The Impact and Performance of Industrial Sites

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THE IMPACT AND PERFORMANCE OF INDUSTRIAL SITES:
EVIDENCE FROM THE NETHERLANDS

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The Impact and Performance of Industrial Sites: Evidence from the Netherlands

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promotoren: prof.dr. P. Rietveld
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Chapter 1

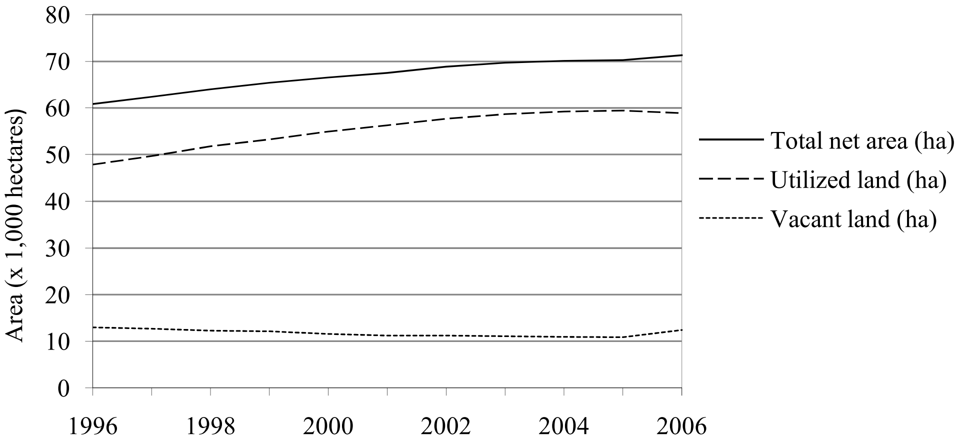
Introduction

1.1 Setting the scene

Industrial sites are the result of urban policy aimed at providing places to work. Working and living are spatially separated, as the land uses concerned are considered incompatible, i.e. industrial land is supplied at locations which are primarily intended to accommodate firms, and not residences or recreational activities (O'Sullivan, 2003; De Graaf, 2005; Snep, 2009). In the Netherlands, the conventional approach is that any firm that wants land on an industrial site should be able to buy a plot of land, already serviced and without delay, from the municipality. Accordingly, the municipality should buy and service land for industrial sites so as always to be able to offer suitable plots (Needham and Louw, 2006). This practice embraces both a spatial and an economic dimension. In fact, (local) economic policy meets spatial policy in the field of industrial-site provision (Louw et al., 2004; Olden, 2010). Spatial policy is primarily aimed at a balanced assignment of space to the various spatial functions, which has to take account of various land-use claims. But economic policy is primarily focussed on promoting local economic growth, by providing sufficient space for economic activity. Accordingly, Dutch industrial-site planning implies multifaceted objectives, and ditto outcomes.

Industrial sites have become the main location for supplying industrial land in the Netherlands. Slowly but steadily, both the amount and share of employment on industrial sites are rising. Industrial sites have become a favourable place to settle for many firms (Louw and Bontekoning, 2007), and can be considered important contributors to the (local) economy: such sites accommodate 2.4 million jobs, which was 32 per cent of the total employment in the Netherlands in 2006 (Arcadis and Stec Groep, 2007; Weterings et al., 2008). However, there are concerns about the possible negative external effects of industrial activities on other firms, on nature, and particularly on households (Schuur, 2001; Needham and Louw, 2003; Louw et al., 2004; Blaauw, 2007). Although the development of industrial sites implies separating industry and housing, residents may still be affected by industrial sites because of a multitude of perceived disamenities, such as noise, traffic, congestion, air pollution, and obstruction of view.

In this respect, much public debate is devoted to the urgency of supplying new industrial sites. It seems that local and regional government strategies, to have sufficient industrial land available, have resulted in an amount of available industrial land which may be expected to be sufficient for at least the upcoming 10 to 20 years (Van der Krabben and Van Dinteren, 2010). Over the past two decades, the gross land area assigned to industrial sites in the Netherlands increased from 44,640 hectares in 1988 to 94,560 hectares in 2006 (Arcadis and Stec Groep, 2007). This implies a rise of industrial-land area from 1.3 per cent to 2.7 per cent as a share of the total area of the Netherlands. Given the growth rate of land designated for housing (8.0 per cent in the period 1993 to 2000), we can infer that the area of industrial land has risen substantially by 12.9 per cent in the same period (Gordijn et al., 2007). Figure 1.1 illustrates that during the period 1996 to 2006 the total net area of industrial land has increased by about 1,000 hectares per year.[1] In terms of the number of formal industrial sites, this represents an increase from 3,203 to 3,605 sites.



Source: Dutch Industrial Sites Database (IBIS).

Figure 1.1 Aggregate area of industrial sites in the Netherlands, 1996–2006, in thousands of hectares

In Figure 1.1, it is also shown that the number of hectares of vacant land has remained relatively stable, i.e. a considerable area has been designated for industrial use, but has not yet been brought into use by any firm(s) or organization(s). Given the continuous rise of industrial-site supply and the substantial amount of vacant land on industrial sites over time, concerns are being raised particularly about the amount of land assigned to industrial

[1] The net area of an industrial site is defined as the total area designated for industry minus the area which is used for infrastructure, water, green space, and other forms of public open space.

sites, and the intensity of land use on industrial sites (e.g., Louw et al., 2004; Knoben and Traa, 2008; Renes et al., 2009).

Additionally, the amount of industrial land varies from region to region, indicating region-specific circumstances, which are to a great extent related to the level of economic development and urbanization (see Figure 1.2). Generally, the urbanized Western (viz. the Randstad) and the Southern part of the Netherlands has a relatively high presence of industrial sites, as compared with the less urbanized regions, which can mainly be found in the North and East of the country.

Source: Dutch Industrial Sites Database (IBIS).

Figure 1.2 Distribution of industrial sites in the Netherlands, 2006

The realized development of industrial sites is the result of a practice which has remained unchanged over the last decades. Industrial sites were originally developed to locate (heavy-) industrial activities. But new technologies and new activities appeared, which changed the Dutch economic structure. The economy deindustrialised in favour of the development of the services sector. Many new firms were created, especially in the business services sector, but also in the high-tech sectors of manufacturing. The location requirements of these activities differ in many respects from the industrialised sectors in the 1950s and 1960s (Lambooy and Wever, 2001; Louw et al., 2004). However, the changing economic structure has not resulted in the revision of the practice of supplying industrial sites. Since the 1990s the number of industrial sites has grown considerably. In particular, due to increased mobility a great many industrial sites have sprung at easily accessible locations in the relatively low-populated urban periphery, but these sites mainly accommodate services activities (Louw et al., 2004).

Hence, local economic development promotion and the emergence of externalities are rooted in industrial-site planning. However, studies of the corresponding performance and impact of industrial sites generally lack empirical insights. In this thesis we elaborate on these issues, after undertaking various empirical studies concerning industrial-site provision in the Netherlands.

1.2 Industrial-site planning

1.2.1 A short history

The first important historical event in the path taken by industrial-site planning was the introduction of the Nuisance Act (Hinderwet) in 1875 (Needham and Louw, 2006). This law introduced a form of zoning in the Netherlands, and for the first time it was possible to exclude some types of manufacturing from locating in residential areas. This kind of zoning was introduced to reduce environmental risk and to protect public health. In 1901 the Housing Act was introduced, by which it was possible for municipalities to develop residential and industrial areas (Bak, 1961). The Housing Act gave local authorities the power to make plans to develop greenfield sites and, if necessary, to expropriate land. These two events made possible the present policy for industrial sites (Needham and Louw, 2006).

After World War II, all efforts of the Dutch government were aimed at the recovery of the Dutch economy. The welfare-state emerged, which means that the government interferes in social and business activities in order to protect and promote social equity (Van der Cammen and De Klerk, 2006). The government strived for full employment and increasing purchasing power by actively promoting the industrialization throughout the country. This has led to, among other things, a large number of industrial sites, developed during the 1950s and 1960s (Louw and Bontekoning, 2007).

The chosen strategy to achieve the recovery of the Dutch economy appeared to be successful. From 1950 onwards, the Gross National Product increased about 5 per cent per year, and average incomes rose considerably. As a result of the flourishing economy, car ownership increased rapidly in the 1950s and 1960s, making it necessary to develop new infrastructure (Van der Cammen and De Klerk, 1996; De Graaf, 2005).[2] Because of the increased mobility, working and housing became gradually separated from each other, and the numbers of commuters doubled. As a result of the increased importance of the car, and freight traffic by trucks, industrial sites emerged in this period at locations well-connected to road infrastructure, waterways, and railroads (Louw et al. 2004).

From the 1970s and 1980s onwards, industrial sites increasingly located close to highways and major roads, and – in the 1990s – close to corridors between economically important centres (Blokhuis, 2010). These sites, characterized by their high accessibility, represent the most recent generation of industrial sites. Locating the industrial sites close to highways and main roads can be explained by the decreasing share of transport of freight by rail and water and the increasing share of transport by road. Furthermore, the economic structure also changed: the share of small-scale companies and service providers on industrial sites increased, rather than large-scale industrial companies. But industrial sites were still only assigned to economic activities. This generation of industrial areas has experienced considerable growth in recent years (De Graaf, 2005).

1.2.2 Spatial economic policy

For many decades, the national government pursued a regional economic policy of stimulating development in those regions where welfare was significantly below the national average. These were the peripheral regions in the North, East, and South of the Netherlands. The national policy for the redistribution of population and employment included many different measures, such as financial stimulus to firms setting up in lagging regions, extra infrastructural works, and the movement of government offices out of the Western part of the country to the North and East (Needham, 2007).

Since the late 1980s the focus of regional economic policy has changed. ‘Regions must stand on their own feet’ was the motto of the Fourth National Policy Document on Spatial Planning (*Vierde Nota* – VROM, 1988). This announced a new regional economic policy. The national government stimulates economic growth in all regions, irrespective of the position of one region relative to another region. In other words, regional income differences have no longer been a reason for giving economic assistance to poorer regions. The traditional ‘problem region’ has nearly disappeared, and the notion of *spatial* economic policy replaced *regional* economic policy. Interest waned in the need for a

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[2] Between 1960 and 1971, the number of cars increased from about 500,000 to almost 2.5 million (Van der Cammen and De Klerk, 1996).

regional development policy.[3] Nevertheless, the policy still concentrates on the improvement of the physical business environment, but it focuses on aspects that are primarily relevant for the national economy (Lambooy and Wever, 2001).

The Netherlands has three tiers of government: the national government, provinces (twelve), and municipalities (418 in 2011).[4] Each of the levels of government has a role in spatial planning. National and regional plans, which define location, size and type of future land use, are prepared years in advance. Municipalities accordingly translate this into land-use plans, specifying the use of land in detail (Louw, 2000). These days, in the main, the national government no longer pursues a policy concerned with the location of new industrial sites. It is now the municipalities which are responsible for supplying industrial-site area within their borders. The national government only offers subsidies very selectively when industrial sites considered obsolete need to be modernized (Louw et al., 2004; Needham, 2007).

1.2.3 Definitions

Originally the location for heavy, large-scale, nuisance-generating industrial activities, industrial sites have recently transformed into a location for all kinds of economic activities, such as logistics, services, and retail. The increased presence of non-industrial sectors on locations allocated as industrial sites has complicated the classification of these locations. In this respect we follow Louw et al. (2004), who define 'industrial site' as a planning term for an area designated by local, regional and, in some cases, national authorities to accommodate multiple companies that produce, transfer, or store goods. These areas can, according to their functional qualities, economic requirements, spatial-visual qualities and flexibility, be divided into heavy-industry sites, harbour sites, miscellaneous sites, high-tech sites, and transport sites (Arcadis and Stec Groep, 2007). Other classifications used refer to these sites as 'business sites', 'business districts', 'business parks', 'industrial districts' or industrial estates (Snep, 2009). Office sites, which are designated exclusively for offices, are not covered by this definition (Louw et al., 2004; Arcadis and Stec Groep, 2007).

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[3] Economic assistance for the poorer areas of the country is only available from the Structural Funds of the European Union: Objective 2 for infrastructure works and Objective 3 for employment and training (Needham, 2007).

[4] The number of municipalities varies, but on January 1, 2011 it was 418. In 2010, for instance, twenty-one municipalities were abolished, and six new ones created. The Netherlands is the only country in Europe which reduces its number of municipalities annually (Statistics Netherlands, 2010).

1.2.4 Industrial-site planning outside the Netherlands

Outside the Netherlands, the creation of locations of economic activity is similar to the Dutch practice (Snep, 2009). In many countries, areas are indicated where the establishment of firms is planned, but the degree of public sector involvement varies. For instance, the development of industrial sites in the United Kingdom is dominated by a strong private sector involvement. Similar to the Netherlands, industrial-site development in Belgium and Germany is mainly a matter for the public sector (Van der Krabben and Van Dinteren, 2010). In the international planning and real-estate literature, issues concerning 'brownfields' have received particular attention (Van der Krabben and Van Dinteren, 2010). Ferber and Grimski (2001) argue, however, that the concept of 'brownfield' is lacking a common definition across Europe, which hinders international comparison of issues involved with industrial-site planning.[5] In this respect, a 'brownfield' is generally defined as 'derelict land dominated by abandoned and decrepit industrial property'. The issues concerning industrial sites in the Netherlands are different.

1.3 Objectives and research questions

The main objective of this thesis is to provide empirical evidence on a series of important issues relating to industrial sites in the Netherlands. It is not our intention to produce a synthesis of these different approaches, but rather to indicate, empirically, how they can be used to enhance our understanding of different major issues with respect to the impact and performance of industrial sites in the Netherlands. In order to do this we have formulated a series of four research questions.

The first part of the thesis is devoted to the occurrence and the nature of external effects (i.e. externalities) concerning the spatial concentration of economic activities on industrial sites. Research questions 1 and 2 deal, respectively, with the effects of both positive and negative externalities:

1. *To what extent is the performance of industrial sites affected by their local economic structure and accessibility?*
   Positive externalities related to the clustering of firms, i.e. agglomeration economies, are supposed to promote local economic growth. So far, the level of spatial aggregation of the industrial site has been neglected in testing the relationship between agglomeration and growth. Using a quantitative method, inspired by Glaeser et al.

[5] Ferber and Grimski (2001) have provided estimates of brownfield area availability of several European countries: 128,000 hectares of brownfield sites for Germany; 39,600 hectares for the United Kingdom, 20,000 for France; and about 9,000 hectares for Belgium.

(1992), we aim to explain the economic performance of industrial sites, in terms of local employment growth, as a function of the sectoral composition of the industrial sites concerned. As such, the sectoral composition provides us with indicators of the level of specialization, diversification and competition, with respect to the associated agglomeration externalities: Marshall-Arrow-Romer (MAR), Jacobs and Porter externalities. Additionally, we explicitly consider the importance of the accessibility of industrial sites as a growth-promoting factor.

2. *What is the impact of the presence of industrial sites on their immediate vicinity?*
   Considering negative externalities generated by industrial sites, a hedonic pricing model is specified and estimated. We aim to measure the negative externalities generated by industrial sites, and to obtain insight into the scope of these externalities. In this respect, we contribute to the planning debate by elaborating on the impact of the presence of industrial sites in their immediate vicinity.

The second part of this thesis is devoted to studying the underlying mechanisms of industrial-site planning in the Netherlands as an instrument of local economic development promotion. Research questions 3 and 4 refer, respectively, to land-use policy and the interdependence of local industrial-site provision policies as determinants of local industrial-site supply:

3. *What is the role of spatial location characteristics as determinants of the location choice of industrial-site area provision, and the resulting intensity of land use in terms of employment?*
   By applying econometric techniques we explore the relationship between various spatial location characteristics and the outcomes of land-use policy, in terms of the area of industrial sites supplied and the corresponding level of industrial-site employment.

4. *To what extent is the amount of supplied industrial-site area subject to strategically competitive behaviour between municipalities?*
   Potential strategic interaction between municipalities' industrial-site policies is considered to be an important driver of the supply of local industrial-site area. For that reason, we aim to quantify strategic interaction between Dutch municipalities' industrial-site provision policies. Inspired by the tax-competition literature, spatial econometric analysis is applied to test to what extent the growth of the available industrial-site area in a municipality is related to the size of industrial-site area provided in surrounding municipalities.

In addition, relevant policy implications are discussed throughout the thesis. As such, we aim to provide useful, evidence-based, insights to policy makers and urban planners with respect to the issues considered.

1.4 Outline

Figure 1.3 presents an overview of the structure and the contents of the thesis. Chapters 2 and 3 of the thesis address the external effects (i.e. externalities) associated with the spatial concentration of economic activities on industrial sites. In Chapter 2, we investigate the positive externalities involved with the economic performance of industrial sites. We test for the existence of statistically significant relationships between agglomeration externalities (specialization, diversity, and competition), accessibility measures, and the employment growth of a particular industry on a particular site located in the municipality of Amsterdam (between 1998 and 2006). Chapter 3 focuses on the impact of negative externalities generated by industrial sites. By applying a hedonic pricing model, we value the negative externalities generated by activities located on industrial sites in the Randstad region and the Province of North-Brabant, in the year 2005. The effect of these negative externalities is quantified by estimation of the distance-decay of house prices in the vicinity of industrial sites.

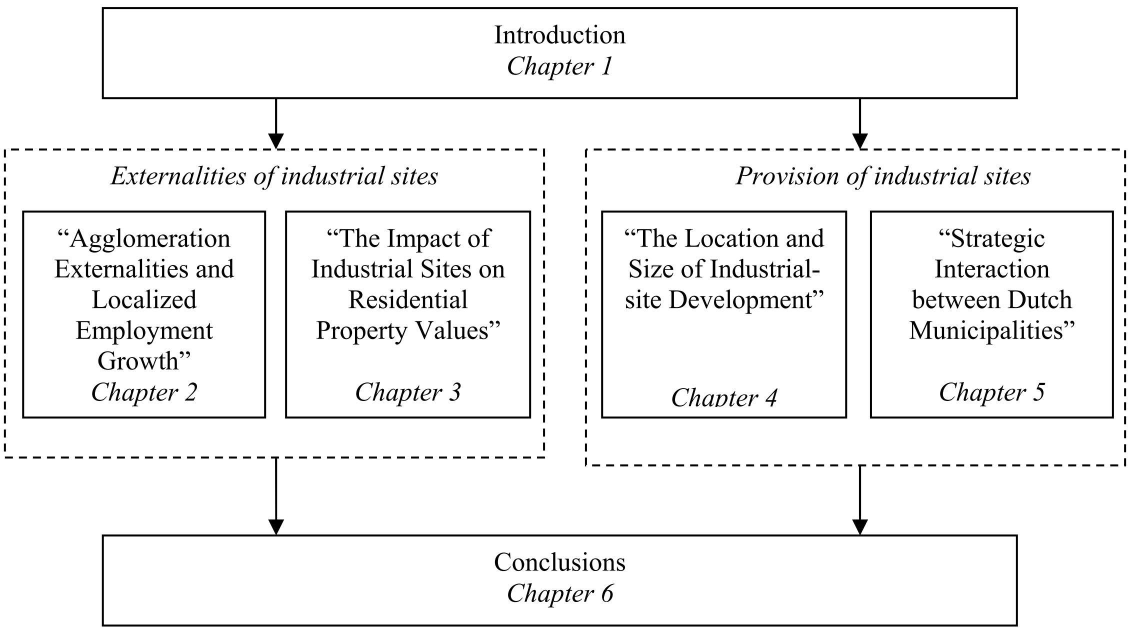

Figure 1.3 Structure of the thesis

Chapters 4 and 5 focus on the determinants of local industrial-site provision, in terms of location and size. In Chapter 4, we investigate the relationship between various spatial location characteristics and the outcomes of land-use policy, with respect to industrial-site development. By applying various econometric techniques, we analyse the distribution of industrial sites, and employment on the industrial sites concerned, across the Province of North-Brabant in the period 2000 to 2008. Chapter 5 investigates strategic interaction as an driver of the supply of local industrial-site area. By means of the techniques of spatial econometrics, we test whether, and to what extent, Dutch municipal councils take into account the decisions of neighbouring municipalities regarding the provision of industrial land, during the period 1996 to 2006.

Chapter 6 concludes by summarizing important research findings, and discussing policy implications and directions for further research.

Chapter 2

Agglomeration Externalities and Localized Employment Growth: The Performance of Industrial Sites in Amsterdam

2.1 Introduction[1]

The planning of industrial sites has been subject to much debate in the Netherlands. In these public discussions much attention is devoted to the urgency of establishing new industrial sites, the location of these sites, and the extent to which these sites harm the environment and landscape. The lack of attention to the economic implications of these formal locations of economic activity is striking. How important are industrial sites for regional development and growth? Do sites provide unique circumstances vis-à-vis other (informal) locations of economic activity? These are questions that are central in the field of regional science. Spatial variables in particular, such as location, proximity and accessibility, traditionally play a crucial role in this field. This is stressed by the widespread belief that “space matters” (Krugman, 1991). However, much debate within regional science occurs about the way space matters. Neoclassical regional growth theory tends to suggest that regional differences will disappear in the long run. This is in marked contrast to the New Economic Geography where agglomeration forces are said to result in geographical clustering and specialization patterns (Hoogstra and Van Dijk, 2004).

In view of these relevant discussions for regional development, this chapter contributes to this debate by elaborating on the importance of (external) agglomeration economies and accessibility for the economic performance of industrial sites. In this sense, our analysis is strongly influenced by the seminal contribution “Growth in Cities” of Glaeser et al. (1992), which provides a dynamic view[2] on the formation and growth of cities. In accordance with this approach, we explain the performance of sites as a function

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[1] This chapter is based on De Vor and De Groot (2008).

[2] A dynamic view refers, instead of explaining the level of productivity at a certain point of time (‘static view’), to explaining the changes in productivity, or growth, over a certain time period (Rosenthal and Strange, 2004).

of Marshall-Arrow-Romer (MAR), Jacobs and Porter externalities. By applying Glaeser et al.'s methodology on industrial sites, we obtain insight into whether local specialization, local diversity, or local competition of an economy is related to local economic growth processes on the aggregation level of industrial sites. Furthermore, we look into the spatial pattern of growth and especially consider the importance of accessibility as a growth-promoting factor. As such, the analysis may reveal useful lessons for development planners and land developers by pointing out some of the more critical factors that affect the performance of industrial sites. Such lessons may be particularly useful in restructuring processes that many industrial sites are currently undergoing.

Our analysis is based on employment data of industrial sites in the municipality of Amsterdam. Being the capital of the Netherlands with a relatively heterogeneous production structure, Amsterdam forms a coherent urban system which is interesting to examine (Van der Vegt et al., 2006).[3] Due to its open character, an essential asset of the Amsterdam urban system is its dynamics: new industries arise whereas other industries decline in terms of economic importance (O+S Amsterdam, 2007). A unique feature of this chapter is that we look at a very low level of spatial aggregation. A review of the existing literature, by means of a meta-analysis, points out that, amongst other things, the level of spatial aggregation matters for the strength with which agglomeration forces are operational (De Groot et al., 2009). So far, the level of spatial aggregation of the industrial site has been neglected in testing the relationship between agglomeration and growth. In the scarce available literature about industrial sites, aspects of restructuring or modernization of sites are typically emphasized. In this literature industrial sites are mainly considered from a planning or environmental point of view, thereby largely neglecting the economic perspective. Hence, by considering employment growth on the scale of industrial sites, located in the municipality of Amsterdam, we aim to get insight into the determinants of growth on the disaggregated spatial level of industrial sites.

This chapter is organized as follows. The next section we provide an overview of the conceptual arguments about the relationship between the proposed externalities – MAR, Jacobs and Porter – and localized growth. Section 2.3 elaborates on the application of Glaeser et al. (1992) on the growth of industrial sites and gives a description of the data. In Section 2.4 we present relevant measures of performance and externalities. Section 2.5 sets out and discusses the estimation methods and accompanying results, and addresses the importance of specific elements of space (such as accessibility). Finally, Section 2.6 concludes.

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[3] On a more pragmatic note, another reason for choosing this case study is related to the availability of data: the municipality of Amsterdam provided detailed employment data relating to the spatial level of aggregation of industrial sites.

2.2 Literature review

Cities provide a natural laboratory to study dynamic externalities as they facilitate communications between economic agents (Henderson, 1997). If an industry is subject to MAR externalities, producers are likely to cluster together. They tend to primarily specialize in a particular activity, or they become closely interconnected to a set of related activities thereby fostering short-term economic growth (Henderson, 2003). MAR (or localization) externalities are associated with a high local concentration of economic activity in a company's own industry. Benefits potentially accrue from three sources: labour market pooling, input-output linkages, and knowledge spillovers (cf. Marshall, 1890). A high concentration of an industry can attract and sustain a large labour force with the skills demanded by that industry. This considerably lowers search costs and augments a firm's flexibility in hiring and laying off personnel. Input-output linkages refer to the fact that a concentration of an industry attracts both supplier firms and client firms to its region. Finally, knowledge is hypothesized to spill over from one firm to another without the donor firm giving its complete permission or receiving complete compensation. These spillovers can arise from job mobility or social activities between employees of different firms (Breschi and Lissoni, 2003). Specialization enhances full exploitation of scale externalities.

However, if an industry is subject to Jacobs externalities, a diverse industrial structure enhances growth (Glaeser, 1999; Henderson, 1997). Jacobs externalities result from local industrial diversity (Jacobs, 1969, 1984). A diverse industrial structure first of all means that the client base can be more diverse and therefore protect an industry from volatile demand. On the other hand, not only the clientele's diversity is beneficial, but also the width of the spectrum of locally available inputs is of value, as it facilitates switching between input substitutes in case of scarcity or a rise in prices. Lastly here as well, knowledge spillovers play a part: in a Schumpeterian setting it is often argued that the most radical innovations are derived from a combination of ideas – *neue Kombinationen* – from totally unrelated fields (Boschma and Lambooy, 2002). Hence, a higher degree of diversity may increase the probability of discovering radically new products or solutions to problems in the production process. Upgrading these dynamics to the level of a city one can argue that in the presence of Jacobs externalities, external economies will be available to all local firms irrespectively of sector, which have a positive effect on overall city diversity and productivity. By the presence of MAR externalities, localized productivity is augmented by concentration on a specific number of sectors (Dissart, 2003). Taking this rationale into account, it is plausible to argue that on the scale of the industrial site these dynamics are even more manifest.

