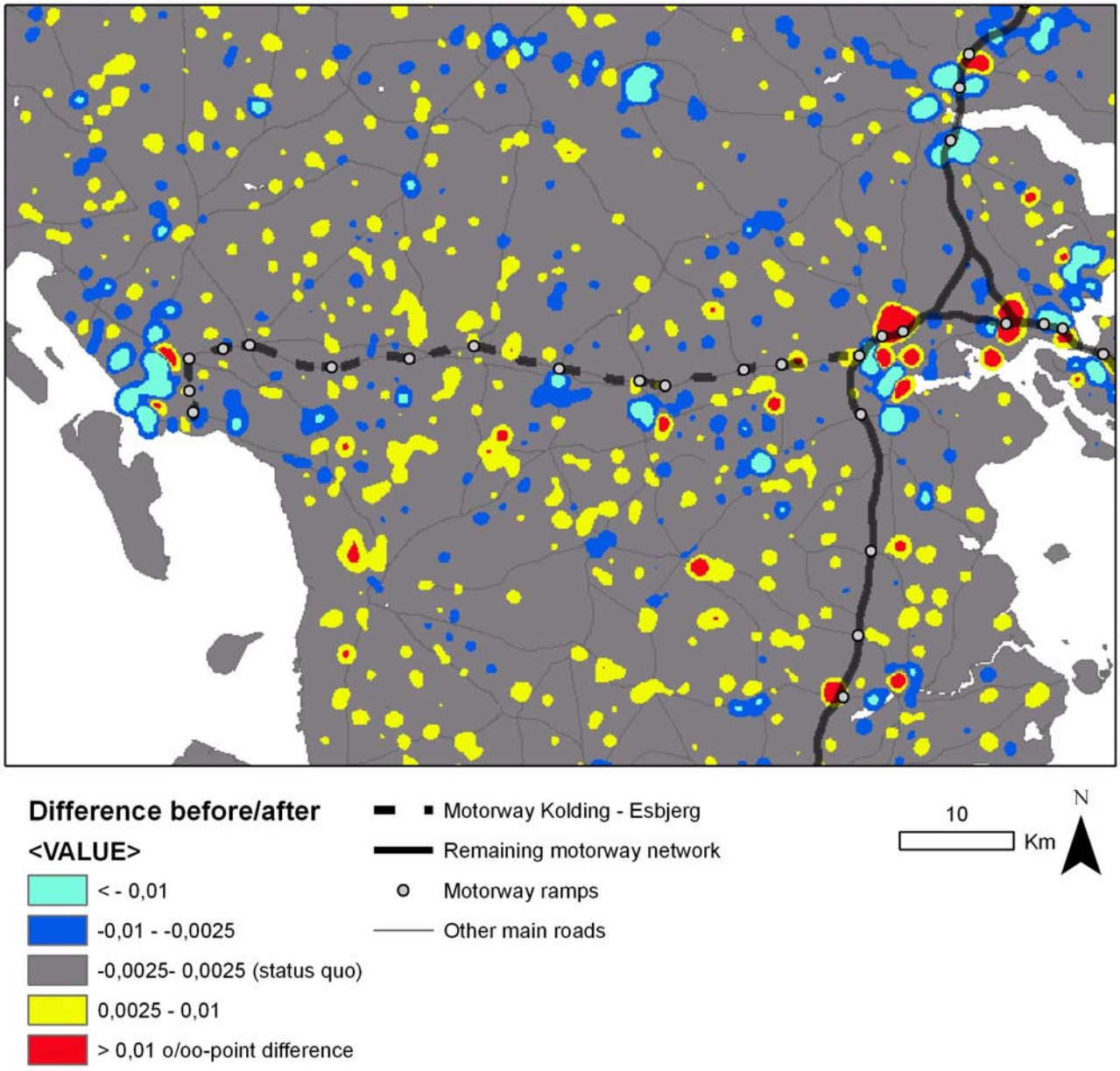


Figure 6: Difference between building activities before and after the motorway in the Kolding-Esbjerg corridor. The difference is mapped as promille-point differences between each gridcells share of added floor-space as derived from the kerneldensity treatment (figure 3 and 4).

A comparison of the maps reveals that the largest urban areas have the largest development densities before the road was build as well as after. To a large extend the development occurs in the same places as it did before the motorway was build. The changes to the development pattern from the before to the after situation can be described like this:

- A number of motorway development sites has appeared
- The level of activity at the motorway sites close to the largest cities has increased.
- The largest new business sites is located with direct access to the motorway
- Building activities outside the larger urban areas seems to be more scattered after the motorway opened (between the two large cities) than before – where most building activities was located along the old highway running parallel to the motorway.

The aggregate location of business building activities in the corridor is shown in figure 7 and 8 that highlights the shift in location along the road (buildings within 10 km from the motorway) and shift in location vis-à-vis the road (up till 10 km from the motorway). Figure 7 suggests that the location of business development in the corridor shifted towards east – from the city of Esbjerg and out into the corridor and from the corridor into the city of Kolding where the new business areas with direct access to the motorway increased its proportion of growth in business floor-space in the corridor. Figure 8 suggest that the opening of the motorway was followed by new developments that to some extend clustered around the road and reduced the distance for added floor-space to the road within the first 3-4 km. Beyond 4 km the cumulative distribution of floor-space witnesses the tendency towards dispersion in the non-urban areas that can be seen on the maps. This tendency towards dispersion is derived from the development in location patterns outside urban areas – whereas the tendency towards concentration of development around the motorway is caused by the development in the largest cities (se figure 9).

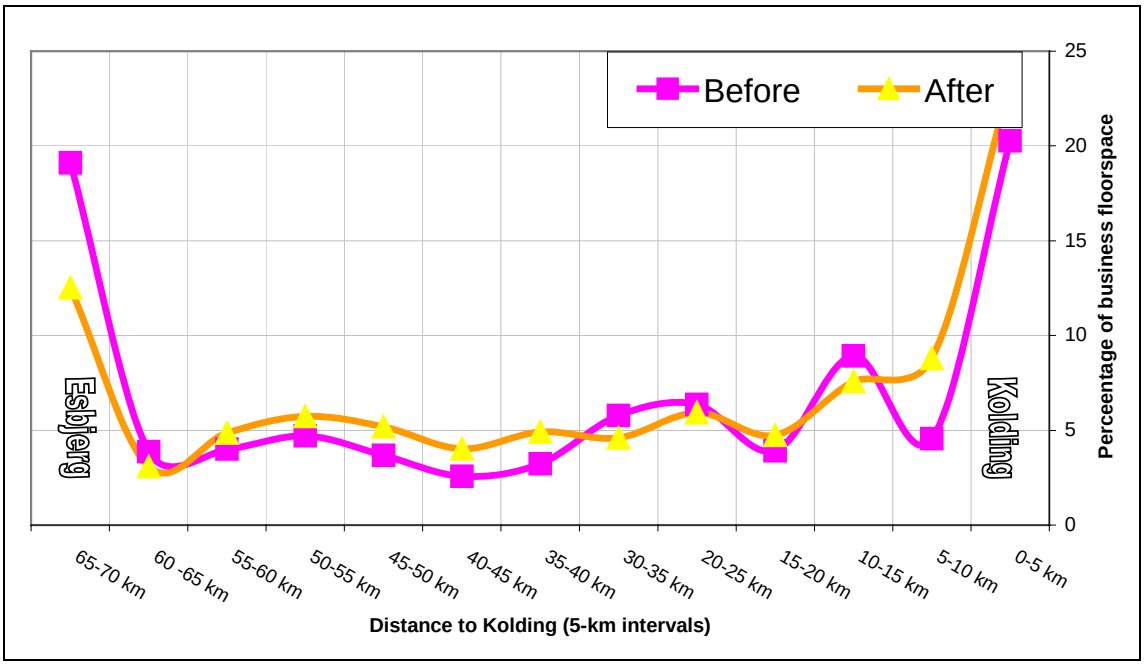


Figure 7: The distribution of added floor-space along the Kolding-Esbjerg motorway before and after the opening of the road. Areas within 10 km from the motorway is included in the inventory and distance intervals of 5-km to the city of Kolding defines the x-axis.

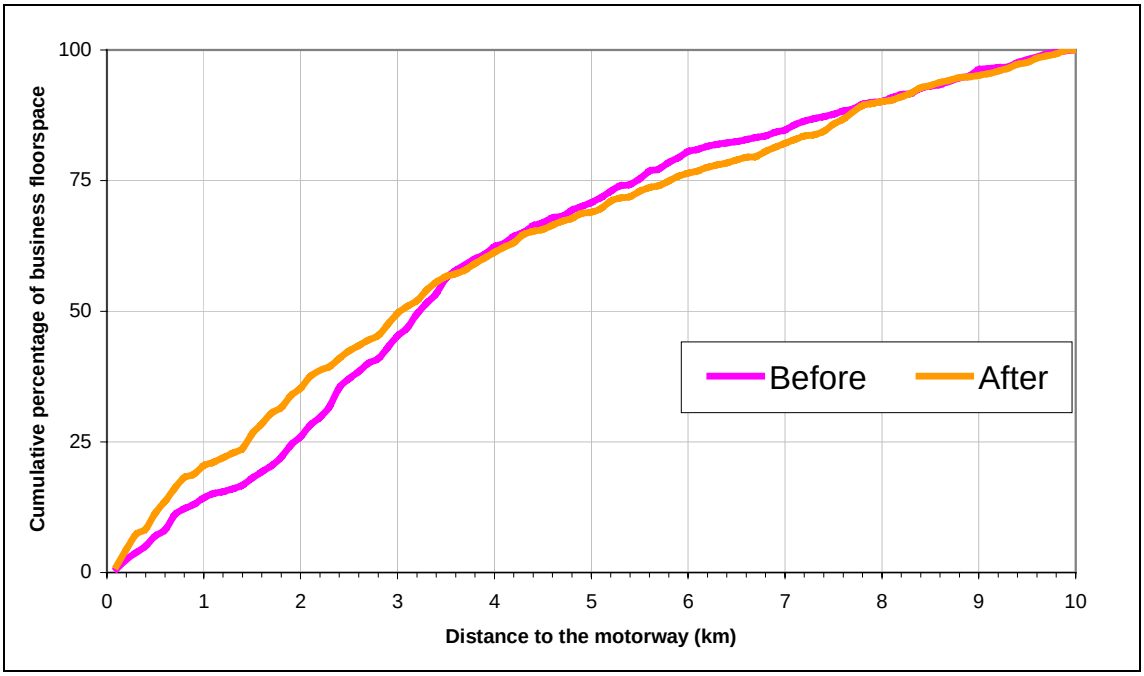


Figure 8: The cumulative distribution of added floor-space vis-à-vis the Kolding-Esbjerg motorway before and after the opening of the road. Areas within 10 km from the motorway are included in the inventory.

Figure 9 displays cumulative distributions processed in the same way as figure 8 – but for 3 sub-areas: Areas within 10 km of the centre of Kolding, Areas within 10 km of the centre of Esbjerg – and the remaining "non-urban" areas where there are only smaller cities. The development in the two large cities Kolding and Esbjerg, is towards concentration of new business floor-space around the motorway – whereas the development in the area in between these two cities is towards dispersal away from the motorway.