The third externality to be mentioned explicitly is competition. Combes (2000) argues that the impact of competition on growth is non-linear. Schumpeterian models underline this trade-off: high competition provides firms incentives to make important R&D investment, but, if the succession of innovations is too fast, returns from R&D are low, which reduces the amount of R&D and this in turn has a negative impact on innovations (see also Aghion and Griffith, 2005). In contrast, Porter (1990) argued that local competition in specialized, geographically-concentrated industries stimulates growth. This is partially in accordance with MAR and partially in accordance with Jacobs. Table 2.1 summarizes the aforementioned agglomeration conditions under which externalities affect growth, according to MAR, Jacobs and Porter.

Table 2.1 Hypothesized relations between agglomeration and growth according to MAR, Jacobs and Porter

	MAR	Jacobs	Porter
Specialization	+	–	+
Diversity	–	+	–
Competition	–	+	+

Source: Van Oort (2007).

Many empirical studies (e.g. Glaeser et al., 1992; Henderson, 1997; Glaeser, 1999; Henderson, 2003; Frenken et al., 2007) have tried to explain the performance of cities or regions by examining the role of MAR, Jacobs and Porter externalities. In general, the literature presents conflicting evidence about the relevance of these externalities. While Henderson (1997, 2003) finds that only MAR externalities are relevant for traditional manufacturing and for new high-tech industries, Glaeser et al. (1992) argue for the importance of Jacobs and Porter externalities. De Groot et al. (2009) present a meta-analysis describing the available evidence and explaining its variation, based on 31 studies, which build on the seminal work of Glaeser et al. (1992). They conclude that the evidence in the literature on the role of the specific externalities is rather mixed: relatively many primary studies demonstrate significantly positive effects of diversity and competition on growth. They found no clear-cut evidence for the effects of specialization.

In summary, on the city level it can be argued that the level of specialization, diversification, and competition, caused by both MAR, Jacobs externalities, and Porter externalities exert an influence on city performance. Although the nature of the relationship between the different externalities and performance of a city is rather complex, it provides a useful framework to analyse industrial sites to which we turn in the remainder of this chapter.

2.3 Data set and research set up

With the difference that our study concerns a different country and a different spatial unit of observation, we apply to a large extent the methodology of Glaeser et al. (1992). The reason for this is twofold. First, Glaeser et al. (1992) provide a tailor-made framework, requiring a rather limited amount of data, for analysing the growth of geographical units on a disaggregated level. Moreover, a growing literature suggests that externalities tend to become stronger as the geographical units of reference become smaller (Baptista, 2000; Wallsten, 2001). As the locus of Glaeser's analysis is the city, we choose the industrial site as locus of our analysis. By looking through a magnifying glass on locations of economic activity, in this case study on industrial sites, we get detailed insight into the agglomeration mechanism on a low geographical scale of aggregation.

Second, employment is a vital indicator in local industrial-site policy, which makes the Glaeser study an interesting point of reference since it uses employment growth as indicator of performance. Local authorities consider the provision of industrial sites as a key instrument of their economic policy. In accordance with their task and responsibility as industrial-land provider, local authorities ensure that there is always a minimum amount of industrial land available for immediate sale to interested companies. Industrial-land provision in the municipality of Amsterdam is in the line with this Dutch tradition (DRO, 2006). Consequently, increasing employment levels are a main argument by local politicians to develop industrial sites. This is underlined by Bak (1985) who argues that in the Netherlands industrial sites are merely developed to meet local economic objectives, i.e. municipalities attempt to facilitate local entrepreneurship and competitiveness. Figure 2.1 gives an impression of the distribution of industrial land in the Amsterdam municipality.

What is evident from Figure 2.1 is that most of the industrial sites are either located close to the ring road around the city-centre or in the harbour area which is located in the North-Western part of the city along the 'Noordzeekanaal' and the Eastern part in the direction of the 'IJmeer'. The city-centre is located central in the area surrounded by the ring road and stretches out towards the South from the riverside ('Het IJ').

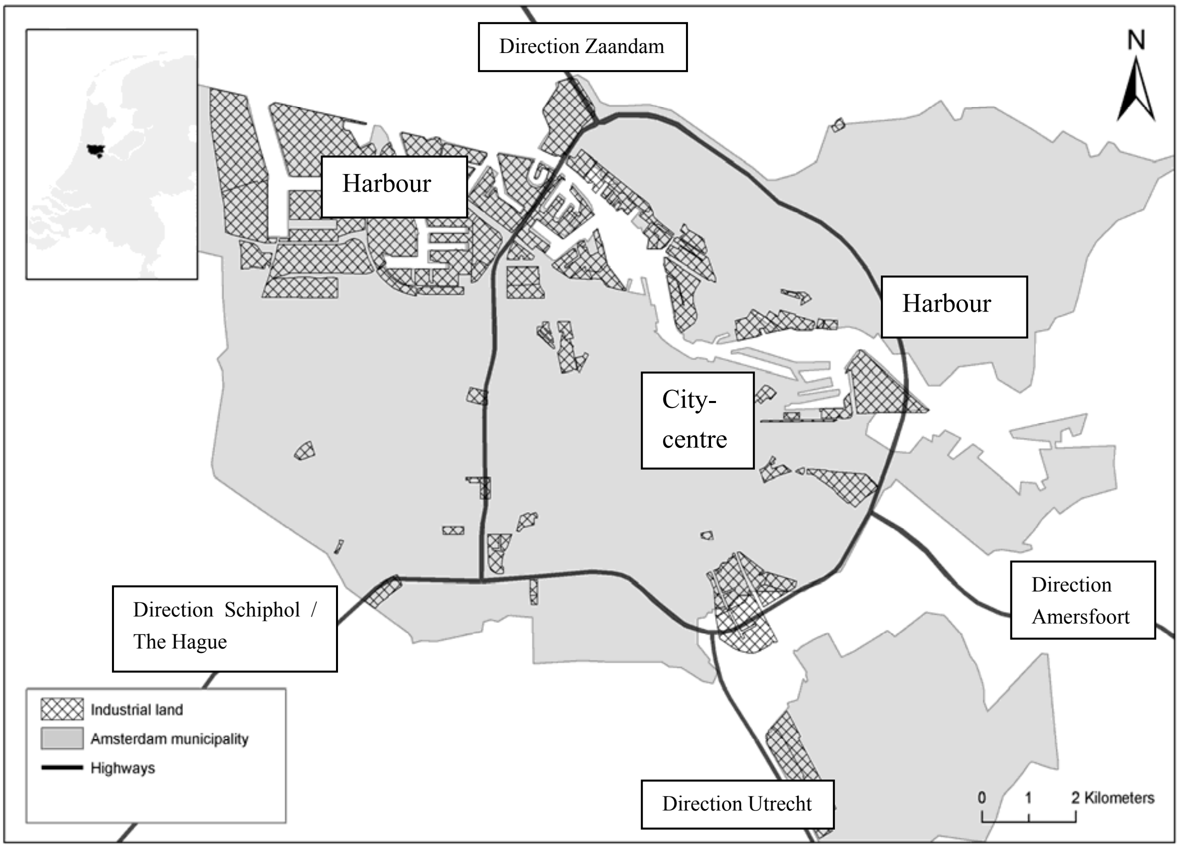

Figure 2.1 Distribution of industrial land in the Amsterdam region (1 January 2006)

We use data on employment and establishments on industrial sites in Amsterdam. These data originate from the 1998 to 2006 editions of the Monitor of Employment on Business Locations (*Monitor Werkgelegenheid Bedrijfslocaties*), produced by the Department for Research and Statistics (*Dienst Onderzoek en Statistiek*) of the City of Amsterdam (O+S Amsterdam). It provides each industrial site's employment level by industry. Besides the employment level, it contains the number of establishments by industry per industrial site. The data cover 68 formal industrial sites, defined as such by the Department for Research and Statistics (see Appendix 2.A).[4] The total number of industrial sites concerned corresponds to 3,437 hectares of (gross) industrial land in 2006, while the total Amsterdam area (residential housing, industrial, offices, infrastructure and water) comprises 21,939 hectares (O+S Amsterdam, 2006). To get an impression of the importance of industrial sites, we can look at Table 2.2. We see that in 2006 around 20 per cent of the total employment in Amsterdam was located on industrial sites (O+S Amsterdam, 2006).

[4] The definition of industrial sites by the Department for Research and Statistics differs slightly from the definition of the Dutch Industrial Sites Database (IBIS) and Louw et al. (2004), resulting in a different number of sites in our study than measured in IBIS. We omitted three sites, viz. *AMC*, *Medisch Centrum Slotervaart* and *Lutkemeerpolder*. This is done because these sites, sometimes called 'solitary sites', contain just one firm or agency.

Compared with 1998, this is a slight increase. In addition, sites exclusively designated for offices cover around a quarter of the total employment in Amsterdam. But since we are interested in business locations denoted as industrial sites, and their performance, we do not include office locations in our analysis. The large share of informal locations (not formal, land-use policy designated industrial sites) is noticeable. Considering the average number of workers per firm, it becomes clear that smaller firms are largely located at other locations. This can be explained, taking into account the availability of space on business locations versus (inner-city) informal locations. Formal business locations are in principle designed to accommodate, mostly large-scale, economic activities which harm the environment or housing conditions by, amongst others, noise nuisance, air pollution and traffic inconvenience (Louw et al., 2004). In Chapter 3 we elaborate on the negative externalities generated by industrial sites, and the spatial scope of these externalities.

Table 2.2 Division of number of employees (×1,000), number of firms (×1,000), and average firm size (number of employees per firm), by type of location in Amsterdam

	1 January 1998			1 January 2006		
Location	Employees	Firms	Average firm size	Employees	Firms	Average firm size
Industrial sites	66.942 (18.9%)	4.744 (9.5%)	14.11	83.134 (20.1%)	5.599 (9.4%)	14.85
Office locations	81.425 (23.0%)	2.446 (4.9%)	33.29	103.720 (25.0%)	2.885 (4.8%)	35.95
Informal locations	205.064 (58.0%)	42.889 (85.6%)	4.78	227.439 (54.9%)	51.293 (85.8%)	4.43
Total Amsterdam	353.431	50.079	7.06	414.293	59.784	6.93

Source: Department for Research and Statistics, City of Amsterdam.
Note: Share of total economic activity by type of location in parentheses.

Table 2.3 presents the developments on the sites concerned. It shows a relative shift of employment and number of firms towards harbour sites in the period 1998–2006. Besides what are called ‘regular industrial sites’, ‘harbour sites’ have been distinguished separately. Like the name already denounces, it concerns locations with harbour facilities. These harbour sites, or simply harbours, are mainly characterized by transport activities and large-scale industry. In Amsterdam, harbour sites represent 15 per cent of total employment on industrial sites.

Table 2.3 Division of number of employees (×1,000), number of firms (×1,000), and average firm size (number of employees per firm) on Amsterdam industrial sites

	1 January 1998			1 January 2006		
Location	Employees	Firms	Average firm size	Employees	Firms	Average firm size
Regular industrial sites	57.200 (85.4%)	4.204 (88.6%)	13.61	70.053 (84.3%)	4.840 (86.4%)	14.47
Harbour sites	9.742 (14.6%)	0.540 (11.4%)	18.04	13.081 (15.7%)	0.759 (13.6%)	17.23
Industrial sites	66.942	4.744	14.11	83.134	5.599	14.85

Source: Department for Research and Statistics, City of Amsterdam.
Note: Share of total economic activity by type of location in parentheses.

The industrial sites concerned are all located within the borders of the municipality of Amsterdam, with the exception of parts of *Weespertrekvaart Zuid* and *Amstel I* and the complete industrial site *Amstel II*, which is located in the adjacent municipality of Ouder-Amstel. The employment level is measured as the number of workers, working 12 hours or more per week. The total number of establishments and the employment figures are classified by economic activity; the Research and Statistics Department employs the Standard Industrial Classification 1993 (SIC 93) of Statistics Netherlands (CBS). Table 2.4 describes the eleven economic sectors involved in the sample, together with the associated number of employees.[5]

[5] Given that we examine industrial sites in the highly urbanized context of Amsterdam, it is evident that the category 'agriculture, hunting and forestry; fishing; mining and quarrying' (SIC 93-code A,B,C) is poorly represented. In 1998 and 2006, respectively, only 27 and 93 workers appear to be present in this category. Therefore, as we are interested in the variation in growth across site-industries, we do not take into account this small category (A,B,C).

Table 2.4 Industry division on industrial sites by number of employees (×1,000)

Industry	Number of employees 1 January 1998	Number of employees 1 January 2006
Renting and commercial services (K)	12.758	22.954
Trade and repair of consumer articles (G)	15.874	17.331
Transport, storage and communications (I)	8.610	13.462
Manufacture; Public Utilities (D,E)	14.686	9.675
Construction (F)	5.533	5.848
Environment, culture and other services (O)	1.944	3.834
Public administration, defence and social security (L)	2.851	3.821
Health and social work (N)	1.499	2.948
Financial intermediation (J)	1.925	1.439
Education (M)	0.915	1.077
Hotels and restaurants (H)	0.347	0.745
Total number of employees	66.942	83.134

Source: Department for Research and Statistics, City of Amsterdam.
Note: SIC 93-code of industry concerned in parentheses.

It appears that renting and commercial services (K) is the most prevalent category represented on Amsterdam industrial sites in 2006. Overall, service categories are well represented on industrial sites in Amsterdam. This is in line with De Dominicis et al. (2008) who find in their analysis of spatial distribution of economic activity in the Netherlands that the region of Amsterdam faces substantial location economies with regard to services, in particular to culture, compared to the rest of the Netherlands. Taking into consideration the availability of office locations, it is quite remarkable that services are represented to such an extent at industrial sites. One would expect a dominance of industrial sectors on industrial sites.

Besides examining agglomeration externalities, we also consider the importance of accessibility as a growth-promoting factor for industrial sites. Martin (1999) argues that spatial agglomeration models suffer from being too abstract and oversimplified as in the end they neglect real places. To take note of these real places, we consider non-contiguous spatial aspects based on the location of an industrial site. Such a non-contiguous spatial aspect of consideration is physical accessibility. In numerous business surveys accessibility has been ranked as a very important location factor (Hoogstra and Van Dijk, 2004). We measure the ease of accessibility by the distance from the centre of an industrial site to its nearest highway exit.[6] By applying a cut-off distance of 1 kilometre, we distinguish

[6] The proximity data (distance from industrial site to nearest highway exit to industrial site) are taken from www.hetvirtuelebedrijventerrein.nl.

relatively easy accessible industrial sites from less accessible sites. As a consequence, our sample comprises 26 industrial sites being well accessible (see Appendix 2.A).

2.4 Measuring performance

Following the framework developed by Glaeser et al. (1992), we use sectoral employment data of the different industrial sites concerned. More specifically, through a cross-section of 'site-industries', we examine the employment growth rates of the sectors on industrial sites concerned as a function of, among others, specialization, diversity, and competition. Glaeser et al. (1992) use the national situation as a benchmark in determining an externality of an individual city. In our study, this benchmark is replaced by the aggregate of industrial sites located in Amsterdam. The rationale for choosing this regional, or, strictly speaking, local benchmark is the scope of analysis: we merely examine the variation in growth of individual site-industries within the area of the municipality of Amsterdam.

The dependent variable in our analysis is defined as the average annual employment growth rate (*GROWTH*) in an industry s (= 1,2,...,m) on a site i (= 1,2,…,n) over the period 1998 to 2006:

$$GROWTH_{s,i} = 100 \cdot Ln\left(\frac{E_{s,i,2006}}{E_{s,i,1998}}\right) / 8\,, \tag{2.1}$$

where E denotes employment.

All explanatory variables are considered at January 1, 1998. The specialization index we consider is the ratio of the employment share of sector s on industrial site i divided by this ratio for the entire industrial area in Amsterdam. This specialization index is commonly known as the 'location quotient' (*LQ*):

$$LQ_{s,i} = \frac{E_{s,i} / \sum_{i=1}^{n} E_{s,i}}{\sum_{s=1}^{m} E_{s,i} / \sum_{s=1}^{m}\sum_{i=1}^{n} E_{s,i}}\,. \tag{2.2}$$

The *LQ* is therefore the ratio of a location's share of industry employment to its share of aggregate employment. Values above (below) 1 imply that a certain sector is overrepresented (underrepresented) at a particular industrial site, as compared to the average situation in Amsterdam.

To test for Jacobs externalities, we use the relative diversity index (*RDI*), which equals the inverse of the Krugman specialization index (McCann, 2001):

$$RDI_i = \frac{1}{\sum_{s=1}^{m} \left| \frac{E_{s,i}}{\sum_{i=1}^{n} E_{s,i}} - \frac{\sum_{s=1}^{m} E_{s,i}}{\sum_{s=1}^{m} \sum_{i=1}^{n} E_{s,i}} \right|} . \tag{2.3}$$

In other words, *RDI* represents the extent to which the employment structure on a particular industrial site *i* deviates from the employment structure of Amsterdam as a whole. The value of the relative diversity index increases as the site-employment distribution approaches that of the overall distribution on Amsterdam industrial sites. By using this measure, we deviate from Glaeser et al.'s approach of measuring diversity, which focuses on the levels of employment among the six largest sectors in each city. To measure diversity, the employment share of the other five largest sectors in total employment of the city's employment is used. However, as many sites in our sample do not comprise six or more sectors, which is mainly due to the broad classification of industries and the limited size of some sites, we decide to adopt the more refined *RDI* to test for Jacobs externalities.

Competition is captured by measuring the number of establishments per employee (*COMP*) in the site-industry relative to establishments per employee in this industry on the overall Amsterdam industrial area:

$$COMP_{s,i} = \frac{F_{s,i} / E_{s,i}}{\sum_{s=1}^{m} F_{s,i} / \sum_{s=1}^{m} E_{s,i}} , \tag{2.4}$$

where *F* denotes the number of firms. The application of this measure is in line with Glaeser et al. (1992), who consider the number of firms per worker as a proxy for competition. A value greater than 1 means that a specific industry contains more firms relative to its size on a industrial site vis-à-vis the total amount of industrial area in Amsterdam. Glaeser et al. (1992) reason that a value greater than 1 can be interpreted that the industry on a site is locally more competitive than it would be on a site elsewhere, in this case, in Amsterdam.

Similar to Glaeser et al. (1992), we control for initial employment by including the log of employment of the site-industry in 1998 ($EMP_{s,i}$). By including the log of the aggregate employment growth of the own industry in the analysis (based on overall employment in the industry on all industrial sites in Amsterdam) defined as $AGGROWTH_s$, we correct for aggregate demand shifts.[7] The sample includes 422 observations. In contrast to Glaeser et al. (1992), who only consider the top six sectors, we consider all sectors, apart from 'agriculture'. However, none of the sectors concerned appears to be present at every individual site. Therefore, we observe 422 site-industries, instead of 748 (11 × 68) which would be the case if all distinguished sectors were present at the each industrial site. Table 2.5 provides descriptive statistics of the key variables in our analysis.

Table 2.5 Descriptive statistics (based on 422 observations)

Variable	Mean	Median	Standard Deviation
Average annual employment growth ($GROWTH_{s,i}$)	2.40	0.80	16.56
Log of employment 1998 ($EMP_{s,i}$)	3.63	3.66	1.88
Average annual aggregate employment growth ($AGGROWTH_s$)	2.79	2.04	4.99
Specialization ($LQ_{s,i}$)	1.68	0.76	3.12
Diversity (RDI_i)	1.27	1.21	0.44
Competition ($COMP_{s,i}$)	3.57	1.85	5.80

2.5 Estimation results

2.5.1 Baseline model

In order to find empirical evidence of the relationship between employment growth across site-industries and the potential growth determinants described in the previous section, we estimate the following model by ordinary least squares (OLS):

$$GROWTH_{s,i} = \beta_0 + \beta_1\, EMP_{s,i} + \beta_2\, AGGROWTH_s + \beta_3\, LQ_{s,i} + \beta_4\, RDI_i + \beta_5\, COMP_{s,i} + \varepsilon_s. \quad (2.5)$$

The results are shown in Table 2.6.

[7] Average annual aggregate employment growth is defined as $AGGROWTH_S = 100 \cdot Ln\left(\frac{\sum_{i=1}^{n} E_{s,i,2006}}{\sum_{i=1}^{n} E_{s,i,1998}}\right)/8$.

Table 2.6 Site-industry average annual employment growth between 1998 and 2006

	(1)	(2)	(3)	(4)
Constant	10.64***	10.69***	9.50***	10.31***
	(6.14)	(4.28)	(4.37)	(3.59)
Log of employment 1998 ($EMP_{s,i}$)	– 2.64***	– 2.89***	– 2.66***	– 2.38***
	(– 6.39)	(– 7.04)	(– 5.85)	(– 4.88)
Average annual aggregate growth	0.78***	0.74***	0.72***	0.78***
($AGGROWTH_s$)	(5.16)	(4.87)	(4.84)	(5.13)
Location quotient ($LQ_{s,i}$)	– 0.48**			– 0.51**
	(– 1.97)			(– 1.96)
Relative diversity index (RDI_i)		0.15		– 0.84
		(0.09)		(– 0.47)
Competition ($COMP_{s,i}$)			0.15	0.13
			(1.04)	(0.91)
F	32.95***	31.38***	31.81***	19.94***
Adjusted R^2	0.19	0.18	0.18	0.18
Number of observations	422	422	422	422

Notes: *t*-values in parentheses; *** Significant at the 1% level; ** Significant at the 5% level.

The control variables all have the expected signs. High initial employment in an industry on a site leads to lower subsequent employment growth. Employment change in an industry on a site is positively associated with aggregate industrial employment in the Amsterdam area. Considering the results on externalities, we observe a statistically significant negative effect of specialization (Table 2.6, column 1). Looking at the relative importance of the externalities concerned, by means of standardized coefficients, we can argue that raising the location quotient by one standard deviation decreases the average annual employment growth rate of the site-industry by 9.1 per cent. This result is the opposite of the prediction of the MAR model.

The effects of the other externalities (diversity and competition) on growth are statistically non-significant. Nevertheless, considering the relative effect of the individual variables, column 2 in Table 2.6 suggests a positive contribution of absence of diversity to growth: the higher the *RDI* (i.e. the more the industrial composition of the site corresponds with the overall distribution on Amsterdam industrial sites), the faster the site-industry grows. In other words, as we augment the *RDI* by 0.44 (a standard deviation), average annual employment growth rate increases by 0.4 per cent. Note that this result may be driven by omitted variable bias from which column 2 may suffer. Comparing column 2 with column 4 (in Table 2.6) demonstrates a change of sign of the *RDI* parameter. Furthermore, Table 2.6 (column 3) suggests a positive effect of competition on site-industry growth: increasing the measure of competition by one standard deviation (5.80) raises the growth rate in the site-industry by 5.3 per cent. Taking into consideration the magnitude of the standardized parameters of the abovementioned variables, it is clear-cut, irrespective of statistical significance, that specialization and competition have a larger effect on the average annual growth rate than diversity.

Accordingly, our analysis of site-industries provides no empirical evidence for the hypothesized relation between growth and, respectively, Jacobs and Porter externalities. This is confirmed by column 4 in Table 2.6. Using all measures of externalities simultaneously results in significant estimates for specialization and non-significant estimates for diversity and competition.[8]

2.5.2 Fixed effects

The analysis, which to a high degree resembles Glaeser et al. (1992), does not take into account sector-specific characteristics nor industrial site-specific characteristics. As such, results may partly be driven by unobserved heterogeneity. Introducing ‘fixed effects’ in the current model allows us to control for these unobserved fixed, or unvarying characteristics. Although the unobserved characteristics can be seen as a ‘black box’ – we do not know which specific characteristics and to which extent each of these unknown characteristics affect the explanatory variables as such – it eliminates potentially large sources of bias.

We consider unobserved attributes of site-industry growth which are not the result of random variation, but do vary across sector or industrial site. Accordingly, we estimate two fixed effects models: a sector-specific version and an industrial site-specific version.

At first, in this subsection we address fixed effects associated with unobserved sectoral characteristics (α_s). Subsequently, we add industrial site-effects (α_i) to our original analysis. Adding sector-fixed effects to the original model results in the following equation:

$$GROWTH_{s,i} = \alpha_s + \beta_1\, EMP_{s,i} + \beta_2\, LQ_{s,i} + \beta_3\, RDI_i + \beta_4\, COMP_{s,i} + \varepsilon_{s,i}\ . \qquad (2.6)$$

The unobserved effect, denoted as α_s, is estimated for each sector *s*. The effect of variable $AGGROWTH_s$ can no longer be identified, because it is sector-invariant and thus captured by α_s.

[8] Employing a panel analysis, dividing the period 1998–2008 into two different periods, viz. (1998–2002) and (2002–2006), gives similar results in terms of direction and statistical significance. Details are available on request.

When we take into consideration industrial site-fixed effects, the model becomes

$$GROWTH_{s,i} = \alpha_i + \beta_1 EMP_{s,i} + \beta_2 AGGROWTH_s + \beta_3 LQ_{s,i} + \beta_4 COMP_{s,i} + \varepsilon_{s,i}. \quad (2.7)$$

The unobserved effect is specified as α_i. This intercept is estimated for each industrial site. Compared to Equation (2.5), we have omitted the variable RDI_i from the model, because *RDI* does not vary within the industrial sites.

The results of the both fixed-effects (FE) estimation methods are presented in Table 2.7.[9] The fixed-effects estimation outcomes are reported vis-à-vis the outcomes of the baseline estimation (α_s and α_i, respectively, vary across sectors and industrial sites), which allows us to obtain insight into the possible correlation between the explanatory variables concerned and unobserved sector- and site-specific effects.

If we compare the sector-fixed effects estimation results (Equation (2.6)) with the baseline estimates (Equation (2.5)) – viz. α_s is constant across industrial sites – it results in some notable outcomes. These fixed-effects results indicate that, when the impact of sector-specific unobserved heterogeneity is controlled for, the influence of local specialization reduces. The same applies to diversity, whereas the influence of competition slightly increases. The specialization coefficient becomes statistically insignificant, while the other estimates remain statistically insignificant. Furthermore, examination of the coefficients of the sector-specific intercepts shows that the level of growth in the categories 'trade and repair consumer articles' (G), 'hotels and restaurants' (H), 'transport, storage and communications' (I), 'renting and commercial services' (K), 'public administration, defence and social security' (L) and 'environment, culture and other services' (O) is above average. Remarkable is the absence of 'financial intermediation (J) in this bundle of well performing sectors. One would expect that 'financial intermediation', in view of the performance of other service-related sectors, would also display growth. A possible explanation could be found in the increasing portion of 'office locations' (see Table 2.1). It is likely that financial intermediation services have a preference for this type of location, given the nature of this industry and designation of the location. Like sector-fixed effects, the inclusion of industrial site-fixed effects results in some mutations of the original OLS outcomes (Equation (2.7)). Most striking is the mutation of the statistical significance of, respectively, the specialization coefficient and competition coefficient. This outcome suggests that space, or more specific location, matters: the variation of unobserved

[9] The reported constants in the fixed effects estimations represent as the average of the individual-specific intercepts. The individual-specific intercepts α_s and α_i are denoted, respectively, as S_s and I_i. The coefficients indicate the extent to which the magnitude of the specific fixed effects deviates from the average of all estimated fixed effects (viz. the constant).