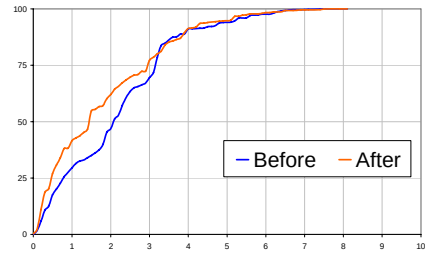
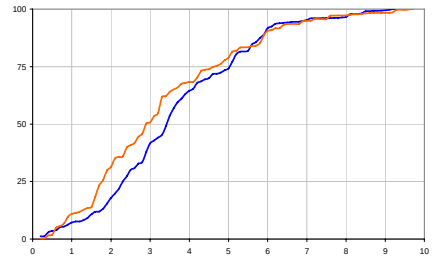
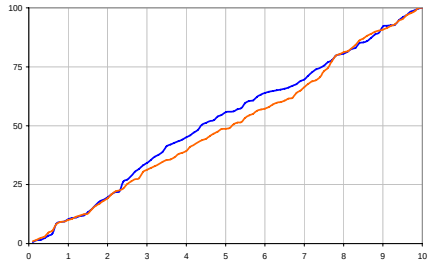
Kolding	
Esbjerg	
Non-urban	

Figure 9: Cumulative distribution of added floor-space before and after the motorway in sub-areas. Only floor-space within 10 km from the motorway is included.

In summary the changes in the pattern of business development in the corridor can be described as a build up of floor-space around the motorway in the largest cities, primarily on sites with direct access to the motorway network, a dispersal of development away from the motorway in the non-urban areas between the large cities – and a general shift in development along the motorway from west to east – where the city of Kolding marks the entrance to the densely populated areas in east Jutland. Theses developments in location patterns will be compared to the Århus-Aalborg corridor in the final chapter "summary and conclusion".

4. Second case: The Århus-Aalborg motorway

4.1 Timing

The second case-corridor is the motorway between the city of Århus and the city of Aalborg that opened in 1992 and 1994. Bypasses had already been constructed at the city of Aalborg and the city of Randers around 1970 and the 100 km of new motorway that was added in 1992/1994 connected these approximately 25 km of bypasses to the national network. The construction was initiated in 1985 for the first section which was followed by laws on the construction of additional sections in 1986 and 1988. The final routing and placement of the road was close to what came out of the debate and considerations in the mid-sixties. Despite doubts on when and if the road would ever be build – the likely location of a north-south going motorway in that part of Jutland had therefore been known quite accurately for 20 years prior the eventual decision to go ahead and build it. Thus the timing with respect to the road planning process is less clear than what was the case in the Kolding-Esbjerg corridor. For the purpose of the analysis the year 1985 where the parliament chose to initiate the road construction is chosen as the cut off point that separates the "before" period from later points in time. In a similar fashion as the Kolding-Esbjerg case the "after" period is taken to be the period from the year after road opening (1994) until present (see figure 10). Accordingly the "after" period is nine years long and the before period is given the same length (the time period used in the Kolding-Esbjerg corridor was only 5 years).

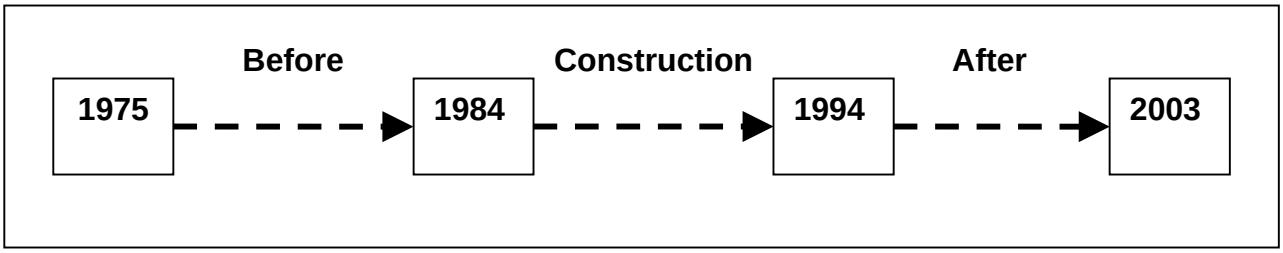


Figure 10: The timing used to delimit the period before the motorway form the period after the motorway in the Århus-Aalborg corridor.

4.2 Århus-Aalborg corridor – "before" and "after" maps

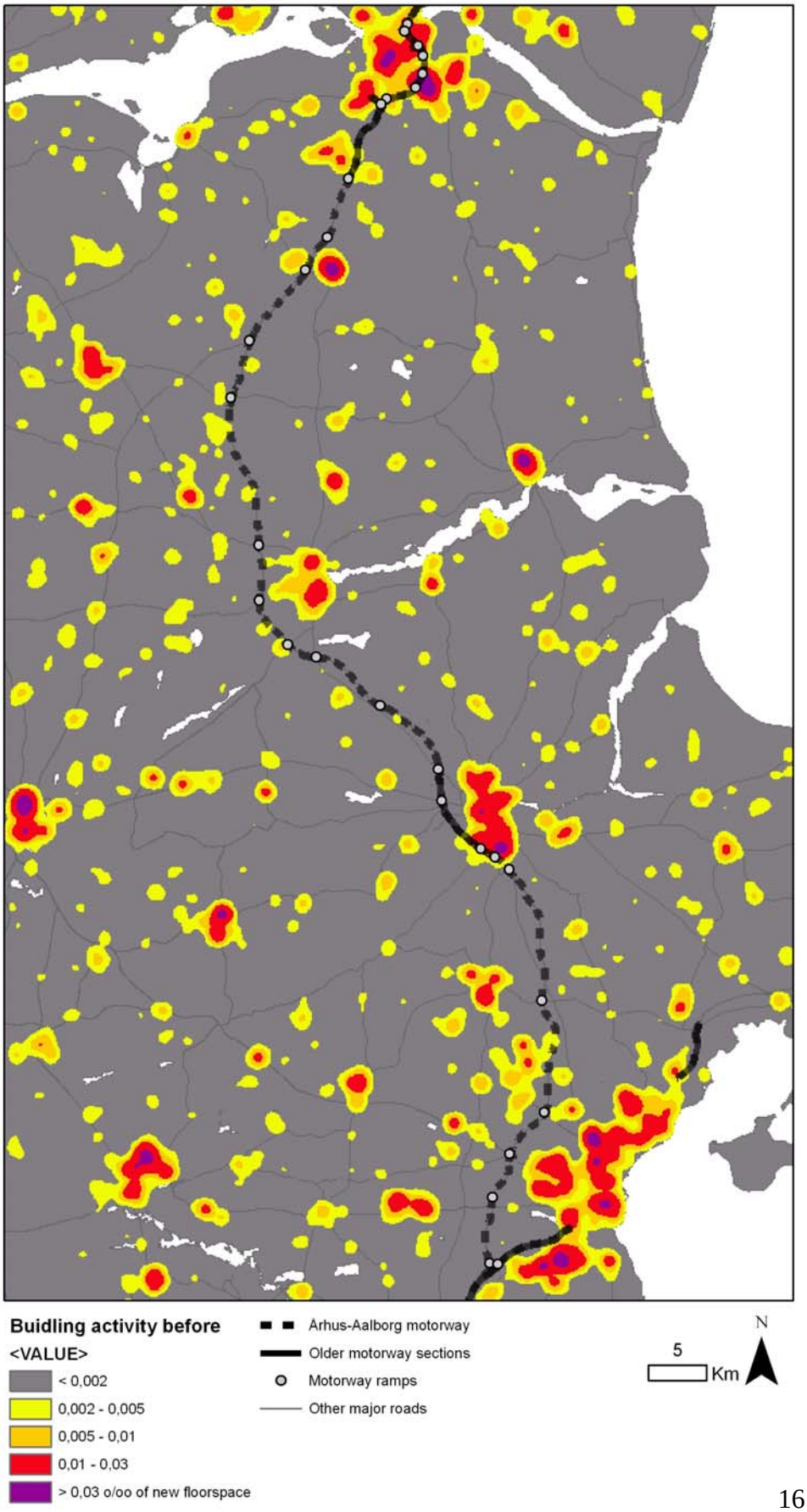


Figure 11: Business-related building activities in the Århus-Aalborg corridor in the 9-year period prior to the Danish parliament's decision to build the first section of the road in 1985. Added business floor-space is mapped as kernel densities. Each building is represented with a normal distribution with 500 meter as standard deviation. The resulting floor-space densities is summarised on a 100x100 meter grid. The map shows each gridcells promille-share of added floor-space through the nine-year period.

Figure 12: Business-related building activities in the Århus-Aalborg corridor in the 9-year following the opening of the last section of the motorway between Århus and Aalborg in 1994. Added business floor-space is mapped as kernel densities following exactly the same procedure that was used to map the "before" data. Each building is represented with a normal distribution with 500 meter as standard deviation. The resulting floor-space densities is summarised on a 100x100 meter grid. The map shows each gridcells promille-share of added floor-space through the nine-year period.