Table 2.7 Site-industry average annual employment growth between 1998 and 2006

	Baseline (Glaeser) Eq. (2.5)	FE-sector Eq. (2.6)	FE-industrial site Eq. (2.7)
Constant	10.31***	12.32***	9.21***
	(3.59)	(4.13)	(4.20)
Log of employment 1998 ($EMP_{s,i}$)	– 2.38***	– 3.05***	– 2.70***
	(– 4.88)	(– 5.06)	(– 5.30)
Aggregate growth Amsterdam industrial-site area	0.78***		0.78***
($AGGROWTH_s$)	(5.13)		(5.46)
Location quotient ($LQ_{s,i}$)	– 0.51**	–0.26	– 0.26
	(– 1.96)	(–0.92)	(– 0.91)
Relative diversity index (RDI_i)	– 0.84	0.51	
	(– 0.46)	(0.28)	
Competition ($COMP_{s,i}$)	0.13	0.26	0.35**
	(0.91)	(1.46)	(2.51)
Sector-specific fixed effects (α_s):			
S_1 Manufacture; Public Utilities (D,E)		– 3.35	
S_2 Construction (F)		– 3.45	
S_3 Trade, and repair consumer articles (G)		1.35	
S_4 Hotels, and restaurants (H)		0.16	
S_5 Transport, storage, and communications (I)		2.71	
S_6 Financial intermediation (J)		– 9.33	
S_7 Renting, and commercial services (K)		7.03	
S_8 Public administration, defence, and social security (L)		3.94	
S_9 Education (M)		– 4.66	
S_{10} Health and social work (N)		– 10.61	
S_{11} Environment, culture, and other services (O)		4.64	
Industrial-site fixed effects (α_i):			
I_1			See
:			Appendix 2.B
I_{68}			for coefficients
F	19.94***	9.00***	3.97***
Adjusted R^2	0.18	0.21	0.33
Number of observations	422	422	422

Notes: SIC 93-code of corresponding industry in parentheses behind sector-specific intercepts; *t*-values in parentheses; *** Significant at the 1% level; ** Significant at the 5% level.

industrial site-specific characteristics is to a certain extent responsible for the observed variation of site-industry growth across industrial sites. The decline of the LQ-coefficient suggests that there is a correlation between local specialization and the industrial site concerned. In other words, the degree of specialization appears to be correlated with unvarying, industrial site-specific, unobserved factors that affect employment growth on a site-industry. Controlling for industrial site-specific fixed effects increases the competition coefficient significantly, the point estimate rising to 0.35. In Figure 2.2, we have mapped the site-specific effect coefficients by industrial site to display the performance of individual industrial sites. Besides information about the performance of individual sites, it also provides information about the possible clustering of (more or less) equally performing sites. The uneven distribution of growth across industrial sites may indicate the occurrence of specific circumstances that determines this pattern of growth. Tentatively, we can infer that, as a result of the observed clustering patterns, the North-Western and the South-Eastern part of the area face specific circumstances influencing performance on the industrial sites concerned.

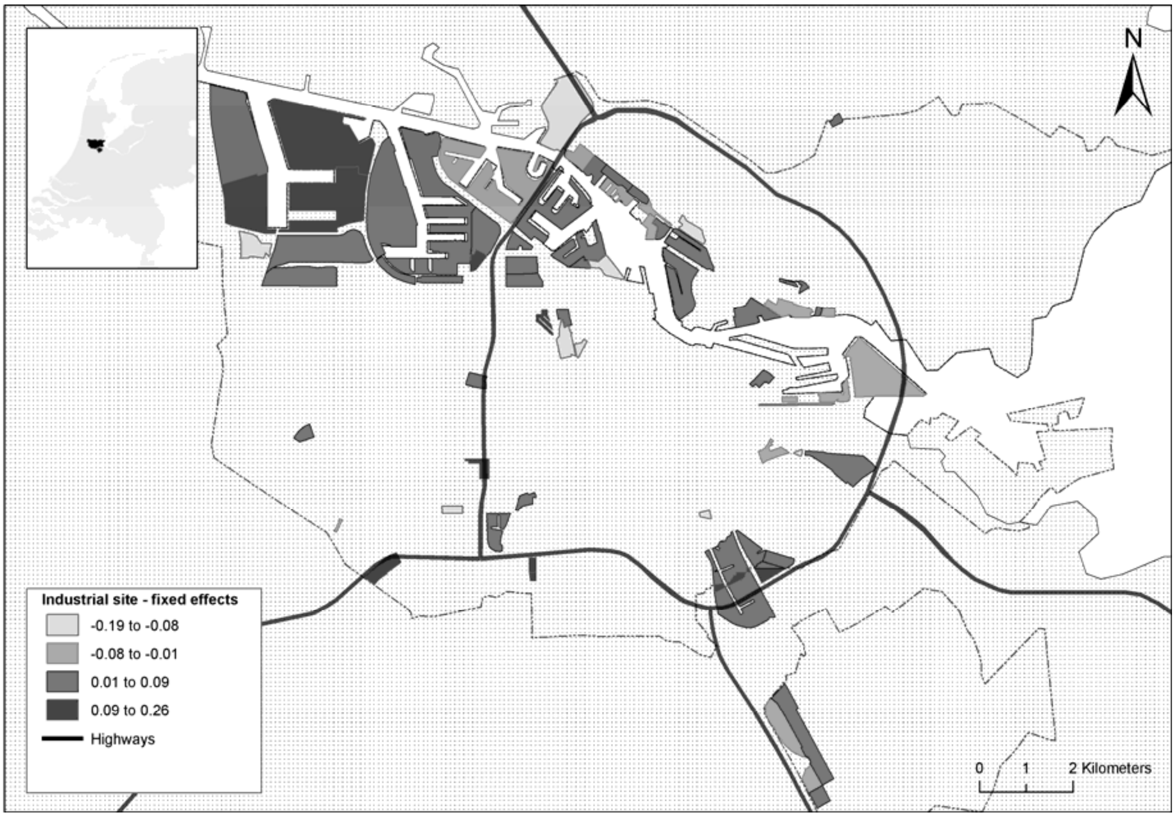

Figure 2.2 Spatial distribution of site-specific effects in Amsterdam

2.5.3 Spatial heterogeneity

Due to our particular interest in the importance of accessibility as a growth-promoting factor, we elaborate on the issue of geographical context-specificity. We model spatial heterogeneity to control for this location-specific attribute.

Introducing space is advocated by various studies that have used a comparative framework of agglomeration externalities reporting mixed evidence for which type of externality matters most for economic growth (Burger et al., 2007; De Groot et al., 2007). Besides different effects of agglomeration externalities on economic growth across sectors and time periods, different effects are identified across spatial regimes. Moreover, the degree of (non-) robustness and inconsistency can be traced back to the scale-dependency of agglomeration externalities. In this respect, Van Oort (2007) argues that results are better controlled for local-specific attributes when analysed on lower spatial scales (detailed municipal level of the Netherlands). Furthermore, it is argued that research results are more informative when non-contiguous spatial regimes on various scales are tested. In accordance with these findings, we may introduce space in our model. The outcomes of the additional analysis concerning fixed effects also suggest that location matters.

Figure 2.2 shows us an uneven distribution – or clustering – of growth which reflects possible forces referring to (geographical) context-specificity. The clusters are positioned in the geographical context of the well-accessible periphery (South-Eastern border) as well as in the geographical context of the harbour area (North-West). Besides it may emphasize effects of accessibility, it implies that forces associated with localization in the harbour area are involved. Possible heterogeneity in these spatial dimensions may be taken into account in explaining variation in employment growth across industrial sites.[10] A way of revealing this spatial heterogeneity is taking into account non-contiguous spatial aspects based on the location of an industrial site. Spatial heterogeneity means variation over space of the relationships under study. More precisely, it implies that functional forms and parameters vary with location and are not homogenous throughout the data set (Anselin, 1988). In view of the nature of our analysed spatial entities (viz. industrial sites), it is reasonable to capture spatial heterogeneity by identifying location-specific characteristics. In this respect, we consider the following specific characteristics: physical accessibility and harbour.

We construct a dummy-variable, ACC_i, indicating the ease of accessibility of the highway (where the dummy equals 1 for sites within 1 kilometre of a highway exit). Besides accessibility, we construct a dummy-variable (HAR_i) equal to 1 for a site-industry being located at a harbour site (see Appendix 2.A). Taking into account these dummies

[10] Spatial heterogeneity is often associated with another spatial effect: namely, spatial dependence, or spatial autocorrelation. This contiguous counterpart of spatial heterogeneity exists when the dependent variable in a model is dependent on neighboring values (contiguous nearness) of this dependent variable (Van Oort, 2007).

results in the following regression model:

$$GROWTH_{s,i} = \beta_0 + \beta_1 EMP_{s,i} + \beta_2 AGGROWTH_s + \beta_3 LQ_{s,i} + \beta_4 RDI_i + \beta_5 COMP_{s,i} + \beta_6 ACC_i + \beta_7 HAR_i + \varepsilon_{s,i}. \quad (2.8)$$

The estimation results are presented in Table 2.8. We report these ‘extended’ estimation outcomes vis-à-vis the outcomes of the baseline estimation (Equation (2.5)).

Table 2.8 Site-industry average annual employment growth between 1998 and 2006, controlling for accessibility and presence at harbour site

	OLS baseline Eq. (2.5)	OLS extended Eq. (2.8)
Constant	10.31***	8.63***
	(3.59)	(3.04)
Employment 1998 ($EMP98_{s,i}$)	– 2.38***	– 2.66***
	(– 4.88)	(– 5.52)
Aggregate growth Amsterdam industrial area	0.78***	0.77***
($AGGROWTH_s$)	(5.13)	(5.17)
Location quotient ($LQ_{s,i}$)	– 0.51**	–0.49**
	(– 1.96)	(–1.93)
Relative diversity index (RDI_i)	– 0.84	–1.29
	(– 0.46)	(–0.73)
Competition ($COMP_{s,i}$)	0.13	0.16
	(0.91)	(1.13)
Dummy distance to highway exit (<1 km) (ACC_i)		6.05***
		(3.86)
Dummy harbour site (HAR_i)		7.63***
		(3.29)
F	19.94***	17.70***
Adjusted R^2	0.18	0.23
Number of observations	422	422

Notes: SIC 93-code of corresponding industry in parentheses behind sector-specific intercepts; *t*-values in parentheses; *** Significant at the 1% level; ** Significant at the 5% level.

The highly statistically significant and qualitatively large effects concerning being located within 1 kilometre from a highway exit and presence at a harbour site provides us with sound insight into the closed black box of unobserved site-characteristics. The coefficient regarding ease of accessibility conveys 6.1 per cent higher average annual growth vis-à-vis poorly accessible sites. Furthermore, harbour sites render 7.6 per cent higher growth than non-harbour sites. By revealing these spatial effects, it is confirmed that employment growth, on the (detailed) site-industry level in the Amsterdam municipality, is sensitive to non-contiguous elements of space.

However, the inclusion of fixed effects in the original Glaeser model has been legitimated, as inclusion effectively eliminates large sources of bias and indicates that, respectively, unmeasured sector-specific and site-specific aspects are involved. This firstly points out that the initial Glaeser model is limited in explaining employment growth in site-industries. By adding sector-fixed and industrial site-fixed effects one can infer the importance of accessibility and the presence at a harbour site as determinants of localized employment growth. Despite the relative small sample we are able to get insight in mechanisms that explain variation of localized growth across industrial sites, but expansion of the sample is preferable. Since we only examine the situation in the municipality of Amsterdam, expanding the sample size would increase the variation which could result in more profound findings considering the occurrence of agglomeration externalities on industrial sites and the influence of spatial effects on the strength of these externalities. The latter specifically refers to the aspect of context-specificity of the performance of an industrial site.

2.6 Conclusion

The main aim of this chapter was to study the performance of industrial sites and to investigate the relationship between the degree of local specialization, local diversity and local competition on industrial sites and the performance of industries on these sites. We have operationalized performance of industrial sites by taking the employment growth of a certain industry on a certain site. In order to explain the variation in employment growth across the site-industries concerned, we regressed growth on measures of specialization, diversity and competition. By taking industrial sites located within the area of the municipality of Amsterdam, we have shown to what extent the economic structure, in terms of specialization, diversity and competition, affects site-industry employment growth between 1998 and 2006. The outcomes of our analysis exhibit substantial empirical evidence of a negative relationship between the degree of specialization and growth (statistically significant at the 5 per cent level). This implies that an overrepresentation of similar economic activity does not generate localization economies.

Extension of the Glaeser model by adding fixed effects provided, amongst other things, support to the notion that location matters, or at least the position of an industrial site. The parameterization of unobserved characteristics generates a ‘black box’. As we were particularly interested in the importance of accessibility we focused on location characteristics. Therefore, adding (non-contiguous) indicators of spatial heterogeneity – ease of accessibility and presence at a harbour site – has helped us disclosing this black box to a certain degree: well-accessible sites convey 6.1 per cent higher average annual growth vis-à-vis poorly accessible sites, and harbours render 7.6 per cent higher growth than non-harbours.

Spatial heterogeneity denotes variation over space of the relationships under study (Anselin, 1988). In our case, the inclusion of non-contiguous spatial aspects deals with the variation of intercepts, but does not allow for parameter variation across industrial sites. In this respect, further research is recommended. In view of the nature of our analysed spatial entities (viz. industrial sites), further investigation of homogeneity of the relationship between agglomeration externalities and employment growth over space is needed. Another challenge for further research would be to extend the analysis by contiguous elements of space. Since this chapter is mainly built on Glaeser et al. (1992), we have treated agglomeration externalities as spatially fixed; we have neglected the issue of spatial dependence. In other words, to what extent is performance on a site affected by the growth of neighbouring industrial sites? It is assumed that the spatial dependence of growth attenuates with distance (Rosenthal and Strange, 2004). In this respect, Van Oort (2007) reports that the inclusion of spatially-lagged versions of explained variables and explanatory variables gives rise to ambiguous results. It seems that the results differ by geographic scale. Despite the relative small sample, Glaeser's model has enabled us to get insight in the extent of which performance of an industrial site is affected by its local economic structure and accessibility. As such, it may provide useful tools to policy makers and urban planners for prioritizing and assessing the (re-)development of industrial sites.

Appendix 2.A Industrial sites in Amsterdam

	Industrial site	Acc.	Har.		Industrial site	Acc.	Har.
1	Amerikahaven Noordwest	0	1	35	Kenniscentrum Amsterdam	0	0
2	Amerikahaven Zuidwest	0	1	36	Weespertrekvaart Noord	1	0
3	Amerikahaven Noordoost	0	1	37	Weespertrekvaart Zuid Amsterdam	1	0
4	Amerikahaven Zuidoost	0	1	38	Weespertrekvaart Zuid Ouder-Amstel	1	0
5	Westhaven West	0	1	39	Weespertrekvaart Zuid Ouder-Amstel/Amsterdam	1	0
6	Westhaven Oost	0	1	40	Amstel I Amsterdam	1	0
7	Petroleumhaven	0	1	41	Amstel I Ouder-Amstel/Amsterdam	1	0
8	Coenhaven	0	1	42	Amstel II	1	0
9	Mercuriushaven	0	1	43	Amstel III deel C	1	0
10	Vervoerscentrum	0	0	44	Amstel III deel D1	1	0
11	Alfa-driehoek Bedrijven	1	0	45	Amstel III deel D2	1	0
12	Sloterdijk III Noord	0	0	46	Sloterdijk II Noord	1	0
13	Sloterdijk III Zuid	0	0	47	Sloterdijk I Bedrijven Zuid	1	0
14	Bedrijvencentrum Osdorp	0	0	48	Sloterdijk I Bedrijven Noord	1	0
15	Oude Haagseweg West	1	0	49	Heining	0	0
16	Confectiecentrum	1	0	50	Zijkanaal I	0	0
17	Schinkel	1	0	51	Metaalbewerkerweg	0	0
18	Bedrijvencentrum Westerpark	0	0	52	Zamenhofstraat	0	0
19	Food Center Amsterdam	0	0	53	Pereboomsloot	0	0
20	Buyskade	1	0	54	Gembo-terrein	0	0
21	Landlust	1	0	55	Nieuwendammerdijk	0	0
22	Houthavens Oost	0	0	56	't Schouw	0	0
23	Noorder IJplas	1	0	57	Conradstraat	0	0
24	C Douwesterrein 0	0	0	58	Veemarkt	0	0
25	C Douwesterrein 2Z	0	0	59	Molukkenstraat	0	0
26	C Douwesterrein 4A	0	0	60	Polderweg	0	0
27	C Douwestterrein 5	0	0	61	Tramremise Lekstraat	0	0
28	C Douwesterrein 6	0	0	62	Pompstation Waterleidingen Buitenveldert	1	0
29	Buiksloterham	0	0	63	Jollenpad	1	0
30	Papaverweg	0	0	64	Karperweg	0	0
31	Hamerstraat	0	0	65	Aletta Jacobslaan	1	0
32	Zeeburgereiland	1	0	66	Jan Tooropstraat	1	0
33	Zeeburgerpad	0	0	67	Sloten Slimmeweg	0	0
34	Cruquiusweg	0	0	68	Sloterdijk II Zuid	1	0

Sources: Department for Research and Statistics, City of Amsterdam; www.hetvirtuelebedrijventerrein.nl.
Notes: Acc.: accessibility (1=within 1 km. of highway exit, 0 otherwise); Har.: harbour site (1=yes, 0=no).

Appendix 2.B Industrial site-fixed effects estimation

Constant		9.21^{***} (4.20)	
Log of employment 1998 ($EMP_{s,i}$)		-2.70^{***} (−5.30)	
Aggregate growth Amsterdam industrial area ($AGGROWTH_s$)		0.78^{**} (5.46)	
Location quotient ($LQ_{s,i}$)		−0.26 (−0.91)	
Competition ($COMP_{s,i}$)		0.35^{**} (2.51)	
Industrial site	Fixed effect (α_i)	Industrial site	Fixed effect (α_i)
I_{1}	0.01	I_{35}	0.00
I_{2}	0.17	I_{36}	0.06
I_{3}	0.10	I_{37}	0.03
I_{4}	0.20	I_{38}	0.17
I_{5}	0.01	I_{39}	0.01
I_{6}	0.02	I_{40}	0.04
I_{7}	−0.03	I_{41}	0.13
I_{8}	0.02	I_{42}	0.02
I_{9}	0.05	I_{43}	0.05
I_{10}	0.04	I_{44}	−0.01
I_{11}	0.06	I_{45}	0.06
I_{12}	0.25	I_{46}	0.17
I_{13}	0.07	I_{47}	0.04
I_{14}	0.03	I_{48}	0.01
I_{15}	−0.14	I_{49}	−0.19
I_{16}	0.12	I_{50}	−0.44
I_{17}	−0.00	I_{51}	−0.09
I_{18}	0.01	I_{52}	−0.04
I_{19}	−0.07	I_{53}	−0.00
I_{20}	−0.11	I_{54}	−0.01
I_{21}	0.11	I_{55}	−0.06
I_{22}	−0.15	I_{56}	0.09
I_{23}	−0.19	I_{57}	0.01
I_{24}	−0.04	I_{58}	−0.04
I_{25}	−0.03	I_{59}	−0.17
I_{26}	−0.04	I_{60}	−0.07
I_{27}	−0.05	I_{61}	−0.11
I_{28}	0.07	I_{62}	0.13
I_{29}	0.02	I_{63}	0.16
I_{30}	0.00	I_{64}	0.02
I_{31}	0.05	I_{65}	−0.12
I_{32}	−0.04	I_{66}	−0.00
I_{33}	−0.08	I_{67}	−0.06
I_{34}	−0.04	I_{68}	0.03
F		3.97^{***}	
Adjusted R^2		0.33	
Number of observations		422	

Notes: Additional regressors, in this case *RDI*, cannot be estimated in the FE-model due to occurrence of perfect collinearity; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Chapter 3

The Impact of Industrial Sites on Residential Property Values: A Hedonic Pricing Analysis from the Randstad and North-Brabant

3.1 Introduction[1]

The results of Dutch policies aimed at providing an adequate supply of industrial land are mixed. In accordance with the spatial policy objectives, industrial sites have become the main location for supplying industrial land. Slowly but steadily, both the amount and share of employment on industrial sites are rising. Industrial sites are now a favourable place to settle for many firms (Louw and Bontekoning, 2007), and can be considered important contributors to the (local) economy: such sites occupy about 2 per cent of the total area of the Netherlands, and account for about one-third of the national output (Louw et al., 2007). However, the recent planning debates about Dutch industrial sites have focused strongly on the quality of industrial sites (Louw et al., 2004). Concerns have been raised about the possible negative external effects of industrial activities on other firms, on nature, and particularly on households (Schuur, 2001; Needham and Louw, 2003; Louw et al., 2004; Blaauw, 2007). Although the development of industrial sites in the Netherlands is based on the mono-functional policy concept of separating industry and housing, residents may still be affected by industrial sites because of a multitude of perceived disamenities, such as noise, traffic, congestion, air pollution and obstruction of view. This chapter contributes to the planning debate by elaborating on the impact of the presence of industrial sites on their immediate vicinity, distinguishing between various types of industrial sites.[2]

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[1] This chapter is based on De Vor and De Groot (2011).

[2] Five categories of industrial sites have been defined: ‘heavy-industry’, ‘sea-harbour’, ‘miscellaneous’, ‘high-tech’, and ‘transport’. This typology of industrial sites, as defined by the Dutch Industrial Sites Database (IBIS), is associated with the nature of the industrial site concerned.

It aims to measure the negative externalities generated by industrial sites, and to obtain insight into the spatial scope of these externalities. By means of a hedonic pricing analysis of residential property transactions, we identify the impact – ceteris paribus – of the distance to industrial sites on property transaction prices. Furthermore, we look into the implications of the characteristics of an industrial site on the magnitude of its impact by differentiating according to the size of the industrial site concerned. Many existing studies dealing with the topic of negative externalities generated by industrial sites consider a specific, tightly framed, study area comprising a restricted number of industrial sites. These studies arrive at a multitude of outcomes referring to a variety of specific cases.[3] In this respect, our study deviates from this literature by employing a more general approach: we analyse a comprehensive sample of industrial sites and identify the effects of these sites on neighbouring house prices in the Randstad region and in the Province of North-Brabant (both in the Netherlands).

The chapter is organized as follows. In section 3.2 we discuss the literature on negative externalities originating from industrial facilities and hedonic pricing. Section 3.3 reviews the Dutch (policy) context with regard to the negative external effects of industrial sites. In Section 3.4 we present the characteristics of the data set underlying our analysis and the research set up. Section 3.5 and 3.6 set out the employed econometric model and the associated estimation results. In Section 3.7 we conclude.

3.2 Literature review

Farber (1998) provides a survey of the literature on the impact of undesirable facilities on house values due to perceived disamenities. Such concerns range from worries about health risks to those about the public image of the community. They can manifest themselves in property markets, since it is most likely that people are willing to pay more to reside in locations further located from perceived disamenities. The survey confirms that undesirable facilities (e.g., landfills, waste sites, hazardous manufacturing facilities) reduce property values in their immediate vicinity. These adverse effects diminish with distance, resulting in increased property values as distance from these sites increases. Moreover, these adverse property value effects appear to be relatively localized. Other examples can be found in a number of studies which have shown effects on property values caused by proximity to a contaminated site. These studies (e.g., Smolen et al., 1991; Mendelsohn et al., 1992) have reported adverse impacts on values, ranging from as low as 0.24 per cent to as high as 25 per cent, depending on the extent of pollution and the location of the

[3] See, for example, Zeiss (1999) who analyses the results of 69 studies dealing with the negative effects of industrial facilities on their direct vicinity.

property. In view of the Dutch situation, Visser and Van Dam (2006) have analysed the housing market in the Netherlands as a whole and have focused on, among other things, the contribution of environmental characteristics to house price variation. By taking into account various characteristics within the immediate vicinity (50 metres) of the dwelling concerned (e.g., presence of parks, open space and industrial land, nature and quality of buildings, social status of the neighbourhood, distance to services, and infrastructure), they conclude that property value is positively affected by the quality of its vicinity in terms of the availability of amenities. For instance, houses located in low-density, leafy neighbourhoods, are valued significantly higher than houses in high-density areas with a lack of parks and open space. Conversely, disamenities, such as the presence of industrial land and proximity to a highway, affect the prices negatively. These findings suggest that effects generated by (dis)amenities operate especially on a local scale, which confirms the notion that impact decreases with distance.

Several detailed studies about the effects generated by specific (dis)amenities, within the Dutch context, confirm these outcomes. Rouwendal and Van der Straaten (2008) show that, in three major Dutch cities (Amsterdam, Rotterdam, and The Hague), parks and public gardens within the immediate vicinity of houses increase their value. Considering the three investigated cities, the city of Amsterdam has the highest price per square metre floor area, which is in line with the tight housing market situation in Amsterdam and the fact that the average floor area is the smallest in Amsterdam. However, the willingness-to-pay for open space appears to be lowest in Amsterdam. This finding is caused by the relatively low average quality of the different parks and public gardens in Amsterdam, compared with those in Rotterdam and The Hague. It shows that, as well as vicinity, the quality of the amenity matters. Dekkers and Van der Straaten (2008) have investigated the effect of aircraft noise on house prices in the highly urbanized area around Amsterdam Schiphol Airport. Controlling for multiple sources of traffic noise, air traffic yields the largest price impact, followed by railway traffic, and road traffic. Finally, Debrezion et al. (2006) analyse the effect of the accessibility provided by Dutch railway stations on residential house prices. It shows that house prices decrease with distance from a railway station, revealing the positive effect of proximity. This effect is enhanced by the increased frequency of train services at a station. Hence, the aforementioned studies provide insights into the efficiency of public policy in terms of optimal open space provision, aircraft noise reduction measures, and railway station accessibility, respectively.

As the existing literature has mainly focussed on cataloguing the adverse effects on property values, less is known about the magnitude with which the property values may increase following a clean-up or restructuring of a site. Exceptions are Dale et al. (1999) and McComb (2004) who report that property values around the sites under investigation appeared to be lower before the clean-up. However, after the clean-up, the prices consistently rebounded, although in the areas closest to the site and the poorest neighbourhoods prices rebounded more slowly. These studies underline that taking into account specific properties of sites may increase the accurateness of predicting the impact effects.

The previously mentioned studies are useful to demonstrate the nature and intensity of the impact of local forms of land use. Generally, they are based on revealed preference methods to observe what individuals really pay or require in compensation for living in the vicinity of sites that generate negative externalities (Farber, 1998). In this respect, the hedonic pricing method is mostly used to identify the impact of the various externalities. Hedonic prices are defined as the implicit prices of attributes, which are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them (Rosen, 1974). More specifically, in hedonic price analysis, house prices are regressed on a vector of inherent attributes. A hedonic equation helps to explain house prices in terms of the house's own characteristics, such as the type of dwelling, age, floor area, neighbourhood characteristics and job accessibility. Each of these attributes is assumed to be implicitly priced. The real-estate literature is replete with hedonic pricing models estimating the willingness-to-pay for housing characteristics (e.g. Linneman, 1981; Palmquist, 2005).

However, hedonic pricing methods have some limitations (Farber, 1998; Kiel and Zabel, 2001). First, property markets may not be in equilibrium when the impact of the undesirable facility is estimated. This is why it would be preferable to use data on house sales over a sufficiently long period of time. Second, there is an inherent problem in statistically identifying the willingness-to-pay to avoid a disamenity. The effects of sorting in property markets play a strong role in residential location decisions. Those people who are most willing to accept a disamenity, or who have limited housing options because of income or discrimination, locate adjacent to a disamenity. As a consequence, property value differentials may underestimate the disamenity effect for the general population. Third, to the extent that the adverse activity may be locally job-enhancing, adjacent house values could be elevated because of the effect of a reduction of transportation costs. Despite these limitations which are important to bear in mind when interpreting results from hedonic pricing models, the model is very suitable to identify the scope of negative externalities generated by industrial sites as it can reveal the effect of distance to industrial sites on residential property values.

3.3 The Dutch context

As in many Western countries, post-war spatial planning in the Netherlands has been dominated by mono-functional approaches. This has resulted in core spatial functions, such as housing, industry, farming, or shopping, being allocated to rather large-scale areas, often separated by 'buffers of open space'. However, several studies and the proliferation of 'mixed land use' approaches have revealed the limitations of mono-functional land use (Lagendijk, 2001; Vreeker et al., 2004). Whereas concepts of mixed land use aim to reduce urban sprawl and to promote spatial and environmental quality, the mono-functional approach presents a rather space-consuming form of land use which also tends to be inferior in terms of spatial quality. This notion is to a great extent reflected by the Dutch case of the provision of industrial sites, which is characterized by an abundant availability of industrial land and an associated decline of spatial quality (Gordijn et al., 2007).

In the Netherlands, local authorities are the main suppliers of building land, whether for housing or industry. On account of their statutory planning and land policy powers, they can plan and develop industrial sites or facilitate enterprise zones. Therefore, the role of private agents in the supply of industrial land has always been limited; approximately 74 per cent of the total area of industrial land is supplied by local authorities (Segeren et al., 2005). Local authorities consider the provision of industrial sites as a key instrument of their economic policy. In accordance with their task and responsibility as a provider of industrial land, local authorities ensure that there is always a minimum amount of industrial land available for immediate sale to interested companies. Over the last decade, this approach has resulted in a yearly average disposal of 1,130 hectares of industrial sites (Gordijn et al., 2007).

An important side-effect of the ample provision of industrial land, besides a shrinking quantity of open space, is the degradation of environment and landscape. This refers not only to the obstructing consequences of the disposal of new industrial land but also to its contribution to the process of the ageing of existing industrial sites. According to the Dutch Industrial Sites Database (Arcadis and Stec Groep, 2007), 29 per cent of the total number of industrial sites (1,052 sites) were considered as 'out-dated' in 2006. These sites have substantial vacancies in the building stock and poorly maintained public spaces. Attracted by the favourable assets of recently serviced land, well-performing companies decide to move to newly developed industrial sites. As a result, this outflow of well-performing firms generates unused industrial premises and substitution by marginal firms which creates a downward spiral of attractiveness of older industrial sites concerned (Louw and Bontekoning, 2007).

In conclusion, the 'buffers' of open space are under pressure in the Netherlands. This involves a gradual diminishing of the distance of housing and other functions from industrial sites. Accordingly, the present policy of mono-functional planning, and the interplay between distance and perceived negative externalities, provides us relevant background with regard to the impact of negative externalities originating from industrial sites, to which we now turn in the remainder of this chapter.

3.4 Data set and research set up

The data used originate from two sources: industrial-site data were collected from the Dutch Industrial Sites Database (IBIS), and property data from the Dutch Association of Real Estate Agents (NVM). The selected data refer to the Randstad region[4] and to the Province of North-Brabant in the Netherlands in the year 2005. The data collected on industrial sites and houses are all geo-referenced, which enables us to link these sets by using GIS (see the detailed map in Figure 3.1).

Since the Randstad region and the Province of North-Brabant are jointly responsible for generating 51 per cent of the total Dutch GDP, these regions are considered as the economic core-regions of the Netherlands. Respectively, 41 per cent and 15 per cent of the Dutch population reside in the Randstad region and North-Brabant (Statistics Netherlands, 2008). The regions studied contain a considerable amount of the national stock of industrial sites. We added a 500-metre buffer zone to the initial study area to incorporate possible effects generated by industrial sites located just outside the examined region. Hence, we obtained a sample containing information on 1,201 industrial sites,[5] acquired from the Dutch Industrial Sites Database (IBIS). These sites cover 26,703 hectares of industrial land. Figure 3.1 shows the spatial distribution of the industrial sites in our sample.

The IBIS database provides an inventory of formal industrial sites[6] containing information on numerous characteristics of the industrial sites concerned, of which the variables 'location' and 'type of industrial site' are the most relevant for the purpose of this chapter. Regarding the variable 'type of site', the IBIS data set distinguishes five categories of industrial sites: 'heavy-industry', 'sea-harbour', 'miscellaneous', 'high-tech', and 'transport'. This typology of industrial sites is associated with the nature of an

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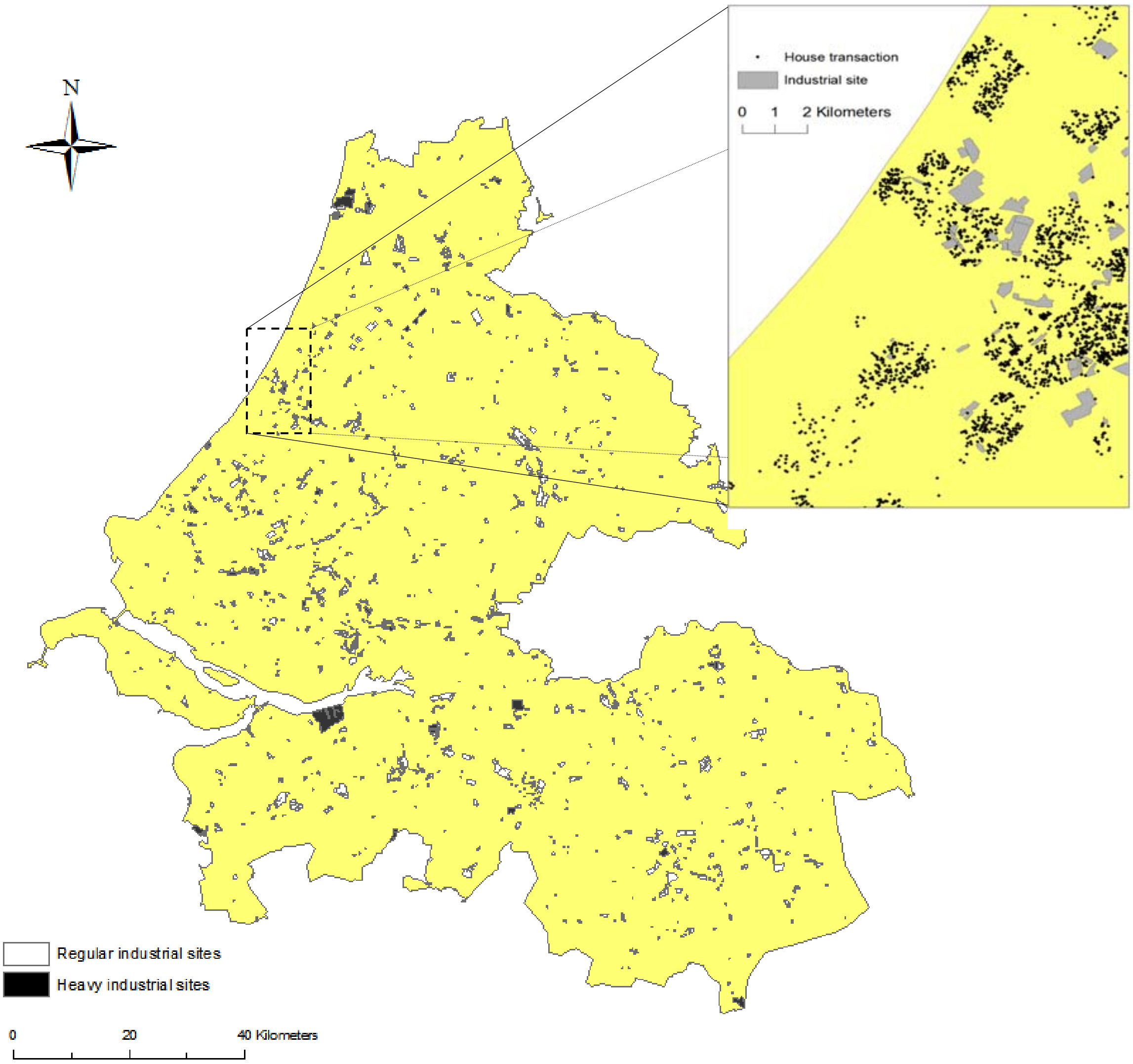
[4] The Randstad region comprises the following areas: the Province of North-Holland (excluding Alkmaar and surrounding area and the Northern part of North-Holland) and the Provinces of South-Holland and Utrecht. We refer to Rietveld and Wagtendonk (2004) for more details about regional definitions.

[5] The examined area originally comprised 1,718 industrial sites. Information on the 'type of industrial site' is only available for 1,201 sites. We eliminated from the sample those houses that are closest to an industrial site but for which no information on the type of industrial site is available.

[6] An industrial site is defined as 'a location which the land-use plans deem suitable for activities in the branches of commerce, manufacturing, commercial services, industry, and whose original design is larger than 1 hectare'.

industrial site;[7] it proxies the quality of the industrial sites concerned (Arcadis and Stec Groep, 2007).



Source: Dutch Industrial Sites Database (IBIS).

Figure 3.1 Distribution of industrial sites in the Randstad and North-Brabant, 2005

However, the typology has a serious drawback in terms of its ability to distinguish between types of sites. In 2006, 60 per cent of the total area of industrial land in the Netherlands (in

[7] Heavy-industry sites are industrial sites on which it is intended to establish highly undesirable facilities in terms of environmental nuisance (e.g. landfills, demolition dumps, waste sites, hazardous manufacturing facilities, etc.). Sea-harbours comprise large-scale sites featuring freight facilities for maritime shipping activities. Miscellaneous sites are commonly seen as regular industrial sites which include a large variety of activities (ranging from small to medium polluting activities), on the condition that these sites may not be categorized as high-tech or transport. High-tech sites are sites which are developed for high-tech production activities and R&D-activities. Transport is characterized by a dominant presence of logistics and wholesale activities.

hectares) was classified as 'miscellaneous'. The categories 'heavy-industry', 'sea-harbour', 'high-tech', and 'transport' represent, respectively, 10 per cent, 18 per cent, 4 per cent and 4 per cent of the area. The remaining 4 per cent of industrial land has been categorized as 'unknown' (Arcadis and Stec Groep, 2007). We deal with this drawback by categorizing industrial sites in two classes which proxy the nature of an industrial site. 'Heavy industrial sites' are sites which were originally classified as heavy-industry, sea-harbour, and transport sites, as these types of sites are assumed to generate substantial nuisance in terms of noise, traffic, congestion and pollution. The category 'regular sites' comprises miscellaneous and high-tech sites. These sites are expected to create less nuisance than 'heavy sites'. In our sample, 61 sites are categorized as 'heavy' and 1,140 sites as 'regular', covering, respectively, 728 and 25,975 hectares of industrial land.

The data regarding residential property values include information on all houses sold by NVM real-estate agents[8] in the Randstad and North-Brabant in the year 2005. We removed all observations referring to a house with a volume of less than 100 m^3, a floor area of less than 40 m^2 or a transaction price exceeding 1 million euro. Furthermore, the upper and lower 0.5 per cent of the transaction values of the remaining observations were excluded (for a similar approach, see Rouwendal and Van der Straaten, 2008). This leaves a sample containing information on 70,684 dwellings within the defined area.

Furthermore, additional geographical information on important control variables, such as the ethnic composition and population density of the neighbourhood, location of highway exits and railway stations, and distance-to-jobs, was acquired from, respectively, Statistics Netherlands (CBS), the National Road Database (NWB), the Dutch Railways (NS) and the Netherlands Institute for Spatial Research (RPB)/Land Use Scanner.[9]

Building on the hedonic valuation methodology, and acknowledging its limitations, as described in the literature review, we assume that residential property values are a function of structural, neighbourhood, and industrial-site variables.[10] The structural variables are the physical characteristics or attributes of the residential property, and include the numerical variables 'floor area' and 'volume'. Categorical variables indicate the presence of central heating, garage and garden, the period of construction and the type of house. The latter incorporates four basic architectural house styles: detached, semi-detached, terraced house, and apartment.

The neighbourhood variables cover the characteristics of the area in which the property is located, such as socioeconomic factors, status of the area, ease of accessibility

[8] NVM real-estate agents deal with approximately 70 per cent of all property transactions in the Netherlands.

[9] These data sets have been provided by SPINLab, VU University Amsterdam.

[10] Rents are controlled in the Netherlands, implying that their values are determined by a restricted system of points that highly disregards neighbourhood characteristics. We therefore do not take into account rented housing in our analysis.

and labour market characteristics. We include the ethnic composition (fraction of ethnic minorities) and the population density of the 4-digit ZIP-code area in which the dwelling is located. Additionally, a regional dummy is included to indicate the region (Randstad or North-Brabant) in which the dwelling of interest is located. We control for the ease of accessibility in two ways. First, we employ the ease of accessibility by road, operationalized by the road distance (metres) from each property to the nearest highway exit. Second, we employ the ease of accessibility by railway, operationalized by the straight-line distance (metres) from each property to the nearest railway station. Allowing for the positive effects associated with the provision of local employment by the industrial site concerned, which may elevate adjacent house values, we include the minimum distance (circle radius in metres) within which a total of 100,000 jobs can be reached. This measure is a proxy for job opportunities in the vicinity of the house.

Industrial-site variables refer to the perceived impact of the industrial sites that are present. This variable encompasses the characteristics of the industrial sites which are located in the vicinity of the properties concerned. The location of an industrial site, vis-à-vis residential properties, is specified by the distance from the approximate centre of a residential property to the nearest industrial site. In this respect, we include the straight-line distances in metres from each residential property to the closest point on the boundary of the industrial site. A dummy variable is included to indicate the category (heavy or regular) to which this nearest industrial site belongs. Furthermore, we assume that the size of an industrial site matters in explaining its impact on property values. Thus, we also control for the gross area[11] in hectares of the industrial sites concerned. Finally, since the data set also contains information about the date of house transactions, we include monthly dummies to capture the effects of the seasonality of the housing market. Appendix 3.A reports the variable names, their sources, definitions and some descriptive statistics.

3.5 The econometric model

A formal way of describing the hedonic price function is as follows:

$$P_j = f\left(S_1,\ldots,S_K;N_1,\ldots,N_L;I_1,\ldots,I_M;D_1,\ldots,D_N\right), \tag{3.1}$$

where houses are identified by the subscript j; P_j is house transaction price; and f relates the transaction price to structural (S) and neighbourhood (N) characteristics of the property, and the characteristics of the industrial sites (I) concerned. Since the effect of distance to

[11] The gross area of an industrial site is defined as the total area designated for industry, including the area which is used for infrastructure, water, green space, and other forms of public open space.

industrial sites on property transaction prices is our variable of key interest (D), we distinguish this variable explicitly. It assumes a housing market in equilibrium, meaning that all individuals have made their utility-maximizing choices, given the prices of alternative housing locations. For individual i living in house j, the utility is given by (see Rosen, 1974):

$$u_i = u(x; S_1,...,S_K; N_1,...,N_L; I_1,...,I_M; D_1,...,D_N), \tag{3.2}$$

which is assumed to be strictly concave. x is all other goods consumed. Set the price of x equal to 1 and the income of individual i, y_i, in terms of units of x. This gives the following budget constraint:

$$y_i = P_j(S_1,..., S_K; N_1,..., N_L; I_1,..., I_M; D_1,..., D_N) + x\,. \tag{3.3}$$

The maximization of utility, subject to the budget constraint, requires choosing x and $(S_1,...,S_K; N_1,...,N_L; I_1,...,I_M; D_1,...,D_N)$ to satisfy the budget and the first-order conditions. So, partial differentiation with respect to, for example, an industrial-site attribute M gives the marginal implicit price for that attribute $\partial P_j / \partial I_M$.

Economic theory provides little guidance regarding choice of functional form for the hedonic price function (Deaton and Hoehn, 2004; Neupane and Gustavson, 2008). The double natural log specification is widely employed for model estimation (Freeman, 1993), largely motivated by the fact that it allows for a simple interpretation of estimated coefficients as elasticities. However, in order to describe the pattern of distance-decay, we measure the effect of distance on house prices by using distance dummies, i.e. a less restrictive functional form, instead of employing the natural log of distance. We use distance categories with a 250-metre range to enable us to examine the effect in a detailed way (see Debrezion et al., 2006). Endogenous determination of the cut-off distance by running models with different cut-off distances results in a distance of 2,250 metres to the nearest industrial site, beyond which house prices are no longer significantly affected by negative externalities generated by the industrial sites concerned.[12] As a consequence, the piecewise specification of distance renders nine categories up to 2,250 metres. In the empirical application, the transaction price of a house j is modelled as follows:

$$LnP_j = \alpha + \sum_{k=1}^{15} \beta_k S_{j,k} + \sum_{l=1}^{6} \gamma_l N_{j,l} + \sum_{m=1}^{2} \delta_m I_{j,m} + \sum_{n=1}^{9} \zeta_n D_{j,n} + \varepsilon_j\,, \tag{3.4}$$

[12] Details are available on request.

where all variables are defined as in Equation (3.1). α is a constant, and β, γ , δ and ζ are coefficients to be estimated. The variables of structural, neighbourhood, industrial-site characteristics, and the distance-to-site variable for property j are, respectively, indexed by k, l, m and n. As we use dummies to measure distance, the distance-to-site variable (D) equals 1 if the house j is located within a certain range n from the nearest industrial site. In accordance with most of the previous literature, Equation (3.4) is estimated by ordinary least squares (OLS). White's heteroskedastic consistent covariance matrix is used to correct the estimated errors for unknown forms of heteroskedasticity.

In our model in its simple and basic form, we assume that house prices rise with increasing distance to the nearest industrial site. More specifically, the sign and the magnitude of estimated coefficients of the separate distance dummies are, respectively, expected to be negative and decreasing at a decreasing rate as distance between the site and the property increases (i.e. the coefficients under consideration express the price differentials between the distance category concerned and the reference group).[13] Furthermore, ceteris paribus, an increase in house prices is hypothesized to result from increases in floor area and housing volume. Increases in the age of the dwelling are hypothesized to cause decline in house values. The price effect associated with the style of housing (i.e. detached, semi-detached, terraced, or apartment) is uncertain, given that the model controls for floor area and volume. Specific assets of a house, such as the presence of central heating, garage and garden, are expected to have a positive price effect. Neighbourhood measures associated with status, such as ethnical composition and population density, are expected to influence house prices negatively, as has been shown by, amongst others, Rouwendal and Van der Straaten (2008). Considering the distance to jobs, we hypothesize a negative effect on house prices. Increased remoteness of households to areas of employment increases the costs of commuting. The associated expenditures will be capitalized into property values. Following Debrezion et al. (2006), we suppose that the effect of increasing distance to highway exits and railway stations on house prices is negative. Increased proximity causes positive effects in terms of accessibility which are assumed to exceed the negative effects, such as inherent traffic nuisance. Since the Randstad is the economic core region of the Netherlands, dwellings located in this region are hypothesized to sell at a higher price than dwellings in North-Brabant. The remainder

[13] Our results may be biased due to a possibly negative correlation between distance to the industrial sites and distance to, for example, public goods provided in the city-centre. This problem becomes more severe if many industrial sites are located in the urban fringe. This bias is likely to be limited in our case because (i) our sample comprises both inner-city industrial sites and fringe sites (e.g., greenfield sites); and (ii) we control in our empirical analysis for a range of characteristics of city-centres that may positively affect house prices, thus reducing the bias due to an omitted variable (viz. distance to 'goods' typically provided in city-centres such as railway stations and employment).

of the variables which are associated with the perceived impact proceeding from present industrial sites on house prices, e.g. the size of the industrial site, and heavy sites compared with regular sites, are hypothesized to affect house prices negatively.

3.6 Empirical results

3.6.1 The basic results

The basic estimation results are shown in Table 3.1. The majority of the results are highly statistically significant (at the 1 per cent significance level) and consistent with our hypotheses,[14] including those for the distance-to-site dummies. Looking at the industrial-site characteristics size and type of site, we see that the corresponding estimated parameters have a negative and positive sign, respectively. On the one hand, this confirms our hypothesis that the larger an industrial site, the more inconvenience it generates. On the other hand, the effect of heavy sites on their immediate vicinity has significantly less impact than that of regular sites, which is remarkable since the heavy-industry sites are defined as industrial sites on which it is intended to establish highly undesirable effects in terms of environmental nuisance. A possible explanation for this unexpected finding is the relatively small occurrence of sites denoted as 'heavy' in our data set. It may also stem from an omitted variable bias (for example, lot sizes close to heavy sites being relatively large).

Considering distance, we find, consistent with our expectations, that increased distance from industrial sites increases house prices. Ceteris paribus, houses located within 250 metres of an industrial site are predicted to sell at 14.9 per cent less than houses located beyond a distance of 2,250 metres from such a site (the reference group). The estimated relationship, employing the linear piecewise distance specification and a given set of characteristics, is shown in Figure 3.2. The figure illustrates the value of the representative property[15] as a function of the distance-to-site dummy (keeping all other variables constant).

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[14] Concerning the impact of the age of the dwelling on house prices, alternative models have been estimated by applying a linear and a quadratic specification for the year of the transaction. The estimated coefficients are consistent with the general findings, regarding sign as well as statistical significance of the estimated effects. Details are available on request.

[15] The representative property is defined as the hypothetical property for which all explanatory variables (viz. attributes of the property), except for the distance to the industrial site, are set at their respective means.

Table 3.1 Estimation results of the hedonic price function for the Randstad and North-Brabant in 2005 using a piecewise specification of distance

Variable	Coefficient	*t*-statistic
Constant	9.649***	260.4
Structural characteristics (S_k)		
Ln Floor area (m^2)	0.391***	29.1
Ln Volume (m^3)	0.407***	29.4
Detached	0.275***	46.0
Semi-detached	0.128***	27.4
Terraced	–0.022***	–7.0
Year of construction (<1906)	–0.008*	–1.7
Year of construction (1906–1930)	–0.086***	–24.2
Year of construction (1931–1944)	–0.126***	–32.1
Year of construction (1945–1959)	–0.157***	–42.9
Year of construction (1960–1970)	–0.175***	–71.6
Year of construction (1971–1980)	–0.155***	–65.8
Year of construction (1981–1990)	–0.099***	–41.7
Central heating	0.081***	21.9
Garage	0.094***	36.0
Garden	–0.000	–0.0
Neighbourhood characteristics (N_l)		
Ethnical minorities (fraction population)	–0.644***	65.3
Ln Population density (inhabitants per km^2)	–0.021***	–16.2
Ln Distance to 100,000 jobs (metres)	–0.096***	–51.4
Ln Distance to highway exit (metres)	–0.019***	–12.7
Ln Distance to railway station (metres)	–0.012***	–13.0
North-Brabant regional dummy	–0.137***	–72.9
Industrial-site characteristics (I_m)		
Ln Gross area of nearest industrial site	–0.012***	–19.1
Heavy industrial-site dummy	0.117***	30.6
Distance in metres (D_n)		
0–250	–0.149***	–21.4
250–500	–0.139***	–20.1
500–750	–0.122***	–17.5
750–1000	–0.109***	–15.5
1000–1250	–0.103***	–14.2
1250–1500	–0.087***	–11.5
1500–1750	–0.051***	–6.3
1750–2000	–0.034***	–3.9
2000–2250	–0.004	–0.4
Adjusted R^2	0.774	
Number of observations	70,684	

Notes: We have controlled for the month of sale; Estimated coefficients are not reported, but are available on request; White *t*-values are reported; *** Significant at the 1% level; * Significant at the 10% level.