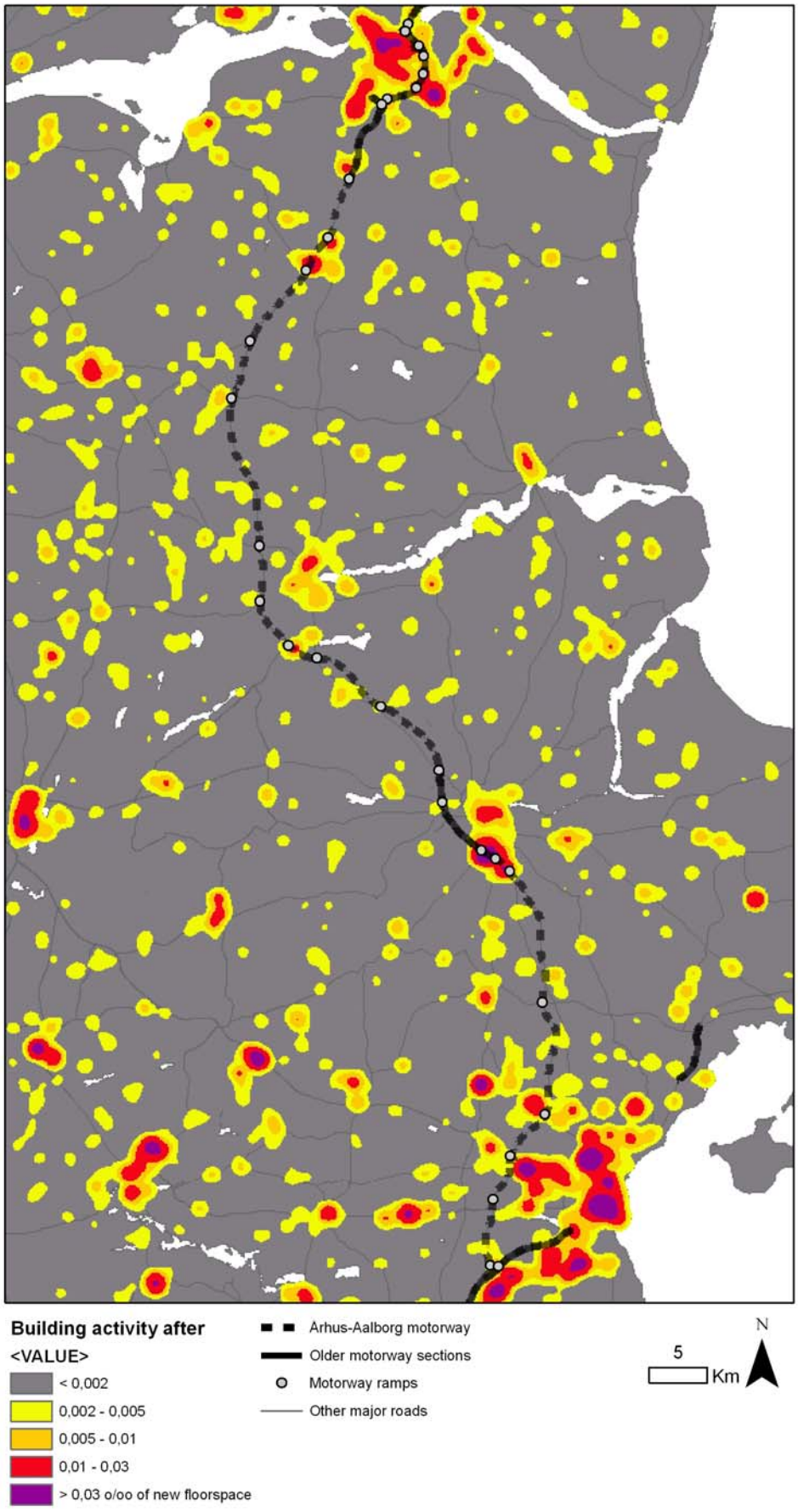
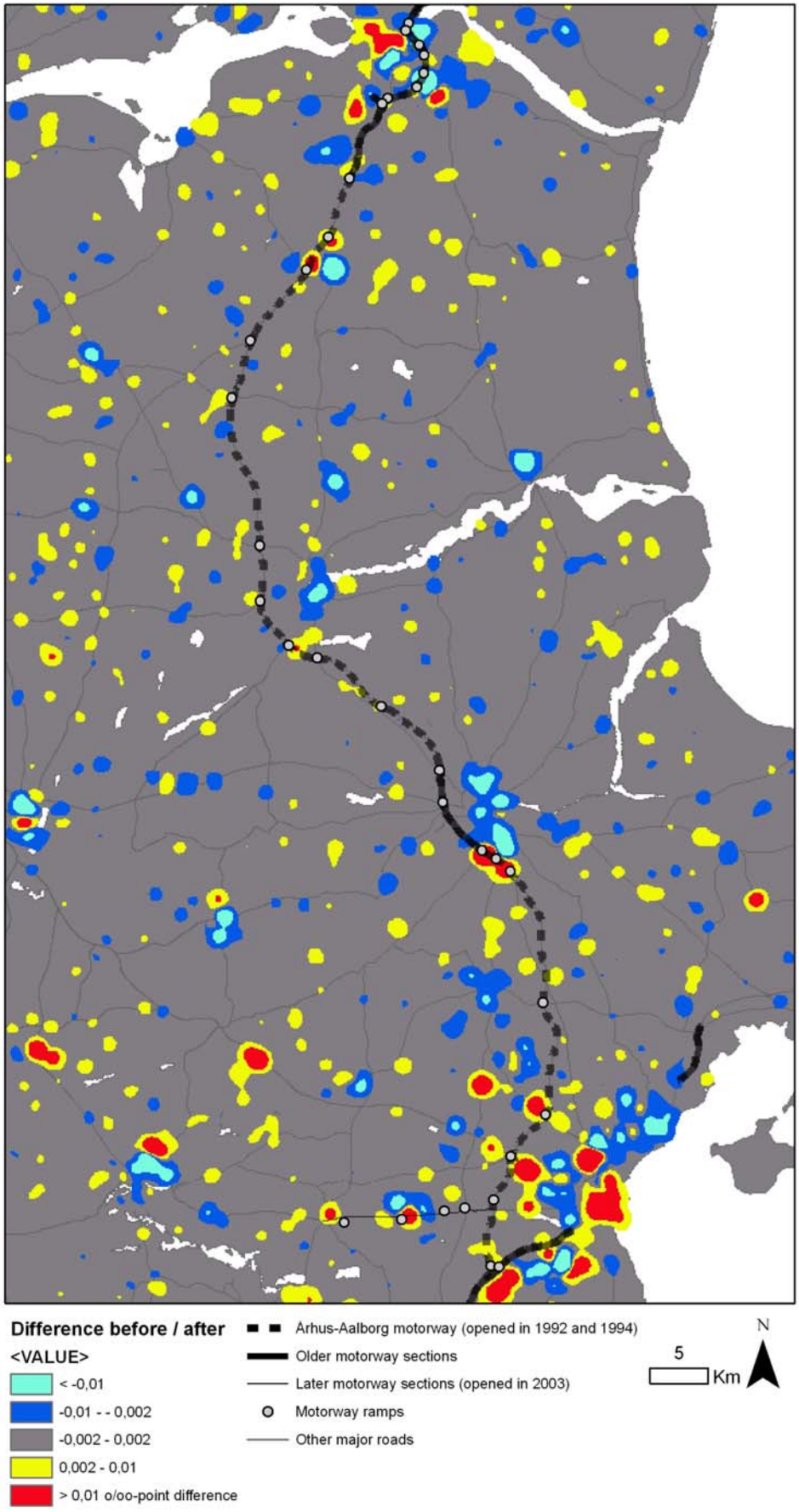


Figure 13: Difference between building activities before and after the motorway in the Kolding-Esbjerg corridor. The difference is mapped as promille-point differences between each gridcells share of added floor-space as derived from the kerneldensity treatment (figure 9 and 10).



A comparison of the Århus-Aalborg corridor maps reveals – as it was the case in the Kolding-Esbjerg corridor, that the largest urban areas has the largest development densities before the road was build as well as after. To a large extend the development occurs in the same places as it did before the motorway was build. The changes to the development pattern from the before to the after situation can be described like this:

- A number of motorway development sites has appeared
- The largest cities along the motorway generally has a minimum of one business area with direct access to the motorway – and a relative large proportion of growth in business floor-space takes place on these sites. Some cities have several of these sites.
- Motorway sites attracting a considerable proportion of growth in business floor-space has also appeared outside the largest cities. However most of the motorway sites between the largest cities seem to be small.
- Contrasting the finding from the Kolding-Esbjerg corridor there is no evidence of a development towards dispersion of business development from before till after.