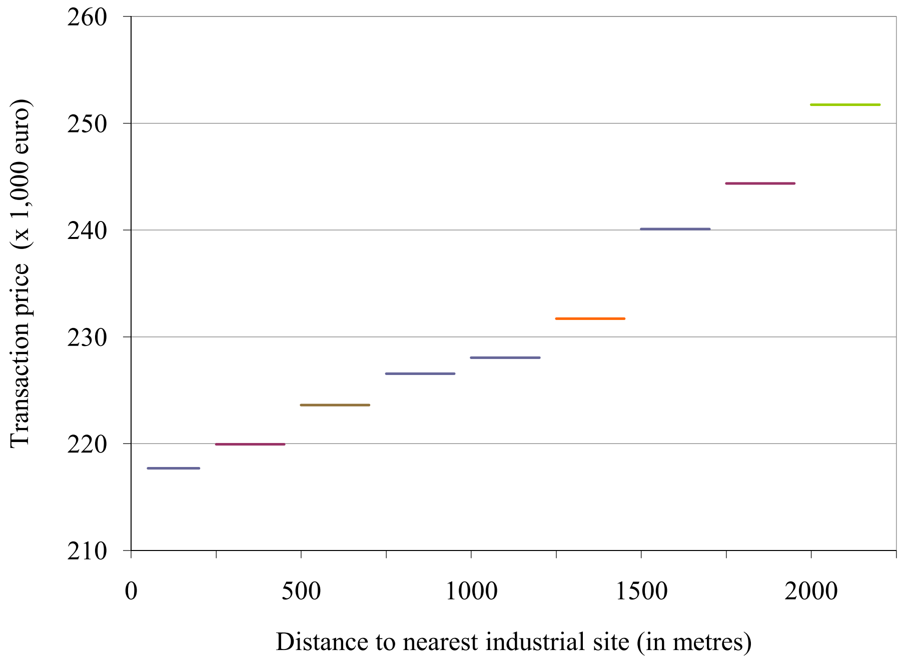

Figure 3.2 Transaction price gradient function for a representative property (piecewise specification)

In Figure 3.2, the depicted pattern suggests a logistic shape, representing the (partial) relationship between the distance to the closest industrial site and house prices. We therefore proceed by replacing the piecewise specification of distance with a logistic functional form of distance. More specifically, we estimate the following model using nonlinear squares (NLS):

$$LnP_j = \alpha + \sum_{k=1}^{15} \beta_k S_{j,k} + \sum_{l=1}^{6} \gamma_l N_{j,l} + \sum_{m=1}^{2} \delta_m I_{j,m} + \eta_1 \frac{e^{\eta_2 + \eta_3 Ln(D_j)}}{1 + e^{\eta_2 + \eta_3 Ln(D_j)}} + \varepsilon_j , \qquad (3.5)$$

where all variables are defined as in Equation (3.1). Because of the transformation into the logistic specification for distance, we estimate three parameters, η_1, η_2 and η_3, which together characterize the partial relationship between distance and the house price. More specifically, the maximum variation of house prices as a function of distance to the nearest industrial site is captured by parameter η_1. Furthermore, the relationship is upward sloping if $\eta_1 \cdot \eta_3 > 0$, and the point of inflection (viz. the distance at which the curve is steepest, and thus beyond which the effect of the presence of the industrial site gradually diminishes) can be derived as:

$$D_j^{\ *} = \left(\frac{\eta_3 - 1}{e^{\eta_2}(1 + \eta_3)} \right)^{1/\eta_3} . \tag{3.6}$$

The point of inflection thus decreases with increasing values of η_3. We refer to Appendix 3.B for technical details.

The results of the estimation are presented in Table 3.2. Since the other estimated coefficients remain generally unchanged, we only report the outcomes referring to the effect of distance from an industrial site on house prices. Appendix 3.C reports the full estimation results.

Table 3.2 Estimation results of the hedonic price function for the Randstad and North-Brabant in 2005 using a logistic specification of distance

Variable	Coefficient	*t*-statistic
Constant	9.506***	261.7
Distance		
η_1	0.169***	8.8
η_2	–18.445***	–10.7
η_3	2.516***	9.6
Adjusted R^2	0.774	
Number of observations	70,684	

Notes: Only the estimation results referring to the effect of distance are reported (full estimation results are reported in Appendix 3.C); White *t*-values are reported; *** Significant at the 1% level.

With reference to the goodness-of-fit and the parsimony of the preceding models, examination of corresponding criteria does not point to one of the models being clearly preferred over the other.[16] However, given the advantages with respect to interpretation and presentation, we decide to use the more parsimonious model to characterize the relationship between distance to industrial site and house prices. On that account, a detailed look at the employed logistic functional form of the house prices as a function of the minimum distance of a house to its nearest industrial site gives us more precise information about the nature of the distance decay of the negative externalities which are

[16] The adjusted R^2 of both models is 0.774. The Aikake's Information Criterion (AIC) for the respective models equals –0.251 for the piecewise model, and –0.250 for the logistic model. The model with a lower AIC is typically preferred.

generated by the industrial sites. The partial relationship between house prices and distance to the nearest industrial site can be represented as:

$$P(D_j) = 0.169 \frac{e^{-18.445+2.516\, Ln(D_j)}}{1+e^{-18.445+2.516\, Ln(D_j)}} = \frac{0.169\, e^{-18.445} D_j^{\ 2.516}}{1+e^{-18.445} D_j^{\ 2.516}}. \tag{3.7}$$

Moreover, from Equation (3.7) the point of inflection (D_j^*) can be derived. It appears that up to distance of 1,093 metres, the house prices are increasing at an increasing rate, whereas the house prices are increasing at a decreasing rate beyond this distance. We have depicted this relationship graphically in Figure 3.3. It illustrates the value of the representative property given a change in the distance-to-site variable, holding the other variables constant.

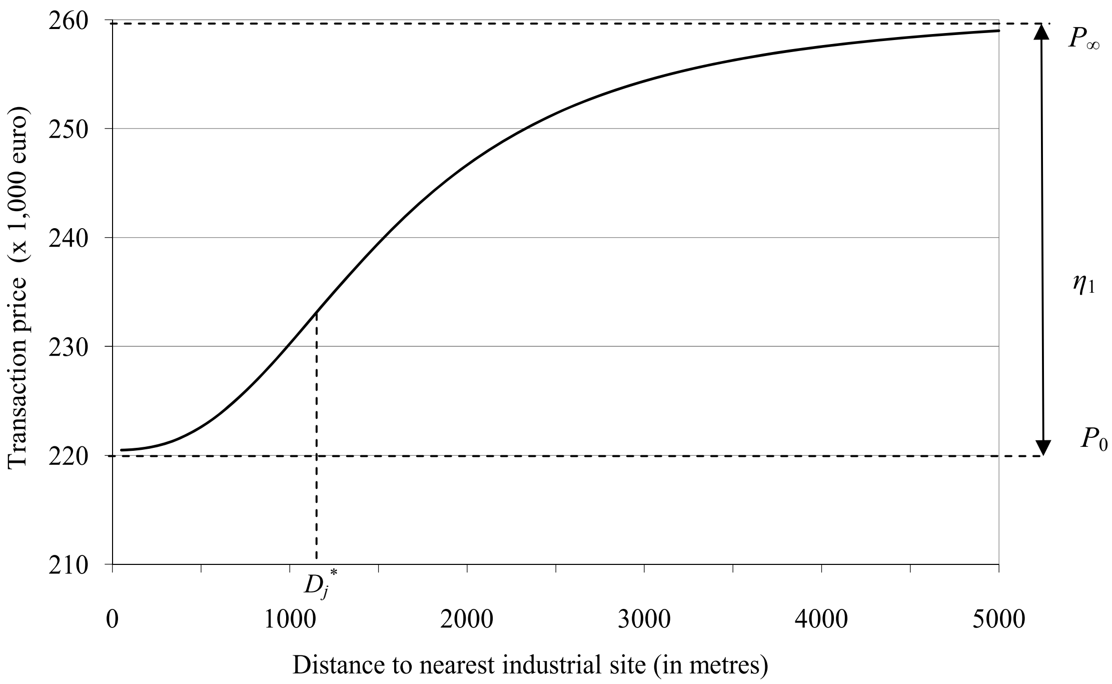

Figure 3.3 Transaction price gradient function for a representative property (logistic specification)

The revealed shape of the curve in Figure 3.3 is in accordance with our expectations. It illustrates that the impact of negative externalities generated by industrial sites is largely localized. Increasing distance leads to a gradually diminishing increase of house prices.

3.6.2 A more detailed look at industrial-site size

In view of the estimation results of Equation (3.5), we infer that the nature of the distance-decay of negative externalities generated by industrial sites is largely localized. Amongst other things, we have seen that the point of inflection is at 1,093 metres. However, we have neglected the potential relevance of the interplay between the effect of distance and another relevant industrial-site characteristic, such as the gross area of the site.

The value of the estimated coefficient of the gross area of the nearest industrial site, irrespective of which model we use, equals –0.012 (statistically significant at the 1 per cent level). This implies that an increase of 1 per cent of the gross area of the nearest industrial site decreases house price by 0.012 per cent. However, it is plausible to contend that the effect of the increase of site area on house prices modifies with increasing distance from the site concerned. We therefore allow for interaction effects between gross site area and distance to the nearest site. Interaction of these parameters with industrial-site area will result in a change of the nature of the distance decay, in that it becomes conditional on site area. However, sequential regression model runs (NLS) for separate 'site size-distance' interaction terms, and all three site size-distance interaction terms together, only yield statistically significant estimates (at the 5 per cent level) for the model which controls for $\eta_1 \cdot LnGrossarea$ (φ_1).[17] This model is specified as follows, where all variables are defined as in Equation (3.5):

$$LnP_j = \alpha + \sum_{k=1}^{15} \beta_k S_{j,k} + \sum_{l=1}^{6} \gamma_l N_{j,l} + \sum_{m=1}^{2} \delta_m I_{j,m} + \eta_1 \frac{e^{\eta_2 + \eta_3 Ln(D_j)}}{1 + e^{\eta_2 + \eta_3 Ln(D_j)}}$$
$$+ \varphi_1 (\eta_1 \cdot LnGrossArea_j) \frac{e^{\eta_2 + \eta_3 Ln(D_j)}}{1 + e^{\eta_2 + \eta_3 Ln(D_j)}} + \varepsilon . \qquad (3.8)$$

The results of the estimation are presented in Table 3.3. We only report the outcomes referring to the effects of site size, distance from an industrial site, and the corresponding interaction effect on house prices.

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[17] The estimation results of the other models which are related to the interaction between site size and distance are available on request.

Table 3.3 Estimation results of the hedonic price function for the Randstad and North-Brabant in 2005 using a logistic specification of distance: the interaction effect between distance and industrial-site size

Variable	Coefficient	*t*-statistic
Constant	9.511***	261.7
Size of nearest industrial site		
Ln Gross area	–0.013***	15.6
Distance		
η_1	0.147***	7.5
η_2	–17.700***	–10.6
η_3	2.419***	9.4
Interaction distance and size		
φ_1	0.008**	2.3
Adjusted R^2	0.774	
Number of observations	70,684	

Notes: Only the estimation results referring to the (interaction) effects of distance are reported (full estimation results are reported in Appendix 3.C); White *t*-values are reported; *** Significant at the 1% level; ** Significant at the 5% level.

The estimated interaction coefficient (φ_1) indicates that the effect of distance on house prices, referring to the range, rises with increasing site size. In other words, an increase of 1 per cent gross area of the industrial site concerned elevates the accompanying distance effect by 0.008 per cent, ceteris paribus. This effect is illustrated graphically in Figure 3.4. We have depicted the price gradients of representative properties whose nearest industrial sites have a gross area of 1 hectare, 25 hectares and 50 hectares, given a change in the distance-to-site variable. As well as observing that the overall price-level of houses located near 'small' industrial sites exceeds the price level of 'larger' sites, we also observe that the range or variation of the house prices increases as the size of the nearest industrial site increases. Furthermore, the relationship between site size and distance to the site appears to be nonlinear, in the sense that the effect of size change is relatively larger for 'small' sites than for 'large' sites.

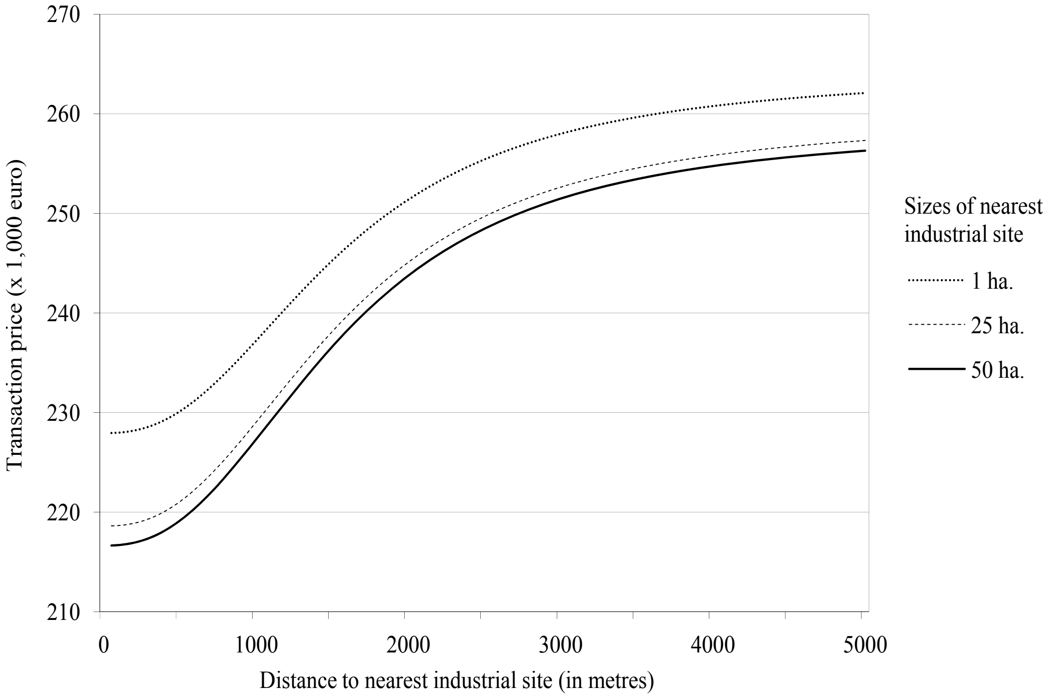

Figure 3.4 Transaction price gradient functions for various different site sizes

3.6.3 Robustness analysis

The results so far show that the findings concerning the marginal effect of the presence of an industrial site on house prices, as measured by distance-to-site, are robust to the employed functional forms, viz. the piecewise and logistic specification of distance. In accordance with our findings concerning goodness-of-fit and parsimony of the model, we prefer to use the logistic functional form. In order to test the robustness of our results, we replicated the corresponding regression model employing different subsets of the original data, and, finally, we have added municipality dummies to the basic model to examine whether the results are sensitive to potential unobserved local circumstances.

First, we conducted model runs for four different subsamples comprising houses which are located, respectively, within 500, 1,000, 1,500 and 2,000 metres from the nearest industrial site.[18] The regression estimates are strongly in line with the findings discussed before: they confirm that there is a lack of variation in house prices within short distance from an industrial site, and, conversely, that expanding the sample sizes leads to a rise of

[18] Sampling along the spatial dimensions concerned creates data sets consisting of the following number of observations: <500: *N*=27,711; <1,000: *N*=50,660; <1,500: *N*=62,485; <2,000: *N*=67,600. The estimation results related to this sensitivity analysis are available on request.

house prices variation across distance as, amongst others, represented by an increasing parameter η_1.

Second, we examined the sensitivity of the empirical results to regional specifications by dividing the transaction data into two subsamples, viz. the Randstad and the Province of North-Brabant, respectively.[19] The model run for the Randstad sample yields coefficients which are fully consistent with the general findings, regarding sign as well as the statistical significance of the estimated effects. However, the impact of the presence of an industrial site on house prices appears to be more pronounced in the Randstad region than in the entire area of examination, in the sense that house prices are increasing at a faster rate as the distance to the nearest industrial site increases. For the sake of comprehensibility, these outcomes have been displayed graphically (see Figure 3.5). Conversely, the results for North-Brabant with regard to distance yield statistically insignificant outcomes. Displaying the corresponding transaction price gradient reveals a relationship between distance and house price which exhibits a logarithmic form.[20] In North-Brabant the effect of industrial-site presence on house prices is, apparently, manifested within a relatively short distance of the site concerned. To get more insight into this regional anomaly, we have conducted additional model runs for the Province of North-Brabant and the Randstad separately, explicitly accounting for the nature of industrial sites in terms of type and size.[21] The outcomes turned out to be consistent with the aforementioned findings. In North-Brabant, beyond a distance of approximately 750 metres there is no discernible impact of distance to the closest site on house prices, irrespective of type and size of the industrial site. Concerning the Randstad, the revealed partial relationship between distance to industrial site and house prices features a logistic shape. Given that we have controlled for the industrial-site characteristics of the investigated regions, the functioning of regional housing markets thus seems to differ considerably. Likewise, replicating the preceding regressions using the piecewise distance specification instead of the logistic distance specification yields consistent results, indicating that the employed model is sensitive to geographical considerations.[22]

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[19] Sampling along the regional dimensions concerned creates data sets consisting of the following number of observations: Randstad: N=51,689; North-Brabant: N=18,995.

[20] This has been confirmed by running an alternative regression (OLS) using the natural logarithm of distance. The regression yields statistically significant estimates of the log of distance (at the 1 per cent significance level). Estimation results are available on request.

[21] The additional models comprise four basic regression runs per region for different compositions of the samples: a sample with only small sites (<35 ha.), a sample with only large sites (>35 ha.), and samples with only heavy and non-heavy sites, respectively. The estimation results are available on request.

[22] The estimation results are available on request.

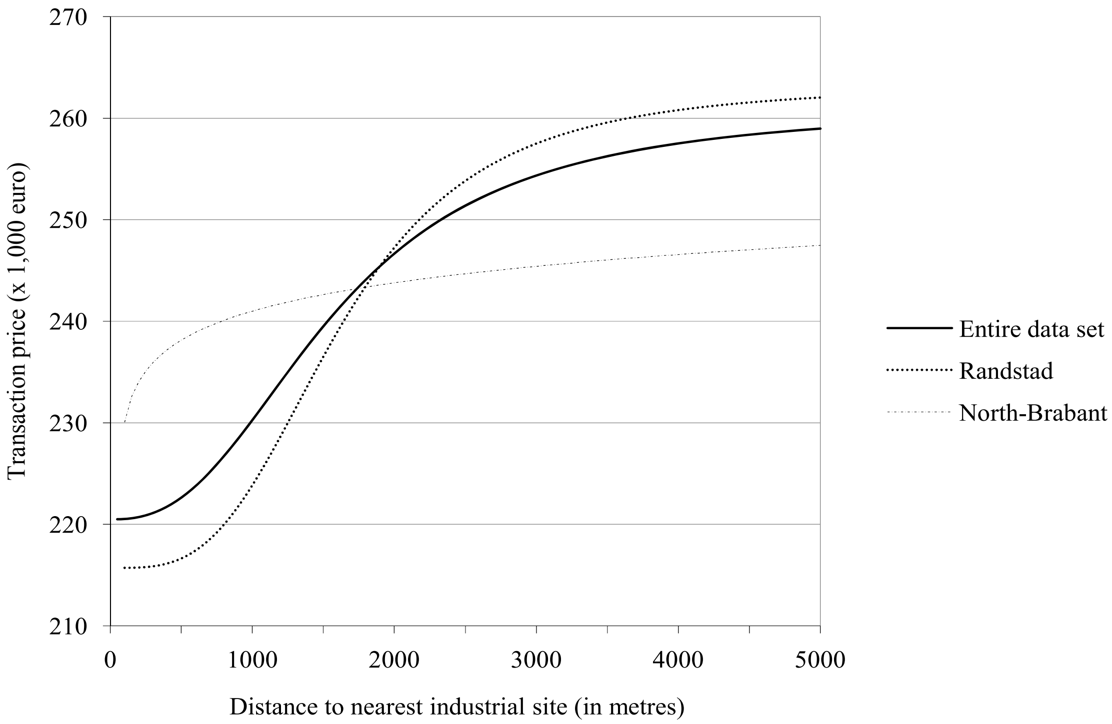

Figure 3.5 Transaction price gradient functions for different regional samples

Finally, estimating the basic model with the inclusion of 219 municipality dummies, each corresponding to the municipality in which the dwelling concerned is located (taking the municipality of Amsterdam as reference group), yields outcomes which are qualitatively as well as quantitatively comparable to those obtained with the basic logistic specification (see Table 3.4). Considering the estimated partial relationship between distance to industrial site and house prices, the parameter η_1, which captures the maximum variation of house prices as a function of distance to the nearest industrial site, slightly increases from 0.169 to 0.186. Furthermore, by using Equation (3.7) the point of inflection is at 1,133 metres (instead of at 1,093 metres). The remainder of the estimated coefficients are also consistent with the basic model estimates. Hence, we may infer that the revealed effect of distance-to-site on house prices is robust, in the sense that its nature is hardly affected by potential unobserved heterogeneity, stemming from specific local circumstances.

Table 3.4 Estimation results of the hedonic price function for the Randstad and North-Brabant in 2005, including municipality dummies

Variable	Coefficient	t-statistic
Constant	9.510***	232.6
Distance (D_j)		
η_1	0.186***	2.7
η_2	–13.006***	–8.0
η_3	1.653***	5.8
Adjusted R^2	0.839	
Number of observations	70,684	

Notes: Only the estimation results referring to the effect of distance are reported (full estimation results are reported in Appendix 3.C); White t-values are reported; *** Significant at the 1% level.

3.7 Conclusion

The main aim of this chapter was to study the impact of the presence of industrial sites on their immediate vicinity. Applying a hedonic pricing model, we valued the negative externalities generated by activities located on industrial sites in the Randstad region and the Province of North-Brabant (both in the Netherlands), in the year 2005. The effect of these negative externalities is proxied by estimation of the distance-decay of house prices in the vicinity of industrial sites. In accordance with previous hedonic pricing studies, our results clearly show that the presence of an industrial site has a statistically significant negative effect on the value of residential properties: house prices rise with increasing distance to the nearest industrial site. However, in contrast to previous hedonic pricing studies that we know of, we employ a logistic functional form to reveal the nature of the effect of distance-to-site on house prices. This leads to a relationship between distance and residential property prices which is best described as ‘dichotomous’: relatively close to a site, negative externalities have a strong negative effect on house prices which convexly decreases up to a certain distance. Beyond this point, in our case 1,093 metres, the negative effect on house prices concavely decreases till it fades out with increasing distance. Furthermore, we find that the effect of site size intervenes with the effect of distance on house prices, in the sense that this interactive effect affects the maximum variation of the distance effect: the larger the site, the larger the range of houses which are affected by the presence of the industrial site concerned.

Our outcomes demonstrate that the impact of negative externalities is largely localized, implying that the perception of the spatial quality of the neighbourhood is affected by the presence of an industrial site, and to a certain extent by the size of an industrial site. In addition, our study may provide spatial planners with more insight into setting zoning guidelines in order to decrease potential inconvenience resulting from the presence of an industrial site. We have to be careful, however, in deriving inferences with regard to the latter, as our study only employs the revealed preferences of house buyers in the vicinity. In view of this, we should take into account that our approach is sensitive to sorting of individuals driven by variation in the willingness-to-accept a disamenity. This may be manifested by underestimation of the distance-to-site effect within a short distance of an industrial site. Our results, furthermore, neglect the preferences of other stakeholders, for instance employees of the firms located on the sites or the visitors to these firms, who may attach different values to the impact of industrial sites. Another possible shortcoming is the variation across regions. As we obtained substantially different parameters regarding the effects of distance on house price for the Randstad and North-Brabant subsets, it reduces the general applicability of the method. This regional sensitivity may be of special importance for policy makers.

In conclusion, the findings of this chapter provide insight into the extent of negative externalities involved with location of certain industrial activities on a specific site. The observed impacts address the notion of the spatial quality of an industrial site. Despite some caveats, they provide useful information that can help with prioritizing and assessing spatial planning approaches.

Appendix 3.A Definitions, sources and descriptive statistics for the variables used

Variable	Description	Source	Mean	Standard Deviation
Price	Transaction price in the year 2005 (euros)	NVM	254,522.33	141,377.12
Structural characteristics				
Floor area	Size of living area of the house (m^2)	NVM	120.24	49.51
Volume	Volume of the house (m^3)	NVM	353.28	220.34
Detached	Dummy variable: equals 1 if the house is detached	NVM	0.08	0.27
Semi-detached	Dummy variable: equals 1 if the house is semi-detached	NVM	0.10	0.31
Terraced	Dummy variable: equals 1 if the house is a terraced house	NVM	0.46	0.50
Apartment	Dummy variable: equals 1 if the house is an apartment	NVM	0.36	0.48
Before 1906	Dummy variable: equals 1 if the house was built before 1906	NVM	0.06	0.24
1906–1930	Dummy variable: equals 1 if the house was built in the period 1906–1930	NVM	0.14	0.34
1931–1944	Dummy variable: equals 1 if the house was built in the period 1931–1944	NVM	0.09	0.28
1945–1959	Dummy variable: equals 1 if the house was built in the period 1945–1959	NVM	0.08	0.26
1960–1970	Dummy variable: equals 1 if the house was built in the period 1960–1970	NVM	0.15	0.36
1971–1980	Dummy variable: equals 1 if the house was built in the period 1971–1980	NVM	0.15	0.36
1981–1990	Dummy variable: equals 1 if the house has been built in the period 1981–1990	NVM	0.14	0.35
After 1990	Dummy variable: equals 1 if the house was built after 1990	NVM	0.20	0.40
Central heating	Dummy variable: equals 1 if the house has central heating	NVM	0.92	0.27
Garage	Dummy variable: equals 1 if the house has a garage	NVM	0.20	0.40
Garden	Dummy variable: equals 1 if the house has a garden	NVM	0.56	0.50
Neighbourhood characteristics				
Ethnical minorities	Fraction of inhabitants of non-western origin in the ZIP-code area (4-digit) of the house	CBS	0.12	0.11
Population density	Number of inhabitants per km^2 in the ZIP-code area (4-digit) of the house	CBS	5,361.07	3,935.07
Distance to highway exit	Distance, by road, from the house to the nearest highway exit (metres)	NWB	3,993.81	2,548.18
Distance to railway station	Straight-line distance from the house to the nearest railway station (metres)	NS	3,142.00	3,279.79
Job accessibility	Minimum distance (circle radius) within which a total of 100,000 jobs can be reached (metres)	RPB/LS	8,492.26	4,511.54
North-Brabant	Dummy variable: equals 1 if the house is located in the Province of North-Brabant	NVM	0.27	0.44

Variable	Description	Source	Mean	Standard Deviation
Industrial-site characteristics				
Distance to industrial site	Straight-line distance from the house to the boundary of the nearest industrial site (metres)	IBIS	784.39	606.72
Gross area	Gross area of the nearest industrial site (hectares)	IBIS	34.02	58.45
Regular industrial site	Dummy variable: equals 1 if the nearest industrial site concerns a miscellaneous or high-tech site	IBIS	0.93	0.27
Heavy industrial site	Dummy variable: equals 1 if the nearest industrial site concerns a heavy industry site, sea harbour or transport site	IBIS	0.07	0.27

Notes: The abbreviations stand for: CBS – Statistics Netherlands; IBIS – Dutch Industrial Sites Database; LS – Land Use Scanner; NS – Dutch Railways; NVM – Dutch Association of Real Estate Agents; NWB – National Road Database; RPB – Netherlands Institute for Spatial Research; The sample size is 70,864 observations.