The aggregate location of business building activities in the corridor is shown in figure 14 and 15 that highlights the shift in location along the road (buildings within 10 km from the motorway) and shift in location vis-à-vis the road (cumulative distribution up till 10 km from the motorway). Figure 14 suggests that the location of business development in the corridor shifted towards south – and especially favoured Denmark's second largest city Århus – and the space in between Randers and Århus. The development is comparable with the Kolding-Esbjerg corridor – as the shift along the motorway in both cases is a shift away from the periphery towards the densely populated urban region in east Jutland.

Figure 15 suggest that the opening of the motorway was followed by a general tendency for the new developments to cluster clustered around the motorway and reduce the median distance for added floor-space to the road (within the first 10 km). There was however some differences to the trend in the different sub-areas of the corridor (se figure 16).

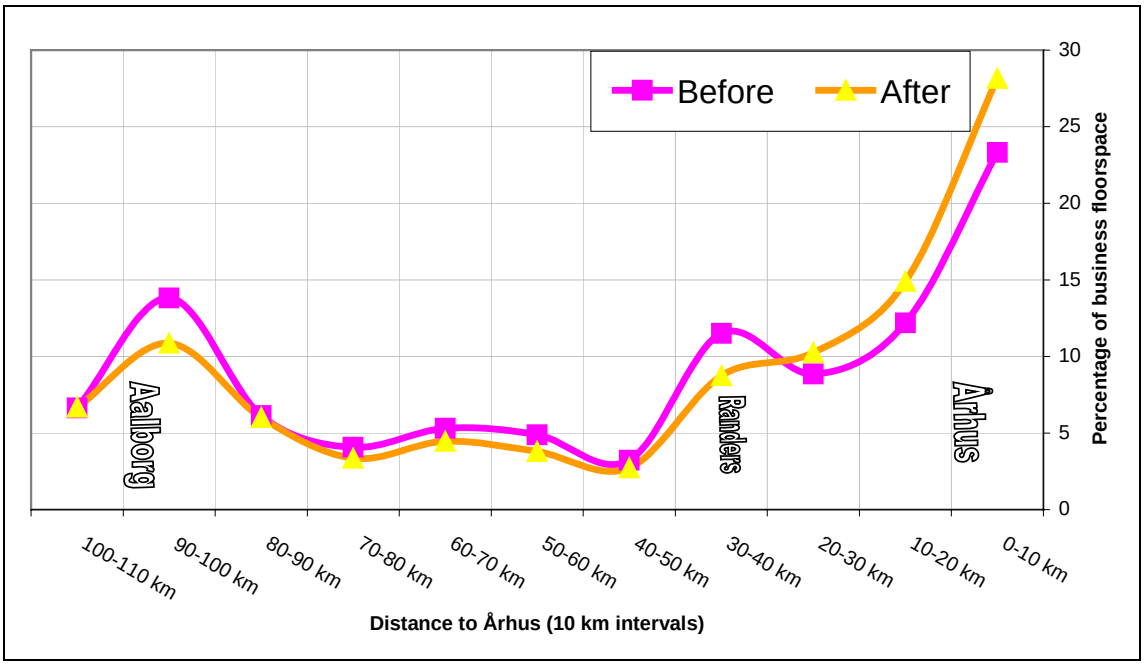


Figure 14: The distribution of added floor-space along the Århus-Aalborg motorway before and after the opening of the road. Areas within 10 km from the motorway is included in the inventory and distance intervals of 10-km to the city of Århus defines the x-axis.

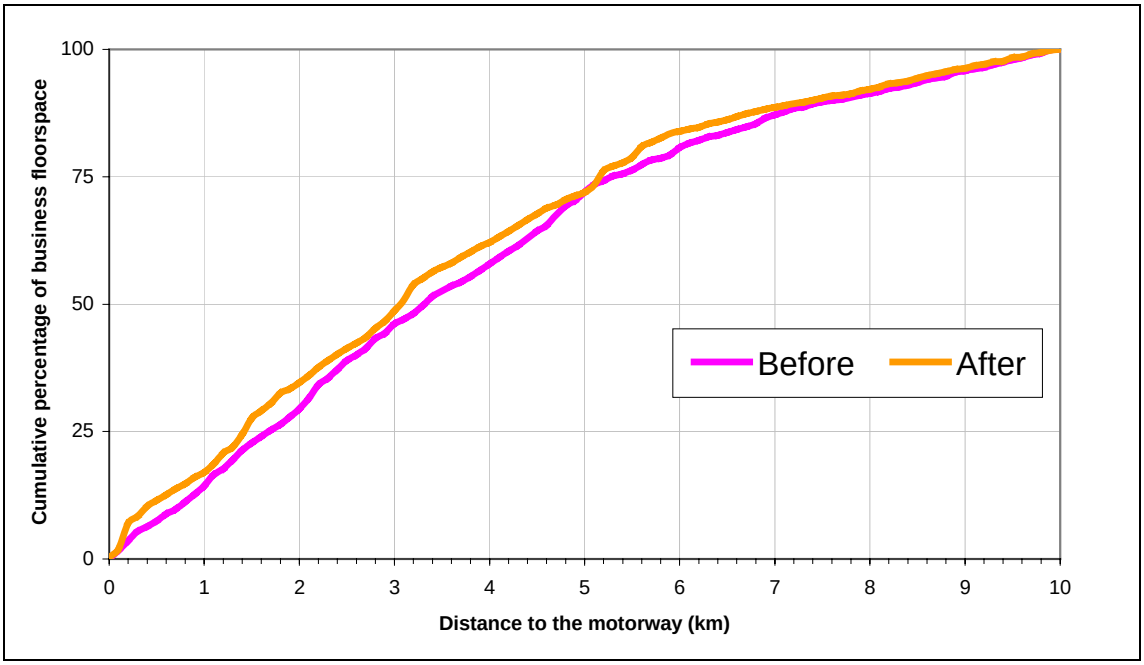


Figure 15: The cumulative distribution of added floor-space vis-à-vis the Århus-Aalborg motorway before and after the opening of the road. Areas within 10 km from the motorway are included in the inventory.