Appendix 3.B Technical details

This Appendix derives the characteristics of the logistic specification for the partial relationship between house prices and distance to the closest industrial sit. We start from the basic function:

$$F(D_j) = \eta_1 \frac{e^{\eta_2 + \eta_3 LnD_j}}{1 + e^{\eta_2 + \eta_3 LnD_j}} = \frac{\eta_1 e^{\eta_2} D_j^{\eta_3}}{1 + e^{\eta_2} D_j^{\eta_3}} . \tag{3B.1}$$

The first-order derivative of this function (*F*) with respect to distance (*D*) equals:

$$F'(D_j) = \frac{\eta_1 \eta_3 e^{\eta_2} D_j^{\eta_3 - 1}}{(1 + e^{\eta_2} D_j^{\eta_3})^2} \text{, so } F'(D_j) > 0 \text{ if } \eta_1 \cdot \eta_3 > 0 . \tag{3B.2}$$

The second-order derivative equals:

$$F''(D_j) = \frac{(1 + e^{\eta_2} D_j^{\eta_3}) D_j^{\eta_3 - 1} e^{\eta_2} \eta_3 \eta_1}{(1 + e^{\eta_2} D_j^{\eta_3})^4} \text{, so } F''(D_j) = 0 \text{ if } D_j^* = \left(\frac{\eta_3 - 1}{e^{\eta_2} (1 + \eta_3)} \right)^{1/\eta_3} . \tag{3B.3}$$

For $0 < D_j < D_j^*$, $F(D_j)$ is an increasing convex function of D_j, if $\eta_3 > 0$. For $D_j^* < D_j < \infty$, $F(D_j)$ is an increasing concave function of D_j, if $\eta_3 > 0$.

Appendix 3.C Full estimation results

Variable	Logistic specification of distance		Logistic specification of distance: interaction between distance and industrial-site size		Logistic specification of distance: municipality-dummies	
	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Constant	9.506***	261.7	9.511***	261.7	9.511***	232.6
Structural characteristics						
Ln Floor area (m^2)	0.392***	29.1	0.392***	29.1	0.387***	27.7
Ln Volume (m^3)	0.407***	29.4	0.407***	29.4	0.417***	29.0
Detached	0.275***	46.0	0.275***	46.0	0.293***	52.7
Semi-detached	0.128***	27.4	0.128***	27.4	0.129***	30.5
Terraced	–0.022***	–7.0	–0.022***	–7.0	–0.008***	–2.8
Year of construction (<1906)	–0.007	–1.4	–0.007	–1.4	–0.056***	–12.9
Year of construction (1906–1930)	–0.086***	–24.3	–0.086***	–24.3	–0.122***	–39.2
Year of construction (1931–1944)	–0.126***	–32.2	–0.126***	–32.2	–0.139***	–41.6
Year of construction (1945–1959)	–0.155***	–42.6	–0.155***	–42.6	–0.157***	–49.2
Year of construction (1960–1970)	–0.174***	–71.4	–0.174***	–71.3	–0.179***	–76.8
Year of construction (1971–1980)	–0.155***	–66.0	–0.155***	–66.0	–0.156***	–70.3
Year of construction (1981–1990)	–0.099***	–41.8	–0.099***	–41.9	–0.111***	–51.6
Central heating	0.080***	21.9	0.081***	21.9	0.083***	27.1
Garage	0.094***	36.0	0.094***	36.0	0.085***	36.2
Garden	–0.000	–0.1	–0.000	–0.1	0.007***	3.3
Neighbourhood characteristics						
Ethnical minorities (fraction population)	–0.645***	65.5	–0.644***	65.3	–0.742***	–79.4
Ln Population density (inhabitants per km^2)	–0.021***	–16.3	–0.022***	–16.5	–0.015***	–10.8
Ln Distance to 100,000 jobs (metres)	–0.096***	–51.5	–0.096***	–51.5	–0.071***	–25.0
Ln Distance to highway exit (metres)	–0.019***	–12.9	–0.019***	–13.0	–0.012***	–6.1
Ln Distance to railway station (metres)	–0.012***	–13.0	–0.012***	–12.8	–0.017***	–12.1
North-Brabant regional dummy	–0.137***	–73.0	–0.137***	–73.3	–0.136***	–72.9
Industrial-site characteristics						
Ln Gross area of nearest industrial site	–0.012***	–18.8	–0.013***	–15.6	–0.006***	–9.6
Heavy industrial-site dummy	0.117***	30.7	0.117***	30.6	0.048***	12.6
Distance						
η_1	0.169***	8.8	0.147***	7.5	0.186***	2.7
η_2	–18.446***	–10.7	–17.700***	–10.6	–13.006***	–8.0
η_3	2.516***	9.6	2.419***	9.4	1.653***	5.8
Interaction distance and size						
φ_1			0.008**	2.3		
Municipality						
Mun_1–Mun_{219}					Estimated coefficients are available on request	
Adjusted R^2	0.774		0.774		0.839	
Number of observations	70,684		70,684		70,684	

Notes: We have controlled for the month of sale; Estimated coefficients are not reported, but are available on request; White *t*-values are reported; *** Significant at the 1% level; ** Significant at the 5% level.

Chapter 4

The Location and Size of Industrial-site Development: The Case of North-Brabant

4.1 Introduction

In the previous chapters, we have discussed the nature and spatial scope of externalities generated by industrial sites. The impact of the effects of both positive and negative externalities is to a large degree related to the absolute and relative geographical location of the industrial sites. The location of industrial sites, and the area around them, however, is typically the result of spatial planning, implemented by means of local land-use policy (Louw et al., 2003). Municipalities intervene on the land market by applying the instrument of zoning. At a certain location, supply restrictions are imposed on the amount of land allocated to, for instance, industrial land use in favour of other types of land use, such as residential or agricultural land use. Given the importance of location with respect to the impact and performance of industrial sites, this chapter investigates the outcomes of land-use policy in terms of the area of industrial sites supplied and the level of employment on the industrial sites concerned. More specifically, we aim to gain insight into the role of spatial location characteristics as determinants of the location choice of industrial-site area provision, and the resulting intensity of land use in terms of employment.

Land values reflect the quality of location, in terms of the availability of public services and the concentration of jobs and knowledge (e.g., De Groot et al., 2010). Taking land value as a starting point of our analysis, we investigate the spatial variation of land values in relation to the development of the industrial-site area at the locations concerned. Explicit attention is paid to the ease of accessibility of the locations, since this has been identified as an important determinant of performance of an industrial site (see Chapter 2). The level of employment on industrial sites is analysed similarly. The policy of supplying land for industrial sites aims to facilitate local employment. Using employment on industrial sites, we measure the response, in terms of settled jobs, to the development of the industrial-site area at a certain location. Furthermore, particular attention is paid to the dynamics of industrial-site development, yielding insight into the trade-off between assigning land to industrial use and an alternative type of use. With respect to employment on industrial sites, the dynamics provides us with, among other things, insights into the effectiveness of the instrument of industrial-site area provision as a driver of local economic growth.

Our analysis covers the location and size of industrial sites, in terms of area and employment, in the Province of North-Brabant. We examine this province in the South of the Netherlands because of its marked industrial character (Atzema and Wever, 1999; Geutink et al., 2006). The economic structure of the Province of North-Brabant is dominated by manufacturing activities, which is, among other things, reflected by a substantial availability of industrial sites. On a more pragmatic note, another reason for choosing this case study concerns the availability of the data: the Province of North-Brabant provided detailed land-use and employment data relating to the spatial level of aggregation of industrial sites.

Land values have been shown to provide important information about the characteristics of a location. However, land values at a refined level of spatial aggregation are not publicly available in the Netherlands. Similar to De Groot et al. (2010), we have employed a hedonic pricing approach, based on a comprehensive sample of residential property transaction data, to reveal the implicit prices of land (viz. parcels) attributed to the associated residential properties. These implicit prices of residential land proxy the attractiveness of the locations concerned. The variation of the revealed land values in the housing market provides information on local scarcity in the land market, which enables us to detect the development of industrial sites and the associated use of land in terms of employment.

The chapter is organized as follows. Next in Section 4.2 we discuss the theory concerning land use and zoning. Section 4.3 reviews Dutch land-use policy regarding the supply of industrial sites. The data set and research set up are described in Section 4.4. Sections 4.5 and 4.6 present the estimation methods and accompanying results with regard to, respectively, the location and size of industrial sites and the associated dynamics of industrial sites. In Section 4.7 we conclude.

4.2 Theoretical considerations on land use

4.2.1 Land market

Most economic studies of the land market are based on the assumption that, in equilibrium, land is devoted to the use that generates the highest potential profitability (Verburg et al., 2004). This assumption builds on the insights of Von Thünen (1966), i.e. land use is the outcome of competition for the accessibility of the centre, leading to ‘concentric circles’ of land use. In contrast to Ricardo (1817), who argues that fertility determines land use, Von

Thünen's model explains, in its simplest form, how distance affects the location of different agricultural products. The model assumes that all agricultural products are shipped to the market (viz. the city-centre), land is of identical quality at all locations, and the transportation costs involved rise linearly with the distance to the market. As the production costs are the same at each location and constant for each quantity, the transportation costs determine the location of each product. Under the assumption of free market-entry, a farmer is willing to pay a land rent which equals, at most, the profit he makes at the location concerned. Thus, land closer to the city will have a higher price than land located further from the city (O'Sullivan, 2003).

Following this rationale, the traditional urban economic model of land-use patterns, the bid-rent model (or monocentric model), emerged (Alonso, 1964; Mills, 1967; Muth, 1969). This model explains how the bidding for land by various types of actors (firms grouped according to sector) results in land-use patterns, with various types of activities taking place in particular zones. Under the assumptions of land-use decisions which are made by utility-maximizing agents and free market-entry, location is optimized by trading off accessibility to the central business district (CBD) and land rent. As a result, the equilibrium pattern of land use, in its simplest form, is described by the well-known concentric circles of different types of land use around the CBD, and associated decreasing land-use intensity as distance from the CBD increases. The corresponding bid-rent curve, which represent the rents payable by sector, will fall with distance from the CBD, but at a decreasing rate.

Subsequently, more sophisticated versions of the bid-rent model have been developed. For instance, taking into account public facilities, infrastructure, and environmental quality has lead to various aberrations from the usual bid-rent patterns so that concentrations may occur in places with particular quality (Fujita, 1989). Clearly, land use does not develop independently at each individual location; each development affects the conditions of neighbouring and distant locations (Verburg et al., 2004). The most prominent example in this respect is the work of Christaller (1933) in which simple mechanisms of interaction between locations are modelled in his 'central place theory', which describes the uniform pattern of towns and cities in space as a function of the distance that consumers in the surrounding region travel to the nearest facilities. More complex is the work of Fujita et al. (1999) and Krugman (1999) which elaborates on the spatial interaction between the location of facilities, residential areas, and industries. Spatial interactions are explained by a number of factors that either cause the concentration of urban functions (such as economies of scale, localized knowledge spillovers, and thick labour markets) and or lead to a spreading out of urban functions (such as congestion, land rents, and factor immobility).

Governments play an important role in land-use planning, and hence also in the models of urban land use. Governments are important suppliers of public facilities, infrastructure, and other amenities. As well as this, governments intervene on the land market to correct for the various externalities involved with land use. Especially in the Netherlands, the assignment of land to different spatial functions is subject to extensive governmental involvement, both in terms of total volume of land and in terms of location (Rietveld and Wagtendonk, 2004).[1] The aforementioned models function as a starting point to examine the effects of governmental intervention with respect to industrial land use at a particular location.

4.2.2 Zoning

Spatial planning, by means of land-use policy, is an important factor of governmental intervention to correct for market failure, i.e. externalities of land use and the non-competiveness of the land market (CPB, 1999; Buurman, 2003). Governments generally intervene in two ways on the land market: via prices and via constraints. The latter is typically applied in the Netherlands. By means of zoning, i.e. restricting or allowing the supply of land for certain spatial functions, land is allocated to different types of land use. The construction of industrial sites can in this respect be considered as a form of zoning, which means that certain industrial activities are allowed, or not allowed, in particular areas in a city or municipality.

Within an urban area, the expansion of the supply of industrial sites results in a larger area for industrial activities than would be provided in a non-regulated land market. More specifically, this kind of zoning policy restricts the area of residential land in favour of industrial land. Considering the bid-rent model, this form of subsidizing industrial-site development (or residential-land use restriction) rearranges the pattern of land use, and the associated bid-rent gradient of urban-land use, as compared with the equilibrium pattern of land use which emerges under free-market conditions. As a result, zoning inevitably has welfare implications, i.e. rental-revenue losses arise from land being used for industrial activities (instead of housing) which are unable to pay the maximum rent attainable under a policy without zoning (see McCann, 2001).

However, the interpretation of the welfare implications of zoning policies is complicated, as externalities exhibited by land markets are not correctly priced by the market mechanism (McCann, 2001). For instance, the aesthetic aspects of an open rural landscape are inclined to be undervalued by private-sector cost considerations, such that the profitability of individual manufacturing activities takes precedence over the perceived positive benefits associated with an open landscape. De Groot et al. (2010) address this

[1] A description of the background and the objectives of recent Dutch spatial planning policies can be found in, respectively, Louw et al. (2003) and Rietveld and Wagtendonk (2004).

issue by studying the spatial variation of land values across the Netherlands. They demonstrate that land in cities is valued markedly higher than land in peripheral regions. The large differences in value is imputed to the interplay between the supply of location-specific amenities, which are more present in city(-centres) than at remote locations, and the number of (good) jobs available. The high level of amenities in the city attracts people and jobs, and vice versa, resulting in a rise of productivity growth which enables people to buy a highly valued plot of land in the city. The value of land reflects the benefits associated with the location concerned. These benefits are mainly ascribed to scale and corresponding externalities. In this respect, the occurrence of externalities justifies the implementation of spatial planning measures, such as zoning (at least as a second-best instrument).

Regarding the empirical literature concerning the use of land and associated (local) land markets, much attention is paid to the development of residential areas, rather than the development of industrial sites (e.g., Rietveld and Wagtendonk, 2004; Verburg et al., 2004; Dekkers, 2010). Inspired by this literature, we use similar approaches to investigate the interplay between land-use policy and land market characteristics by considering the development of industrial sites.

4.3 Dutch land-use policy

In the Netherlands, national, provincial, and local authorities play distinct roles in spatial planning (Rietveld and Wagtendonk, 2004). Local authorities (municipalities) implement spatial planning through land-use plans, which define the location, size and type of future land use. These local plans have to be consistent with the land-use policies formulated at the provincial and national level. Considering the practice of expanding urban areas (viz. residential and industrial areas), the corresponding municipal land-use plans can be implemented by means of active land policy or passive land policy. *Active land policy* implies that municipalities, in the process of land development, act as an active actor on the land market. As such, municipalities acquire land, which is serviced and divided into building lots, and provide it to builders and occupiers (Louw et al., 2003). In the case of *passive land policy*, the public instruments of land acquisition are not used pro-actively. The private sector has the initiative in the development of a building site and the municipality concerned restricts its own land acquisitions to land for public services.

The development of industrial sites in the Netherlands is mainly subject to the active participation of municipalities on the local land market. The main reason for adopting an active land policy in the development of industrial sites is that municipalities can exert more influence on the spatial development process than if they apply a passive land policy. In the latter case, they can only control spatial development on the basis of their powers under the Spatial Planning Act (the public law powers) (see, e.g., Louw et al., 2003). In addition, Louw (2000) and Segeren et al. (2005) argue that municipalities consider building land as a public good, which inclines local authorities to supply industrial sites by themselves, consistent with the land-use plan at the national and provincial level.[2] In turn, municipalities prepare the use of land in detail stipulated by local land-use plans. The amount of time it takes for a municipality to plan and realize an industrial site varies from roughly six to eight years (Louw, 2000; SER, 2004).

4.4 Data set and research set up

The spatial configuration of the economy of the Province of North-Brabant, and corresponding heterogeneous land-use requirements, provides us with a setting to examine the effect of spatial location characteristics associated with the location of industrial-site area provision, and the corresponding intensity of land use in terms of employment. The Province of North-Brabant is considered as an economic core-region as it generates around 15 per cent of the total Dutch GDP (Statistics Netherlands, 2008). This output is characterized by a large industrial component. Over 20 per cent of the Dutch industrial firms are located in this region. In particular, those activities categorized as manufacturing (SIC 93- classification) are overrepresented. In 2008, the manufacturing sector contributed 24.2 per cent to the total gross added value in North-Brabant, whereas in the aggregate Dutch economy manufacturing accounted for 15.9 per cent (Statistics Netherlands, 2008). Additionally, due to the presence of both considerable urbanized regions and international transportation links, the transport and distribution sector is relatively important (Province of North-Brabant, 2010). Figure 4.1 gives an impression of the distribution of industrial sites in North-Brabant.

The Province of North-Brabant contains 603 formal industrial sites, many of which are located close to or inside urban areas, and especially in the larger cities. The presence of a substantial number of industrial sites at inner-city locations can be considered as a relic of North-Brabant's industrial history. Many cities in North-Brabant went through a process of industrialization during the late 19th and first half of the 20th century. The spatial structure of cities has been typically formed by the development of sectors classified as manufacturing. As such, this period of industrialization is to a large degree still reflected in the present spatial configuration of the cities concerned. For instance, the emergence of the textile industry and the electronics industry has substantially shaped the cities of Tilburg and Eindhoven. Large areas of land at easily accessible locations were assigned to textile

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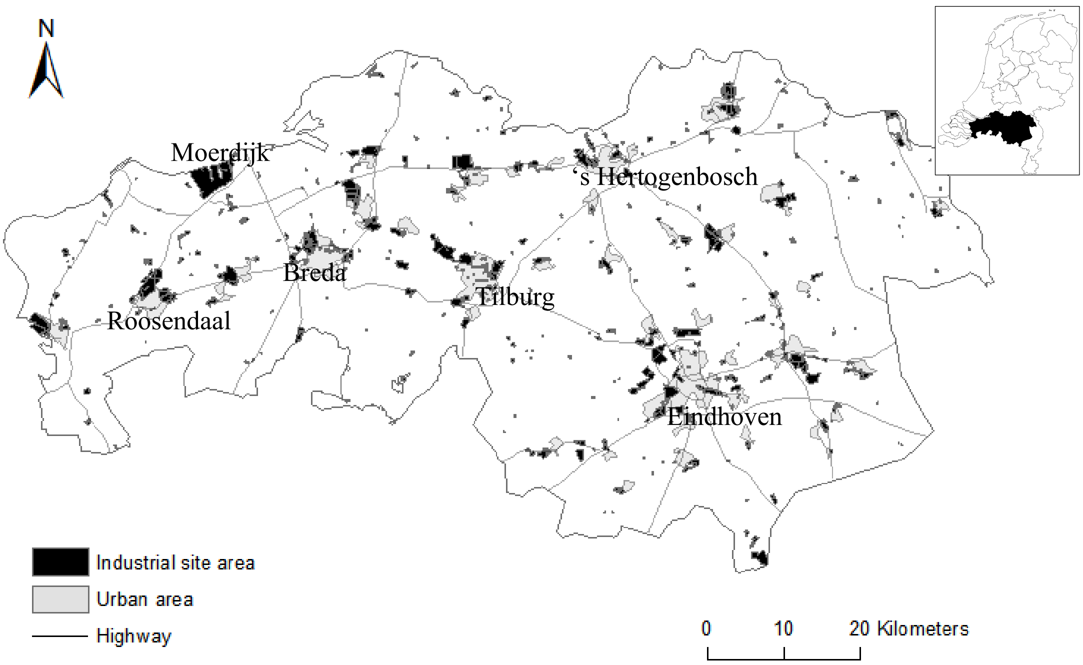
[2] In assessing whether national and regional (provincial) plans create sufficient space for future economic development, an important task has been assigned to the Business Location Monitor (BLM). The BLM is an applied model which provides provincial planning authorities with estimates of future demand for new business areas (Schuur, 1999; Knoben and Traa, 2008). The BLM is discussed in more detail in Chapter 5.

mills and light-bulb factories, while the workers were accommodated around these centrally-located factories (see, e.g., Atzema and Wever, 1999). Furthermore, the municipality of Moerdijk, in the North-West of the province, has a notable number of industrial sites. This location comprises a cluster of large-scale 'heavy-industry sites' which house highly undesirable facilities in terms of environmental and health nuisance (e.g., chemical plants, landfills, demolition dumps, waste sites, hazardous manufacturing facilities, etc.). Due to the access to open water, and its relative proximity to the Port of Rotterdam, the location of Moerdijk also features a substantial number of sea-harbour activities (i.e. freight facilities for marine shipping activities). Finally, many of the industrial sites are located along highways which indicates the importance of accessibility (see also Chapter 2).



Source: The Department of Spatial Planning, Province of North-Brabant.

Figure 4.1 Distribution of industrial sites in North-Brabant (1 January 2008)

We use data which originate from various sources. In order to specify spatial location, we aggregate the data at the 4-digit ZIP-code area. Our sample comprises 499 observations, corresponding to the number of 4-digit ZIP-code areas in North-Brabant in the period under study. Each location (i.e. the 4-digit ZIP-code area) comprises a number of characteristics, in particular referring to the size of industrial-site area and the corresponding level and composition of employment.[3]

[3] In the case of industrial sites which overlap different ZIP-code areas, we have assigned the total area of the industrial site to the ZIP-code area that contains the largest part of the industrial site concerned.

The Department of Spatial Planning of the Province of North-Brabant has provided an inventory of formal industrial sites, and their corresponding characteristics, located in North-Brabant in 2000 and in 2008.[4] Considering the industrial-site area, the total number of industrial sites concerned occupied 11,130 hectares of (net) industrial land in 2000, and 12,420 hectares in 2008.[5] This implies a growth of 11.5 per cent of land assigned to industrial sites during the period under study. Additionally, in 2008 the total number of industrial sites accommodated 40.8 per cent of the total number of jobs in North-Brabant, whereas the share of employment that can be found on industrial sites in the Netherlands in aggregate is around 35 per cent (Louw and Bontekoning, 2007). Table 4.1 gives an impression of the importance of industrial sites.

Table 4.1 Division of number of jobs (×1,000) by type of location in North-Brabant

	1 January 2000	1 January 2008	Change 2000–2008
Industrial sites	447.747 (43.5%)	479.696 (40.8%)	+7.1%
Other locations	582.653 (56.5%)	696.877 (59.2%)	+19.6%
Total	1,030.400	1,176.573	+14.2%

Source: Department of Spatial Planning, Province of North-Brabant.
Note: Share of total economic activity by type of location in parentheses.

Table 4.1 shows that, during the period 2000 to 2008, the relative importance of industrial sites as the location of employment has decreased. Concerning the dynamics of employment, the growth of jobs can mainly be found on other locations (i.e. outside industrial sites), rather than on industrial sites. Other locations (not formal, land-use policy designated industrial sites) have shown a substantial growth of 19.6 per cent, whereas on industrial sites the number of jobs has just grown by 7.1 per cent. Moreover, the area of industrial sites has grown by 11.5 per cent, which may point to a certain ineffectiveness of the policy of industrial site provision as a driver of economic growth.

The decreasing importance of industrial sites as a location of economic activity is associated with the change of production structure of the economy, i.e. the share of manufacturing is decreasing, in favour of, amongst other activities, services. As such, the sectoral composition on industrial sites is affected correspondingly. Table 4.2 presents the distribution of jobs across sectors on industrial sites in North-Brabant. We see that the

[4] The sample provided contains an inventory of industrial sites which is based on the Dutch Industrial Sites Database (IBIS).

[5] In 2000, 283 4-digit ZIP-code areas have been identified containing industrial-site area.

fraction of manufacturing jobs is decreasing, mainly in favour of services jobs (categories K, L, and N) and logistics and wholesale (categories G and I).

Table 4.2 Industry division on industrial sites by number of jobs (×1,000)

Industry	1 January 2000	1 January 2008
Agriculture, forestry and fisheries (A,B)	0.867	0.823
Mining and Quarrying (C)	0.127	0.113
Manufacture; Public Utilities (D,E)	191.130	170.438
Construction (F)	41.611	41.147
Trade and repair of consumer articles (G)	84.218	94.151
Hotels and restaurants (H)	5.764	5.589
Transport, storage and communications (I)	39.387	45.381
Financial intermediation (J)	3.259	11.241
Renting and commercial services (K)	55.805	71.160
Public administration, defence and social security (L)	5.462	11.273
Education (M)	4.763	2.785
Health and social work (N)	8.994	17.534
Environment, culture and other services (O)	6.360	8.061
Total	447.747	479.696

Source: Department of Spatial Planning, Province of North-Brabant.
Note: SIC 93-code of industry concerned in parentheses.

We use residential property data from the Dutch Association of Real Estate Agents (NVM) to reveal the land prices of the locations concerned (viz. the 4-digit ZIP-code areas). Due to the absence of a comprehensive data set on transactions of parcels on industrial sites, the value of land at the locations concerned is proxied by the real implicit prices (in constant prices of 2005) of land per square metre per ZIP-code area, attributed to residential properties. The implicit prices of land have been derived by means of hedonic pricing techniques, based on data of residential properties sold in the Province of North-Brabant. The data concern the period 1985 to 2005. The obtained land prices vary from € 27 per m^2 in the town of Rucphen to € 890 per m^2 in the city of ‘s Hertogenbosch. Additionally, the distribution of the land prices across the ZIP-code areas concerned has a pattern which is largely in accordance with bid-rent theory: land prices decrease with increasing distance from the respective city-centres. We refer to Appendix 4.A for more (technical) details.

From Regional Key Figures (*Regionale Kerncijfers*), produced by Statistics Netherlands, we have acquired data concerning the working-age population. In order to capture the effects associated with labour market opportunities at the locations concerned, we use the number of inhabitants within the age category of 20 and 65 years, measured at the level of the municipality to which the 4-digit ZIP-code area belongs. As such, we consider the municipality as the relevant labour market. Data referring to accessibility are collected from the ABF Research Real Estate Monitor. The Euclidean distances, in metres, from the midpoint of the defined 4-digit ZIP-code areas to their nearest highway exit and intercity-railway station are used. These measures are a proxy of the accessibility, by road and rail, of the locations concerned.