Figure 16 displays cumulative distributions processed in the same way as figure 15 – but for 5 sub-areas: Areas within 10 km of the centre of Århus, within 10 km of the centre of Randers, within 10 km of the centre of Hobro, within 10 km of the centre of Aalborg – and the remaining "non-urban" areas. The trend in the location of new floor-space in the city of Aalborg is in the opposite direction of the motorway. The city of Århus shows a weak tendency towards clustering around the motorway. Both cities have motorway sites and the likely explanation of the aggregate trend is that the renewed development of central areas – notably the harbour-areas counterbalances growth on motorway sites on the fringe. The cities of Randers and Hobro and the non-urban areas between the large cities all display a tendency towards clustering of new business development around the motorway.

In summary the changes in the pattern of business development in the corridor can be described as a build up of floor-space around the motorway in the mid-sized cities and the non-urban areas between the cities. In the largest cities the development can be described as polarisation as development is occurring in central areas as well as on

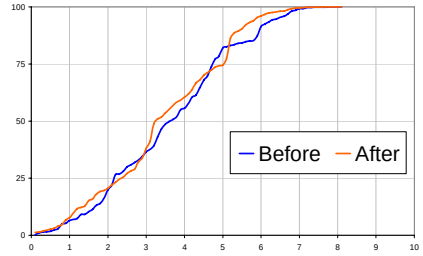
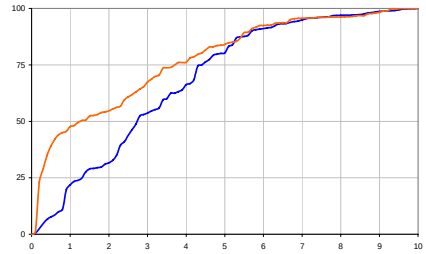
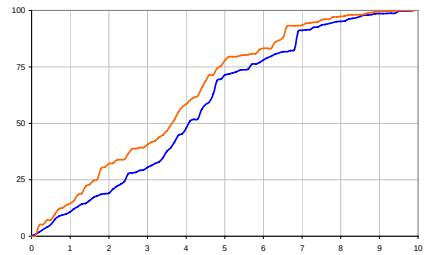
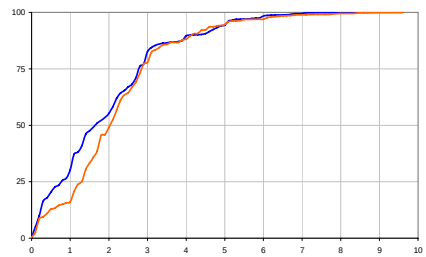
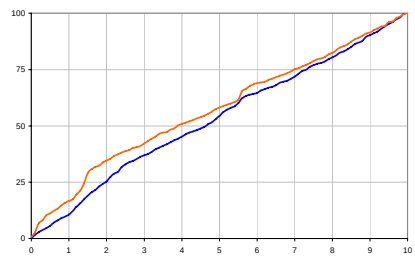
Århus	
Randers	
Hobro	
Aalborg	
Non-urban	

Figure 16: Cumulative distribution of added business floor-space before and after the motorway in sub-areas. Only floor-space within 10 km from the motorway is included.

motorway sites on the fringe. Simultaneously development generally shifts towards south where the areas in and near the city of Århus hold a larger proportion of total added floor-space in the years after the opening of the motorway.

5. Summary and conclusion

These papers has presented maps on the location of added business floor-space, before and after the motorway was build in two Danish motorway corridors. The data-scource was the Danish building register and with address-coordinates on the individual buildings. The findings can be summarised under the three headings: motorway sites, clustering tendencies and shifts along side the motorway.

Motorway sites

In both case corridors the construction and opening of the motorway is followed by building activity on a number of "motorway sites" in the sense that these – often new sites separated from existing build up areas – is located in the immediate vicinity of the new road (often with access within a very short distance and/or visibility form the road). In both corridors the motorway sites with the highest buildings intensities is located in conjunction with the largest cities in the corridor. In the Kolding-Esbjerg corridor, development on motorway sites in non-urban areas has a very limited extend. In the Århus-Aalborg a comparatively larger part of development took place on non-urban motorway sites – and the four large and mid-sized cities all shifted a proportion of their growth in business floor-space to sites next to the motorway.

Shift in locations vis-à-vis the motorway

An aggregate shift in the location of new floor-space in the direction of the motorway was evident in the Århus-Aalborg corridor where this development was especially strong around the mid-sized cities in the middle of the corridor – and it was also present in the non-urban areas between the mid-sized and larger cities. In the Kolding-Esbjerg corridor the shift in the direction of the motorway only included the areas within 3-4 km from the motorway. The explanation being that a large proportion of growth after the motorway occurred on sites very close to the motorway primarily immediately outside Kolding but also outside the city of Esbjerg – while the locations in the non-urban parts of the corridor appeared to be more dispersed after the motorway than it was before.

Shifts in location along side the motorway

The development in both corridors displayed a shift in the location of the growth in floor-space towards the densely populated urban region in east Jutland. It is outside the scope of this analysis to assign responsibility to the motorway for this development. According to recent writings on the spatial development of the Danish urban system this could be part of a general trend: everything shifts towards the capital and the urban region in east Jutland (Christoffersen, 2003).The strategy adopted for the expansion of the motorway network can however bee seen as an underpinning of the centrality of the urban region in east Jutland (see for instance Fisher, 1962 – on the significance of network configuration) and it therefore could stimulate further concentration in that area (given high levels of mobility).