On the basis of the aforementioned data, the following sections present models which explore the role of the various spatial location characteristics as determinants of the observed supply of industrial sites and the level of employment on the industrial sites concerned. We employ models which explain the location and size of industrial sites, in terms of area and employment, from both a static and a dynamic point of view. Appendix 4.B lists the names of the variables used, their sources, definitions, and provides some descriptive statistics.

4.5 Explaining location and size of industrial sites

4.5.1 The econometric model

First, we estimate the effect of location characteristics on the supply of industrial-site area at the locations concerned. We use the following empirical model which explains the level of net industrial-site area provided, Y_i, in a 4-digit ZIP-code area i (=1,2,…,n), in the year 2000:

$$LnY_i = \beta_0 + \beta_1 LnV_i + \beta_2 LnPop_i + \beta_3 LnDh_i + \beta_4 LnDs_i + \beta_5 LnZ_i + \varepsilon_i, \qquad (4.1)$$

where V_i is the real value of residential land (in constant prices of 2005); Pop_i is the size of the working-age population of the municipality to which the ZIP-code concerned belongs; Dh_i is the distance to the nearest highway exit; Ds_i is the distance to the nearest intercity-railway station; and Z_i is the size of the 4-digit ZIP-code area. The β's are coefficients to be estimated, and ε_i is the error term. We employ a double natural log specification, motivated by the fact that it allows for a simple interpretation of estimated coefficients as elasticities. Equation (4.1) is estimated by ordinary least squares (OLS) and functions as a benchmark.

Given our focus on industrial land use at a disaggregate level, this implies that there are a number of observations in our sample which are recorded as zero or missing. More specifically, our sample consists of 499 ZIP-code areas of which just 283 areas contain land assigned to industrial site-use. However, neglecting the zero-valued observations (viz. 216 ZIP-code areas) can bias the results, if they do not occur randomly (Linders and De Groot, 2006). By excluding zero-valued observations, we lose relevant information on the location choice of industrial-site area supply. Moreover, a log-linear formulation of the econometric model cannot include zero-valued industrial-site area, because the logarithm of zero is undefined.

In order to address the potential bias caused by the neglect of zero values, we employ a sample selection model, the two-stage Heckman selection model (Heckman, 1979). Similar to Linders and De Groot (2006), who deal with zero-valued trade flows in gravity modelling of bilateral trade, we prefer the sample selection model in order to take into account zero-valued observations (viz. locations containing no industrial-site area).[6] In general, the sample selection model first determines whether or not an 'event' occurs (for instance, trade flow or, in this case, industrial-site development), and subsequently it determines the potential size of the 'event'. The size of net industrial-site area supply within a ZIP-code area i, in 2000, is indicated by Y_i. Accordingly, the two-stage Heckman selection model of industrial-site supply is specified by the following equations:

$$\overline{\pi}_i = \gamma_0 + \gamma_1 LnV_i + \gamma_2 LnPop_i + \gamma_3 LnDh_i + \gamma_4 LnDs_i + \gamma_5 LnZ_i + \mu_i, \tag{4.2}$$

where $\overline{\pi}_i = 1$ if $Ln\overline{Y}_i > 0$, and $\overline{\pi}_i = 0$ if $Ln\overline{Y}_i = 0$.

$$Ln\overline{Y}_i = \beta_0 + \beta_1 LnV_i + \beta_2 LnPop_i + \beta_3 LnDh_i + \beta_4 LnDs_i + \beta_5 LnZ_i + \varepsilon_i, \tag{4.3}$$

where $LnY_i = Ln\overline{Y}_i$ if $\overline{\pi}_i = 1$ and $LnY_i =$ not observed if $\overline{\pi}_i = 0$.

Both equations are estimated by using Maximum Likelihood (ML) estimation. Equation (4.2) is the selection equation which determines whether we observe an industrial site within a ZIP-code area. Equation (4.3) represents the regression equation which determines the size of the corresponding industrial-site area. The selection equation should, in general, at least contain all variables that are reflected in the regression equation (Verbeek, 2000).[7]

The effects of spatial location characteristics on the level of employment on the industrial sites concerned have been investigated in a similar way. In the empirical application, the number of jobs on an industrial site, E_i, in a 4-digit ZIP-code area i

[6] Linders and De Groot (2006) investigate various approaches to deal with zero-valued or missing observations. Besides omitting zero values from a sample, Tobit estimation, truncated regression, probit regression, and substitutions for zero-valued observations have been discussed.

[7] From the parameter estimates in the selection equation, the inverse Mill's ratio is computed for each ZIP-code area, denoted λ. If Heckman's λ is included as an additional regressor in the second-stage estimation of the model, the remaining residual is uncorrelated with the selection outcome, and the model parameters can be estimated consistently with OLS. The parameter estimated for Heckman's λ in the second-stage regression captures initial selection bias in the residual of the equation (see, Linders and De Groot, 2006).

(=1,2,…,n), in the year 2000, is modelled as follows:

$$LnE_i = \beta_0 + \beta_1 LnV_i + \beta_2 LnPop_i + \beta_3 LnDh_i + \beta_4 LnDs_i + \beta_5 LnY_i + \beta_6 J_i + \varepsilon , \quad (4.4)$$

where all variables are defined as in Equations (4.1) to (4.3), except for J_i which represents the fraction of logistics jobs of the total number of jobs on industrial sites, in 2000, in the ZIP-code areas concerned. We have included the initial level of net industrial-site area and the fraction of logistics jobs as explanatory variables to control for, respectively, the intensity of land use and the associated composition of employment. Logistics is considered to be capital-intensive compared with other sectors, such as services and manufacturing. Additionally, logistics is a sector which typically locates on industrial sites (see Table 4.2). Equation (4.4) is estimated by ordinary least squares (OLS). Since we can only include ZIP-code areas containing land which is assigned to industrial sites, our sample consists of 281 observations.[8]

4.5.2 Estimation results

Table 4.3 reports the empirical results. Column 1 reports the results of the uncorrected model estimated by OLS, whereas columns 2a and 2b report the results of the sample selection model (two-stage Heckman) estimated by ML. Column 3 reports the estimation results concerning the employment on industrial sites, estimated by OLS. All variables are in natural logs, except for the fraction of logistics jobs which refers to the sectoral composition on the industrial sites concerned.

With respect to the location of industrial-site area in 2000, both regressions on a sample with and without zero values yield quite comparable results. This concerns the signs as well as the sizes of the estimated coefficients. There is marginal indication that in the OLS specification the effects are underestimated due to sample selection bias. This is taken into account by the sample selection model, revealing positive but small correlations between the disturbance terms of the two stages in the Heckman model ($\rho_{\varepsilon\mu}$).[9] We have to keep in mind, however, that the OLS estimates only consider the non-zero sample. Moreover, the extent of bias in OLS estimates depends on the distribution of the regressors

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[8] The entire sample includes two ZIP-code areas which contain completely vacant industrial-site area, i.e. industrial sites without employment. As a result the number of observations slightly differs from the sample size used for Equation (4.1), viz. 281 instead of 283 observations.

[9] The observed sample has a positive value for the disturbance term in the selection equation, μ_i, in order for the selection decision to be positive. Because of the positive correlation, $\rho_{\varepsilon\mu}$, the expected error term in the regression model, ε_i, is positive as well. As a result, the observed sample is expected to be higher than potential 'events', which is unconditional on being observed or not (see, Linders and De Groot, 2006).

in the subsample which causes uncertainty about potential bias (Linders and De Groot, 2006).

Table 4.3 Estimation results for the size of industrial sites, in terms of area and employment in 2000

Dependent variable:	*Ln* net industrial-site area in 2000			*Ln* employment on industrial sites in 2000
Specification:	OLS	Heckman		OLS
		selection	regression	
	(1)	(2a)	(2b)	(3)
Constant	5.17 (1.45)	–11.18*** (–5.04)	4.04 (0.83)	–4.66** (–2.77)
Ln Land price per m² (euros)	0.28* (1.75)	0.45*** (4.69)	0.32* (1.65)	0.30*** (3.46)
Ln Working-age population size in 2000 (at municipal level)	0.32** (2.13)	0.11 (1.14)	0.33** (2.17)	0.08 (0.93)
Ln Distance to nearest highway exit (metres)	–0.19* (–1.75)	–0.20*** (–2.42)	–0.20* (–1.75)	0.03 (0.58)
Ln Distance to nearest intercity railway station (metres)	–0.01 (–0.06)	–0.15 (–1.33)	–0.00 (–0.02)	–0.15* (–1.67)
Ln Size of ZIP-code area (m²)	0.21* (1.74)	0.70*** (8.92)	0.27 (1.25)	
Ln Net industrial-site area in 2000 (m²)				0.85*** (25.21)
Logistics jobs in 2000 (fraction of employment on industrial sites)				–0.72*** (–2.65)
Observations	283	499		281
Censored		216		
$\rho_{\varepsilon\mu}$		0.10		
σ		1.51		
Inverse Mills ratio (λ)		0.17		
Adjusted R^2	0.06			0.74

Notes: *t*-values are given in parentheses, except for the Heckman specification where *z*-values are reported; The Inverse Mills ratio is computed at the mean value of the regressor variables; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Looking in more detail at the individual estimates, we can infer that, ceteris paribus, residential land value induces industrial-site area supply with an elasticity of 0.3. The obtained positive relationship implies that high residential land values are associated with a high level of industrial-site area supply. De Groot et al. (2010) argue that the supply of public services determines the variation of land values across space. The supply of production facilities on a location, such as areas for economic activity, coincides with the availability of consumption facilities, such as culture, shopping, and urban aesthetics. It is a matter of economies of scale which drives the emergence of public services, giving rise to increasing attractiveness of the location, reflected by the corresponding land value. Considering the supply of industrial sites, it implies concentration of firms which contribute to the attractiveness of a location. The positive sign of the estimated coefficient alludes to the importance of economies of scale: the more land assigned to housing and other services, the more potential is yielded for the development of (extra) industrial-site area, and vice versa. Moreover, this is consistent with the outcome with regard to the effect of the size of the working-age population on industrial-site supply. A relatively large working-age population contributes to the attractiveness of a location, in terms of labour market opportunities. Besides increasing the supply of industrial-site area, it induces an reinforcing effect on the land value concerned.

The found estimates concerning the accessibility of locations of industrial-site supply emphasizes the importance of accessibility by road for an industrial site. We only yield a statistically significant effect (at the 10 per cent level) with respect to the distance to the nearest highway exit, for both the OLS specification and the sample selection specification. The negative sign implies that the supply of industrial-site area is positively correlated with the ease of accessibility of the location concerned. Furthermore, irrespective of the specification, statistically insignificant but plausible estimates for the control of the size of the ZIP-code area are revealed.

The empirical analysis with respect to employment on industrial sites (Table 4.3, column 3) yields mixed results. We find a positive relationship between land price and the level of employment on industrial sites (statistically significant at the 5 per cent level). Ceteris paribus, the level of employment, controlled for net industrial-site size, is predicted to rise by 0.30 per cent as corresponding land values rise by 1 per cent. This is consistent with economic theory which asserts that high land values are associated with a high density of use for residences or work (see, e.g., De Groot et al, 2010). At a location with high land values, labour-intensive activities, in relation to land, will emerge.

The effect of the net industrial-site area on employment refers to the intensity of land use. We found a value of the estimated coefficient which equals 0.85 (statistically significant at the 1 per cent level). As the value of the estimated elasticity is smaller than 1, the level of employment increases at a decreasing rate as the industrial-site area concerned increases, i.e. the smaller a site, the more it promotes the intensity of land use. This implies that land-use policy aimed at a restriction of industrial-site supply, inducing higher prices and the provision of industrial areas in relatively small sites, may increase the intensity of land use in terms of employment density. Furthermore, capital-intensive firms may be inclined to locate on large-scale sites (i.e. extensive use of land related to employment), as high land values are associated with smaller sites. The latter is supported by the estimated coefficient referring to the relationship between sectoral composition and employment. The induced effect of –0.72 (statistically significant at the 1 per cent level) implies that a higher fraction of logistics jobs present on industrial sites hampers the total level of employment, as compared with sectors which are assumed to be less capital intensive, such as manufacturing and services (reference categories).

The outcomes, with regard to the relationship between the accessibility of location and employment, yield partly statistically significant effects. The level of employment decreases by 0.15 per cent if the distance of the location of the industrial-site area to the nearest intercity-railway station increases with 1 per cent (statistically significant at the 5 per cent level). This points to the relevance of access to public transport. The availability of an intercity-railway station in the vicinity of an industrial site facilitates good transportation of workers, resulting in the emergence of labour-intensive activities, in relation to land, rather than capital-intensive activities at those locations.

4.6 Explaining the dynamics of industrial sites

4.6.1 The econometric model

We now turn to the analysis of the dynamics of the size of industrial sites, in terms of area and employment. First, an additional analysis is undertaken by modelling the location characteristics related to the probability of land-use change. More specifically, a multinomial logit (MNL) approach is used to detect the impact of the distinguished location characteristics on (industrial) land-use choice.

Concerning the transition of land into industrial-site area, we observe five developments. In the period 2000 to 2008, 102 ZIP-code areas demonstrated a growth of industrial-site area supply: at 87 locations the growth encompassed an addition of industrial land to the initial stock of the available industrial-site area, whereas at 15 locations the emergence of industrial land appeared as a new type of land use. A decline of industrial-site area was observed in 39 ZIP-code areas, i.e. industrial land use had been transformed into alternative uses, such as housing and nature.[10] In the same period, in 157 ZIP-code areas the net industrial-site area supply remained unchanged. In the remainder of the areas examined (201 locations) we observed an absence of industrial sites. Table 4.4 presents the frequencies and corresponding probabilities of the defined categories of industrial land-use change.

[10] Decline includes both shrinkage and abolishment of land assigned to industrial use. In our analysis, we do not distinguish between these categories of decline because only two locations demonstrate abolishment of industrial sites over the period 2000–2008.

Table 4.4 Distribution of categories of industrial land-use change across North-Brabant, during the period 2000–2008

	Initial stock	Change in stock	Frequency	Probability
Addition	+	+	87	0.15
New	0	+	15	0.03
Decline	+	–	39	0.08
Stable	+	0	157	0.36
Absence	0	0	201	0.39
Total			499	1.00

Source: Department of Spatial Planning, Province of North-Brabant.

In order to model the respective probabilities, P_{ic}, of land-use change, c (=1,2,3,4,5), in a 4-digit ZIP-code area i (=1,2,…,n), we use the following equation:

$$P_{ic} = \frac{\exp\left(\beta_c X_i^{'}\right)}{\sum_{c=1}^{C} \exp\left(\beta_c X_i^{'}\right)}, \tag{4.6}$$

where categories of land-use change are specified as multinomial logistic functions of a linear combination of a vector of explanatory variables, X_i, and a vector of unknown parameters β_c. The change, c, is defined as: addition (1), new (2), decline (3), stable (4), and absence (5).

In the empirical application, the probabilities of occurrence of each of the possible categories of land-use change are normalized with respect to one of them, usually the category that occurs most frequently in the given sample. It allows us to estimate the influence of the characteristics identical for each of the possible alternatives. In this case, the most frequent outcome is absence of industrial-site area at the locations examined (see Table 4.4). Taking this absence as the reference category (β_5=0), it follows that:

$$P_{i5} = \frac{1}{1 + \sum_{c=1}^{C-1} \exp\left(\beta_c X_i^{'}\right)}, \tag{4.7}$$

and

$$P_{ic} = \frac{\exp\left(\beta_c X_i^{'}\right)}{1 + \sum_{c=1}^{C-1} \exp\left(\beta_c X_i^{'}\right)} \text{ for } c=1,\ldots, C-1. \tag{4.8}$$

A logarithmic transformation of Equation (4.8) yields the following *C*–1 equation system (see, e.g., Nagubadi and Zhang, 2010):

$$Ln\left(\frac{P_{ic}}{P_{i5}}\right) = \beta_c X_i^{'} + \varepsilon_{it} \text{ for } c=1,..., C–1. \quad (4.9)$$

The included explanatory variables, which represent the various location characteristics, are similar to those employed in Equation (4.1). The coefficients on the explanatory variables vary across categories of land-use change. As such, each estimated coefficient indicates how the logarithmized probability of the corresponding category of land-use, relative to the reference category (viz. absence), changes if the explanatory variable concerned changes. The MNL model is estimated by ML.[11]

In a slightly different but straightforward fashion, we have investigated the change of employment on industrial sites. To capture the dynamics of the number of jobs on a plot of industrial land, we use the average annual growth rate of employment on an industrial site, GRE_i, in a 4-digit ZIP-code area i (=1,2,…,n), between 2000 and 2008. This is controlled for the initial level of net industrial-site area (Y_i) and employment in the year 2000 (E_i). Furthermore, we take into account the associated change of industrial-site area and the composition of employment on the industrial sites concerned per 4-digit ZIP-code area by determining their respective growth. GRY_i represents the average annual growth rate of net industrial-site area supply, while GJ_i refers to the growth (decline) of the fractions of logistics jobs of total employment on industrial sites over the period 2000 to 2008.

In the empirical application, the average annual growth rate of employment, GRE_i, between 2000 and 2008 is modelled as follows:

$$\begin{aligned} GRE_i = \beta_0 + \beta_1 LnV_i + \beta_2 LnPop_i + \beta_3 LnDh_i + \beta_4 LnDs_i + \beta_5 LnY_i \\ + \beta_6 LnE_i + \beta_7 GRY_i + \beta_8 GJ_i + \varepsilon_i , \end{aligned} \quad (4.10)$$

where the remainder of the variables, which refer to spatial location characteristics in 2000, are defined as in Equation (4.4). Equation (4.10) is estimated by OLS. Since we can only

[11] OLS yields mostly insignificant outcomes.

include ZIP-code areas which demonstrate change of employment level, our sample consists of 281 observations.[12]

4.6.2 Estimation results

Table 4.5 presents the results of the MNL analysis concerning the dynamics of industrial-site expansion (decline) in the Province of North-Brabant in the period 2000 to 2008. For ease of interpretation, we have reported the marginal effects.[13] As the explanatory variables are in natural logs, the obtained marginal effects represent the change of probability per defined category of land-use change due to a doubling of the explanatory variable concerned. This implies that, in case of the category addition, a doubling of the land price (per m^2) is associated, ceteris paribus, with an increased probability that the industrial-site area is increased from 0.15 to 0.21. Accordingly, the probability of new development, decline, and the stabilization of industrial-site area increases by a proportion of 0.03, 0.04 and 0.10, respectively. The probability that at a location the initial industrial-site area was absent, and that it remained absent, decreases by a proportion of 0.23 (from 0.39 to 0.15) if the corresponding land price doubles. The results for the other variables can be interpreted in a similar fashion.

Table 4.5 Marginal effects of location characteristics on land-use change

	Addition	New	Decline	Stable	Absence
Probability in the sample	0.15	0.03	0.08	0.36	0.39
Ln Land price per m^2	0.06^{**}	0.03^{***}	0.04^{*}	0.10^{***}	-0.23^{***}
	(2.25)	(2.92)	(1.75)	(2.69)	(–5.63)
Ln Working-age population size in 2000 (at municipal level)	0.02	0.00	0.02	0.01	–0.05
	(0.66)	(0.56)	(0.96)	(0.19)	(–1.09)
Ln Distance to nearest highway exit	-0.04^{*}	–0.00	–0.00	-0.05^{*}	0.09^{***}
	(–1.88)	(–0.13)	(–0.05)	(–1.75)	(2.61)
Ln Distance to nearest intercity-railway station	–0.00	0.00	–0.03	–0.02	0.05
	(–0.09)	(0.62)	(–1.60)	(–0.54)	(1.14)
Ln Size of ZIP-code area	0.15^{***}	0.02^{***}	0.04^{**}	0.12^{***}	-0.33^{***}
	(7.26)	(2.95)	(2.57)	(3.96)	(–9.28)

Notes: Marginal effects are computed at means of the variables; *z*-values are given in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

[12] Our initial sample consisted of 499 ZIP-code areas. During the period 2000 to 2008, no industrial-site area, and thus employment, was observed at 201 locations. Due to the applied log transformation, locations containing no industrial-site employment in the initial year (in 2000) or in the final year (in 2008) had to be omitted. So, 15 observations which are classified as ‘new’, and 2 observations which are classified as ‘abolishment’ (see footnote 11), have been dropped. The remaining sample consists of 281 observations.

[13] Estimated model coefficients are reported in Appendix 4.C.

We find no statistically significant effects concerning the size of the working-age population, whereas among the accessibility variables we observe only a few statistically significant marginal effects. The land-use change categories ‘addition’, ‘stable’ and ‘absence’ appear to be sensitive to a change in a location’s proximity to a highway. However, regarding a location’s railway-accessibility, we obtain no statistically significant marginal effects. Apparently, the probability of land-use change on a certain location is not sensitive to a change of distance to the nearest intercity-railway station.

Irrespective the category of land-use change, we find that a change of land price has the largest impact on the corresponding probabilities of occurrence of the defined categories of land-use change, as compared with the other relevant location characteristics concerned (i.e. excluding the ZIP-code area). Distance to highway exits and intercity-railway station do not play such a clear role as a determinant of industrial-site dynamics. But, as land price represents the attractiveness of a location, the corresponding effect may also capture the effect of accessibility. However, the difference between the accessibility to the two modes makes sense: given the type of industry predominantly present at industrial sites, it is evident that proximity to a highway exit is more important than proximity to a railway station.

Ultimately, we examine the results concerning the analysis of the change of employment level on industrial sites during the period 2000 to 2008. Based on Equation (4.10), we estimate the impact of various spatial location characteristics on employment growth on industrial sites, controlled for industrial-site area and economic sector composition characteristics (OLS). Table 4.6 presents the corresponding estimation results. Except for the difference in the fraction of logistics jobs, the double natural log specification is employed for model estimation. Thus, the corresponding estimated coefficients are interpreted as elasticities.

Again, the variation of land value across space appears to be associated with industrial-site development. Similar to the static situation (Equation (4.4)), we may argue that the found positive effect of land value on employment growth (statistically significant at the 1 per cent level) is consistent with economic theory. At a location with high land values, labour-intensive activities, in relation to land, will emerge resulting in an increase of employment growth.

Concerning the accessibility of a location by road and railway, we found weak but statistically significant results (at the 10 per cent level) (see Table 4.5). The difference in signs is notable: locations which are easily accessible by rail appear to be negatively associated with employment growth, whereas increased accessibility by road is positively associated with employment growth. This finding is to a large degree consistent with that of Ritsema van Eck et al. (2010). They demonstrate that employment growth, in the period 1996 to 2008, mainly emerges outside the immediate vicinity of railway stations. It is argued that land in the direct vicinity of railway stations, and in particular intercity-railway stations, is already intensively used which gives rise to employment growth at more distant locations, in particular on industrial sites. In turn, this may also explain the positive effect of decreasing distance to a highway exit, as distant locations are mostly easily accessible by road.

Table 4.6 Growth rate of employment on industrial sites in the period 2000–2008

Dependent variable:	Average annual growth rate of employment on industrial sites
Specification:	OLS
Constant	–55.43*** (–3.68)
Ln Land price per m^2 (euros)	3.25*** (4.06)
Ln Working-age population size in 2000 (at municipal level)	0.24 (0.33)
Ln Distance to nearest highway exit (metres)	–0.61* (–1.76)
Ln Distance to nearest intercity-railway station (metres)	0.92* (1.71)
Ln Employment on industrial site in 2000	–5.95*** (–2.58)
Ln Net industrial-site area in 2000 (m^2)	6.03*** (11.09)
Growth rate of net industrial-site area 2000–2008	0.61*** (4.51)
Δ fraction of logistics jobs from 2000 to 2008	–7.53** (–2.47)
Observations	281
Adjusted R^2	0.38

Notes: *t*-values are given in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The control for the initial level of employment on the industrial sites indicates, as expected, that high initial employment in an industry on a site leads to lower subsequent employment growth, and vice versa (statistically significant at the 1 per cent level). Conversely, employment growth is positively associated with the initial size of the industrial-site area concerned. What is striking, however, is the response to the growth of the net industrial-site area in the period 2000 to 2008, in terms of employment growth. We find an elasticity of 0.61, which is substantially less than 1, indicating that employment on industrial sites grows at a decreasing rate of industrial-site area growth. Given the dynamics of employment (viz. high rates of employment growth) during the period under study, we may infer that the contribution of industrial sites as locations of economic growth seems to be rather modest. Accordingly, the relatively low rate of employment growth, vis-à-vis the expansion of industrial-site area, reflects a decreasing intensity of land use, in terms of employment, on the industrial sites concerned. Additionally, the estimate concerning the growth of the fraction of logistics jobs points to the relevance of the change of sector structure for industrial sites and the associated effects in terms of land-use intensity. The growth of capital-intensive industries induces a more extensive use of land per employee on industrial sites.

4.7 Conclusion

The aim of this chapter was to study the role of spatial location characteristics as determinants of the location choice of industrial-site area provision, and the resulting intensity of land use in terms of employment. By applying econometric techniques we have explored the relationship between various location characteristics and the outcomes of land-use policy, in terms of the area of industrial sites supplied and the corresponding level of industrial-site employment, in the Province of North-Brabant. At the level of spatial aggregation of the ZIP-code area (4-digit) we have analysed the distribution of industrial sites, and employment on industrial sites, across North-Brabant.

The residential land value and the proximity to the nearest highway exit and nearest intercity-railway station can be considered as the main location characteristics for describing the locations concerned. By using the real residential land value (in constant prices of 2005), we have measured the attractiveness of the ZIP-code areas concerned. In turn, the value of land varies with the size of industrial sites, in terms of area and employment, across the locations concerned. Various model specifications employed have clearly indicated the importance of concentration of firms (and jobs) which contribute to the attractiveness of a location. From a dynamic perspective, industrial-site development seems to be mostly sensitive to land value, as compared with the other included explanatory location-specific variables, such as distance to the nearest highway exit and the nearest intercity-railway station.