The differences between the two corridors: dispersal away from the motorway in non-urban areas the Kolding-Esbjerg corridor – and concentration around the motorway at the fringe of the largest cities – versus concentration around the motorway in the non-urban areas in the Århus-Aalborg corridor and the mid-sized cities – can be ascribed to several factors: The Kolding-Esbjerg motorway is younger than the Århus-Aalborg motorway. The Danish ministry of the environment has raised awareness on the detoriating effects on urban containment of “loose” motorway business sites – an aspect that is likely to have influenced zoning in the Kolding-Esbjerg corridor more than the Århus-Aalborg corridor. The location-pattern for business floor-space in the Kolding-Esbjerg corridor was already clustered around the highway running parallel to the new motorway. Thus given an increased protection of the sites that would be immediately visible from the motorway, the old highway will effectively be an American style “frontage road” available for business that value good access to the motorway. On top of this the opening of the motorway may improve the conditions for development at sites in some distance from the road with a dispersion as the aggregate result (see fore instance the finding of Sanchez et. al., 1999; Sanchez, 2004). The overall short distance from the areas in the Kolding-Esbjerg corridor to the infrastructure hub in east Jutland, the Capital and the German border may also play a part in this respect. However it will be interesting to see whether this trend will continue over a longer time-span than the 5 year period taken into consideration here.

Comments on the methodology

The mappings and inventories can be seen as exploratory analysis of actual development trends in corridors likely to be affected by new road infrastructure. The mappings and inventories may help to provide new perspectives in a field that is extremely complex and effected by numerous factors. In order to arrive at a more rigid interpretation of the shifts in urban form and development brought about by the opening of new motorways – there are two different paths. The first would be case-studies of smaller areas (urban areas) that could take the development of traffic, commute patterns, and urban planning into consideration together with business locations. This type of studies could be particularly helpful when it comes to the role of planning. The second type of study would try to objectify the spatial location and preconditions for growth as quantitative variables in order to try and single out the effects in a statistical analysis (fore instance similar to Sanchez, 2004). This type of analysis would be particularly helpful in trying to quantify the all-things-equal effect of the accessibility provided by the new infrastructure. However the path dependent (Arthur, 1988) nature of growth and the location of the new motorways in established corridors will cause some problems no matter what.

Bibliography

Arthur, W. B. (1988). Urban systems and historical path dependence. In: Ausubel, J. H. and Herman, R. (Ed.), *Cities and their vital system: Infrastructure past, present and future*, National acandemy of sciences

Baerwald, T. J. (1978). The emergence of a new “downtown”. *Geographical review*, vol. 68, issue 3, pp 308-318

Baerwald, T. J. (1982). Land use change in suburban clusters and corridors. *Transportation research record* 861, pp 7-12

Berry, B. J. L. (1959). Recent studies concerning the role of transportation in the space economy, *Annals of the association of American geographers*. Vol. 49, issue 3, pp 328-342

Boarnet, M. amd Chalermpong, S. T. (2002). *New highways, Induced travel and urban growth patterns: A before and after test*, The University of California transportation center and the environmental protection agency

Boarnet, M. G. and Chalermpong, S. (2001). New highways, house prices, and urban development: A case study of toll roads in Orange county, CA, *Housing policy debate*, vol. 12, issue 3, pp 575605

Buffington, J. L.; Chui, M. K. and Memmott, J. L. (1985). Effects of freeway stage construction on nearby land uses and vehicle user costs. *Transportation research record* 1046, pp 62-69

Christoffersen, H. (2003). *Det danske bymønster og landdistrikterne*, AKF-forlaget, Copenhagen

deLeon, P. and Enns, J.(1973), The impact of highways upon metropolitan dispersion: St. Louis. The rand corporation, Santa Monica, California

Erickson, R. A. and Marylynn, M. (1985). Suburban nucleations. *Geographical review* vol. 75, issue 1, pp 19-31

Eyerly, R. W. (1966). Land *use and land value in four interchange communities: an interim report on the york study*, The Pennsylvania state university in coorperation with The Pennsylvania department of highways, University Park, Pennsylvania

Feitelson, E. and Salomon, I. (2000). The implications of differential network flexibility for spatial structures, *Transportation research part A*, vol. 32, 459-479

Fisher, H. T. (1962). Radials and circumferentials – an outmoded urban concept?, In: Williams, T. E. H. (Ed.), *Urban survival and traffic*, E. and F. N. Spon limited, London

Frost, M. and Ludwig, A. K. (1978). Attraction of interstate radial freeway corridors for new office sites, *Transportation research record* 686, pp 10-17

Huang, W. (1994). *The effects of transportation infrastructure on nearby property values, A review of the literature*, Working paper 620, Institute of urban and regional development, University of California at Berkeley

Kawamura, K. (2001). Empirical examination of relationship between firm location and transportation facilities. *Transportation research record* 1747, pp 97-103

Khasnabis, S. and Babcock, W. F. (1977). Analysis of freeway impact in five urban areas in North Carolina. *Transportation research record* 638, pp 26-32

Moon, H. E. Jr. (1988). Modelling land use change around non-urban interstate highway interchanges, *Land use policy*, pp 394-407

Palmquist, R. B. (1986). Impact of highway improvements on property values in Washington state, *Transportation research record* 887, pp 22-29

Payne-Maxie consultants and Blayne-Dyett, Urban and regional planners (1980). *The urban land use and urban development impact of beltways*. U.S. Department of Transportation, U. S. Department of Housing and Urban Development, Washington D. C.

Ryan, S. (1999). Property values and transportation facilities: Finding the transportation land-use connection. *Journal of planning literature*, vol. 13, issue 4, pp 412-427

Ryan, S. (2005). The value of access to highways and light rail transit: evidence for industrial and office firms, *Urban studies*, vol. 42, no. 4, pp 751-764

Sanchez, T. (2004). Land use and growth impacts from highway capacity increases, *Journal or urban planning and development*, vol. 130, no. 2, pp 75-82

Sanchez, T. W., Dueker, K. J. and Rufulo, A. (1999). Geographic information system methodology for assessing growth effects of highway improvements, *Transportation research record* 1660, pp 75-83

Siethoff, T. and Kockelman, K. M. (2002). Property values and highway expansion, Timing, size, location and use effects, *Transportation research record* 1812, pp 191-200