Controlling for the accessibility of location, we obtained mixed results associated with the size of industrial-site development. The outcomes point to the relevance of being located on an easily accessible location in terms of road and rail. The level of industrial-site area is positively associated with accessibility by road, in contrast to accessibility by rail. But locations which are easily accessible by rail are positively associated with the level of industrial-site employment. This finding is associated with the sectoral composition on industrial sites. Industrial sites have gradually become a location for labour-intensive activities, in addition to capital-intensive activities which are typically found on industrial sites. This is especially the case in the Province of North-Brabant which is losing its pronounced industrial character. These types of activities encompass, amongst other things, different location requirements in terms of accessibility, compared with the capital-intensive activities. As such, labour-intensive activities may benefit in particular from the availability of an intercity-railway station in the vicinity as it enhances the access to labour. However, from a dynamic perspective, we have seen the growth of industrial-site employment is predominantly taking place at locations near highway exits, rather than at locations near intercity-railway stations. This can be explained by the intensity of land use, in terms of employment, at locations near an intercity-railway station. Land in the direct vicinity of railway stations, and in particular intercity-railway stations, is used intensively which gives rise to employment growth at more distant locations, located near highways.

Besides addressing some determinants of the location and size of industrial-site supply, our analysis has provided us with some notable insights concerning the effectiveness of industrial-site provision as an policy-instrument for promoting local economic development. During the period 2000 to 2008, we have seen that the growth of industrial-site area exceeded the growth of employment on industrial sites in North-Brabant, by 11.5 per cent and 7.1 per cent, respectively. Regression of the growth rate of employment on the growth rate of industrial-site area demonstrated, ceteris paribus, that employment on industrial sites grows at an decreasing rate of industrial-site area growth. This questions the urgency of the provision of industrial sites as an instrument of local employment stimulation, especially when we take into consideration the economic development, a 19.6 per cent growth of jobs over eight years, which has taken place outside industrial sites.

Hence, the supply of industrial land appears to exceed the demand which leads to, amongst other things, an inefficient use of land on industrial sites. Our analysis has enabled us to obtain insight into the implications of spatial location characteristics on industrial-site development. However, the analysis refrains from considering policy competition between the municipalities concerned. Since the importance of industrial sites as a location for economic growth is emphasized, municipalities are inclined to reserve a generous amount of land for industrial use to attract firms, inducing negative consequences for neighbouring municipalities as business locations. This suggests that the supply of industrial sites may be subject to interdependence between municipalities. By applying spatial econometric techniques, strategic policy interaction processes in local industrial-site provision policy can de discovered, and the corresponding impact on the supply of industrial sites. Chapter 5 elaborates on this issue.

Appendix 4.A Generating residential land price – a hedonic pricing approach

We assume that the value of residential properties is fully capitalized into prices in a property market which is in equilibrium. The associated implicit prices of the non-market attributes of a property are revealed by a hedonic analysis using a standard multiple regression (see, e.g., Rosen, 1974; Sirmans et al. 2006). In order to determine the value of land at a certain location, we have estimated the implicit price which is attributed to the associated parcel size of a residential property. As such, we reveal the price of a marginal square metre of residential land.

We use data provided by the Dutch Association of Real Estate Agents (NVM). The sample contains transaction data on all houses sold by NVM real-estate agents in the Province of North-Brabant during the period of 1985 to 2005, and includes information on a series of structural property attributes, such as parcel size, floor area, type of house (free-standing, semi-detached, terraced, corner house), year of construction, the presence of central heating, parking lot, carport, garage, and extensive garage. Additionally, the data set also contains information about the date of house transactions, which enables us to correct for effects of seasonality, and to derive real prices. Finally, all houses are geo-referenced providing us with information about the locations concerned. As such, we distinguish the location of the houses by dummies corresponding to the 4-digit ZIP-code area. Table 4.A.1 provides the descriptive statistics.

However, since we are interested in the implicit price of land, our sample only comprises 'land-attached' dwellings. So apartments have been dropped since these types of housing do not feature an individual parcel. In addition, properties located on a parcel which are subject to leasehold have been excluded. The prices of the parcels concerned are not implicitly capitalized in the transaction prices, because they are explicitly capitalized by land lease payments to the municipality.

Before we reveal the implicit price for the parcel size of a residential property, we have derived the real transaction prices to remove effects of price changes over time. As the period 1985 to 2005 is considered, we have generated real prices in constant prices of 2005. First, running a regression of transaction price on the respective year dummies, controlled for structural property characteristics, yields estimates indicating the respective price differences with respect to the year 2005 (reference category). Subsequently, it enables us to generate a constant prices series based on a single year's transaction prices. To do this we use the transaction price for the reference year (2005), and then apply the percentage changes in constant prices of residential property transactions. Based on this series, we created the corresponding price index of property transactions (2005=100). Second, we have incorporated the effect of price inflation. Using the Consumer Price Index (CPI) for the years under consideration, produced by Statistics Netherlands, we have adjusted the price index of property transactions. As a result, we have obtained the real price index of property transaction prices (2005=100) which has enabled us to convert the nominal transaction prices into real transaction prices, expressed in constant prices of 2005.

Table 4.A.1 Definitions and descriptive statistics for the variables used

Variable	**Description**	**Mean**	**Standard Deviation**
Price	Transaction price (euros)	211,898.80	135,599.00
Parcel size	Size of the parcel of the house (m^2)	431.22	1,530.32
Floor area	Size of living area of the house (m^2)	143.92	43.83
Detached	Dummy variable: equals 1 if the house is free-standing	0.19	0.39
Semi-detached	Dummy variable: equals 1 if the house is semi-detached	0.25	0.43
Terraced	Dummy variable: equals 1 if the house is a terraced house	0.40	0.49
Corner house	Dummy variable: equals 1 if the house is a corner house	0.16	0.37
Before 1906	Dummy variable: equals 1 if the house has been built before 1906	0.02	0.14
1906–1930	Dummy variable: equals 1 if the house has been built in the period 1906–1930	0.05	0.23
1931–1944	Dummy variable: equals 1 if the house has been built in the period 1931–1944	0.06	0.24
1945–1959	Dummy variable: equals 1 if the house has been built in the period 1945–1959	0.06	0.24
1960–1970	Dummy variable: equals 1 if the house has been built in the period 1960–1970	0.15	0.36
1971–1980	Dummy variable: equals 1 if the house has been built in the period 1971–1980	0.28	0.45
1981–1990	Dummy variable: equals 1 if the house has been built in the period 1981–1990	0.21	0.41
After 1990	Dummy variable: equals 1 if the house has been built after 1990	0.16	0.36
No central heating	Dummy variable: equals 1 if the house has no central heating	0.02	0.14
Parking lot	Dummy variable: equals 1 if the house has a parking lot	0.03	0.16
Carport	Dummy variable: equals 1 if the house has a carport	0.05	0.22
Garage	Dummy variable: equals 1 if the house has a garage	0.42	0.49
Garage and carport	Dummy variable: equals 1 if the house has a garage and a carport	0.03	0.16
Extensive garage	Dummy variable: equals 1 if the house has a garage with a capacity for several cars	0.05	0.21

Notes: All data are from the NVM (Dutch Association of Real Estate Agents); The sample size is 175,914 observations.

We follow a three-stage strategy to reveal the real land prices in turn. In the first stage, we regress the real transaction price on a set of structural characteristics and corresponding

ZIP-code area (4-digit) dummies which refer to the location of the property. In addition, we include interaction variables, composed of the parcel size and the corresponding ZIP-code-area dummy, to control for region-specific characteristics of the land market. In other words, we allow for differences in the slopes of the transaction prices, with respect to parcel size, across the associated locations (viz. 4-digit ZIP-code areas). Regarding the functional form of the hedonic price function to be estimated, we employ, in accordance with Chapter 3, the double natural log specification. In the empirical applications, the transaction price of a house j is modelled as follows:

$$LnP_j = \alpha + \sum_{k=1}^{18} \beta_k S_{j,k} + \sum_{l=1}^{499} \delta_l Dum_{ZIP-code\,j,l} + \sum_{m=1}^{499} \gamma_m (LnParcelsize_j * Dum_{ZIP-code\,j})_{j,m} + \varepsilon_j\,, \tag{4.A.1}$$

where houses are identified by the subscript j; P_j is the house transaction price, explained by the structural (S) characteristics of the property, the 4-digit ZIP-code area ($Dum_{ZIP\text{-}code}$), the interaction term ($LnParcelsize*Dum_{ZIP\text{-}code}$) concerning the parcel size and the location concerned, and the year of sale (Dum_{year}). α is a constant, and β, δ and γ are coefficients to be estimated. The explanatory variables concerned are, respectively, indexed by k, l and m. Equation (4.A.1) is estimated by ordinary least squares (OLS). The estimation results are shown in Table 4.A.2.

The second stage consists of generating the land prices per property. The estimated coefficient referring to parcel size has our key interest as it indicates the implicit price which is attributed to the amount of land of the property (in constant prices of 2005). Additionally, we have obtained the interaction-effects between location and parcel size, providing us with the price differentials with respect to the real implicit price of land per region. The latter provides us with coefficients (γ) which can be considered as region-specific elasticities that indicate the modifying effect of the location of the property on the estimated effect of parcel size on transaction price. Figure 4.A.1 depicts the estimated region-specific elasticities across North-Brabant. It shows the elasticity, i.e. the share of the price which is attributed to land, increases with decreasing distance to the city-centres concerned.

By taking into account the region-specific effects, with respect to the implicit price of land, the real price of land attributed to a residential property (per square metre) is determined as follows:

$$V_j = (\beta_{ParcelSize} + \sum_{m=1}^{499} \gamma_m) \cdot P_j \,/\, ParcelSize_j\,, \tag{4.A.2}$$

where houses are identified by the subscript j, and V_j is the associated land value which is computed by multiplying the estimated coefficient of parcel size ($\beta_{ParcelSize}$), corrected for region-specific characteristics (γ_m), with the house transaction price (P_j) per square metre.

Table 4.A.2 Estimation results of the hedonic price function for North-Brabant in the period 1985–2005

Variable	Coefficient	*t*-statistic
Constant	8.301***	404.2
Ln Floor area (m^2)	0.500***	123.9
Ln Parcel size (m^2)	0.211***	70.4
Semi-detached	–0.124***	–46.5
Terraced	–0.219***	–64.3
Corner house	–0.215***	–65.0
Before 1906	–0.178***	–27.5
1906–1930	–0.241***	–57.3
1931–1944	–0.210***	–51.1
1945–1959	–0.236***	–65.5
1960–1970	–0.255***	–94.6
1971–1980	–0.247***	–104.0
1981–1990	–0.129***	–21.9
No central heating	–0.133***	–24.6
Parking lot	0.009*	1.9
Carport	0.031***	9.7
Garage	0.044***	23.5
Garage and carport	0.082***	19.0
Extensive garage	0.078***	20.0
$\text{Dum}_{ZIP\text{-}code\ 1–499}$ (δ)	Estimated coefficients are available on request	
*Ln*Parcelsize $_{1–499}$*$\text{Dum}_{ZIP\text{-}code\ 1–499}$ (γ)	Estimated coefficients are available on request	
Adjusted R^2	0.799	
Number of observations	175,914	

Notes: We have controlled for the month of sale and the year of sale; Estimated coefficients are not reported, but are available on request; White *t*-values are reported; *** Significant at the 1% level; * Significant at the 10% level.

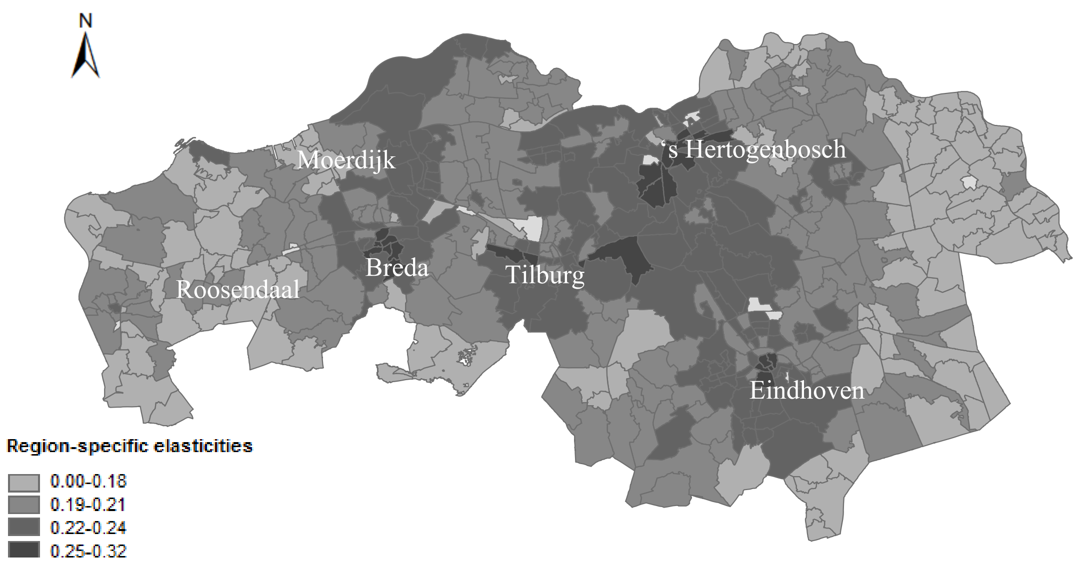

Figure 4.A.1 Quartile map of region-specific elasticities by 4-digit ZIP-code area

In the final stage, we have aggregated the obtained values of land at the 4-digit ZIP-code area, resulting in the real land prices by 4-digit ZIP-code area. Figure 4.A.2 shows the spatial distribution of the associated land values across North-Brabant. The featured pattern is to a large extent in accordance with the distribution shown in Figure 4.A.1. Moreover, it follows bid-rent theory, in the sense that land near the city-centre is generally valued higher than peripheral locations.

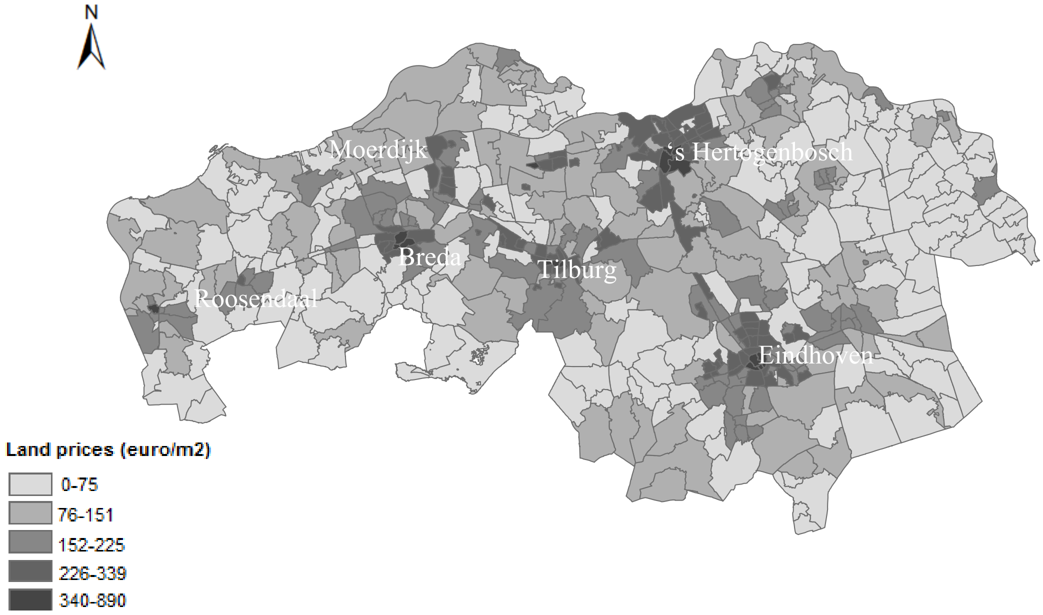

Figure 4.A.2 Distribution of residential land prices by 4-digit ZIP-code area (in constant prices of 2005)

Appendix 4.B Definitions, sources and descriptive statistics

Variable	Description	Source	Mean	Standard Deviation
Industrial-site area				
Net industrial-site area in 2000	Total net industrial-site area per ZIP-code area (4-digit) (m^2)	NBr	221,328.91	677,338.83
Average annual growth rate of net industrial-site area	The annual growth rate from 2000 to 2008 of total net industrial-site area per ZIP-code area (4-digit)	NBr	1.40	5.46
Employment on industrial sites				
Employment on industrial sites in 2000	Total number of jobs located on industrial sites per ZIP-code area (4-digit) in 2000	NBr	1,582.14	2,277.91
Average annual growth rate of employment on industrial sites	The average annual growth rate from 2000 to 2008 of employment on industrial sites per ZIP-code area (4-digit)	NBr	0.86	9.44
Logistics jobs in 2000	Fraction of logistics jobs of the total number of jobs on industrial sites per ZIP-code area (4-digit) in 2000	NBr	0.25	0.19
Δ fraction of logistics jobs	Change from 2000 to 2008 of the fractions of logistics jobs of total employment on industrial sites	NBr	0.03	0.15
Spatial location characteristics				
Land Price per m^2	The real residential land price per m^2 from 1985 to 2005 per ZIP-code area (4-digit) in constant prices of 2005 (euros)	NVM	140.26	101.85
Working-age population size	Number of inhabitants within the age category 20 to 65 years per municipality in 2000 to which the ZIP-code area (4-digit) belongs.	CBS	40,004.19	39,957.08
Distance to nearest highway exit	Euclidian distance from the midpoint of a ZIP-code area (4-digit) to the nearest highway exit in 2000 (metres)	ABF	3,510.92	2,788.72
Distance to nearest intercity-railway station	Euclidian distance from the midpoint of a ZIP-code area (4-digit) to the nearest intercity-railway station in 2000 (metres)	ABF	8,361.33	4,962.14
Size of ZIP-code area	The ZIP-code area (4-digit) (hectares)	ABF	1,008.65	1,008.96

Notes: The abbreviations stand for: ABF – ABF Research Real Estate Monitor; CBS – Statistics Netherlands; NBr – Department of Spatial Planning of the Province of North-Brabant; NVM – Dutch Association of Real Estate Agents; The sample size is 499 observations.

Appendix 4.C Multinomial logit model of land-use change (2000–2008)

Variable	Coefficient	*z*-statistic
Addition, dependent variable: *Ln*(Addition/Absence)		
Constant	–31.01***	–5.51
Ln Land Price per m^2 (euros)	0.96***	4.15
Ln Working-age population size (at municipal level)	0.23	1.00
Ln Distance to nearest highway exit (metres)	–0.47**	–2.54
Ln Distance to nearest intercity-railway station (metres)	–0.15	–0.53
Ln Size of ZIP-code area (m^2)	1.81***	8.49
New, dependent variable: *Ln*(New/Absence)		
Constant	–45.51***	–3.83
Ln Land Price per m^2 (euros)	2.07***	3.45
Ln Working-age population size (at municipal level)	0.36	0.78
Ln Distance to nearest highway exit (metres)	–0.27	–0.77
Ln Distance to nearest intercity-railway station (metres)	0.21	0.36
Ln Size of ZIP-code area (m^2)	1.90***	4.86
Decline, dependent variable: *Ln*(Decline/Absence)		
Constant	–24.63***	–3.56
Ln Land Price per m^2 (euros)	1.06***	3.25
Ln Working-age population size (inhabitants at municipal level)	0.35	1.22
Ln Distance to nearest highway exit (metres)	–0.24	–0.97
Ln Distance to nearest intercity-railway station (metres)	–0.55*	–1.76
Ln Size of ZIP-code area (m^2)	1.36***	5.21
Stable, dependent variable: *Ln*(Stable/Absence)		
Constant	–19.04***	–4.41
Ln Land Price per m^2 (euros)	0.86***	4.57
Ln Working-age population size (inhabitants at municipal level)	0.14	0.76
Ln Distance to nearest highway exit (metres)	–0.37***	–2.38
Ln Distance to nearest intercity-railway station (metres)	–0.19	–0.93
Ln Size of ZIP-code area (m^2)	1.17***	7.24
Pseudo R^2	0.12	
Number of observations	499	

Notes: 'Absence' is taken as the reference category; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Chapter 5

Strategic Interaction between Dutch Municipalities: The Supply of Industrial Sites

5.1 Introduction

Local authorities do not make their policy decisions in isolation. Citizens, firms, and public servants are influenced by the existing and expected policies of neighbouring municipalities. They have information on governmental activity in neighbouring municipalities, and they use this information in order to choose strategically what they want their own local authority to do (Case et al., 1993). Likewise, it is assumed that Dutch municipalities do not act in a vacuum and are sensitive to the provision of industrial sites in surrounding municipalities, which has resulted in an abundant supply of industrial sites in the Netherlands (THB, 2008). Since local authorities (municipalities) in the Netherlands play a dominant role in the development of industrial sites, they consider the provision of industrial sites as a key instrument of their economic policy. As a result, municipalities typically aim at increasing local employment levels by facilitating local entrepreneurship and competitiveness. This is generally attempted through institutionalized growth predictions for the future demand of industrial land, and the guarantee of a minimum amount of directly available industrial land for immediate sale to potentially interested companies (Louw et al., 2003; Knoben and Traa, 2008). In addition, the growth of the number of businesses in a municipality implies more revenues for the local authorities. However, the use of incentives to attract potential businesses in one municipality may induce negative consequences for neighbouring municipalities. Because industrial sites have an important local distributive effect on employment, adjoining jurisdictions with less ‘favourable’ conditions may not have much success in attracting potential businesses (Louw, 2000). Consequently, these incentives may cause a ‘race to the bottom’ between local jurisdictions in their effort to attract new businesses (see, e.g., Frederiksson et al., 2004). Ultimately, these dynamics may result in an overprovision of industrial sites, which may, amongst other things, lead to the inefficient use of land and the diminution of the natural landscape (e.g., Louw and Bontekoning, 2007; THB, 2008).

This chapter investigates the impact of strategic interaction between municipalities in the case of the supply of industrial sites. We test whether, and to what extent, municipal councils take into account the decisions of neighbouring municipalities regarding the provision of industrial land. It is important to note that the jurisdictional interaction in this context is not analysed on normative grounds. The focus here is on whether interaction between local authorities represents strategically competitive behaviour.

Models of strategic interaction have mainly been used in the tax-competition literature.[1] In the basic tax-competition model, communities finance public spending by taxing mobile capital. As capital migrates to equalize after-tax returns across communities, the allocation of capital depends on tax rates in all communities (Brueckner, 1998). Inspired by this tax-competition literature, models of strategic interaction have been widely employed in other research areas, such as in local public economics. Our research contributes to the emerging empirical literature on local policy, and deals with strategic interaction mechanisms concerning the provision of local public goods.

The relevance of strategic interaction was first demonstrated by Case et al. (1993), who in their pioneering study estimate an empirical model of strategic interaction of expenditures between state authorities in the United States. In the same fashion a large number of empirical studies has been undertaken. Brueckner (1998) focuses on the adoption of growth-control measures by municipalities in California, and Lundberg (2001) demonstrates that the levels of local spending on recreation and cultural goods are subject to interdependence between neighbouring jurisdictions, as revealed through the spatial autocorrelation between Swedish municipalities. Borck et al. (2006) examine the existence of spatial interdependence between jurisdictions in Germany by means of the size and structure of public spending. By estimating the associated reaction functions of jurisdictions on public spending in neighbouring regions, they found statistically significant positive effects of spending on local business development support, indicating the presence of competition between the jurisdictions concerned. Likewise, Ermini and Santolini (2007) and Foucalt et al. (2008) analyse interactions concerning different categories of local public spending between Italian and French municipalities, respectively.

The empirical evidence indicates that with the use of spatial econometric techniques strategic policy interaction processes in local public expenditures can de discovered, but there is no consensus on what drives these strategic policy interaction processes (Edmark and Ågren, 2008). Following Revelli (2005), two crucial issues need to be addressed in this respect. First, it has to be ascertained whether the observed spatial autocorrelation pattern can indeed be attributed to a strategic interaction process, or whether it reflects exogenous

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[1] For an overview of the literature about strategic interaction in the tax setting of local authorities, see for instance Oates (2002) and Wilson (1999).

correlation in (omitted) jurisdictional characteristics or common shocks to local policy. Second, the theoretical model generating the observed spatial pattern has to be identified. We therefore elaborate on a model in which jurisdictions aim to maximize welfare by raising their local employment relative to rival, neighbouring jurisdictions.

This chapter is organized as follows. In Section 5.2 we present a theoretical model of the jurisdictional interdependence of local supply of industrial sites. The institutional context of the Dutch 'market' for industrial sites is described in Section 5.3. The data used are presented in Section 5.4. In Section 5.5 we identify potential spatial dependence in the supply of industrial sites between Dutch municipalities. Section 5.6 describes the spatial-econometric estimation techniques we employ, and subsequently presents and discusses the estimation results. In Section 5.7 we conclude.

5.2 Theoretical framework

Brueckner (2003) shows that the general intuition underlying the theoretical constructs of strategic interaction models, irrespective of whether they address local tax or expenditure policies, is straightforward. Local economies are spatially linked, which means that under certain assumptions the policy-setting behaviour of local authorities is correlated with policies of other, predominantly neighbouring, authorities. Although the various theoretical models and the accompanying empirical literature are regularly motivated quite differently,[2] the empirical goals within the literature are formulated rather similarly. Typically, a reaction function is estimated where the decision variable (e.g., the tax rate or the level of public good provision) for a given jurisdiction depends on the choices of neighbouring jurisdictions. Subsequently, a statistical test is used to determine whether or not the slope is significantly different from zero. A finding of a non-zero slope estimate is conjectured to be evidence for the existence of strategic policy interaction.

Considering the provision of industrial sites in the Netherlands, we hypothesize that municipal reaction functions for industrial site supply are positively sloped. This assertion stems from the line of research which studies the effects of competition between local authorities. Inspired by Tiebout (1956), this research domain has shown that inter-jurisdictional competition benefits inhabitants by generating a variety of public good choices within a municipal area. This variety, which emerges as local authorities compete to attract residents, leads to an equilibrium in which actors efficiently self-select into different communities according to their demand for public goods (Brueckner and

[2] Brueckner (2003) divides the underlying theoretical models into two categories: (1) spillover models, which include yardstick competition models; and (2) resource-flow models, which include fiscal competition models.

Saavedra, 2001). In addition, the tax-competition literature has investigated the negative side effects of inter-jurisdictional competition: each local authority sets its tax too low in an attempt to preserve its tax base. In applying this rationale to the provision of industrial sites, we expect that a local authority will respond positively to neighbouring decisions to expand the supply of industrial sites. This mimicking behaviour is induced by the desire to be attractive as a potential location of economic activity. This strategic behaviour may, however, also result in a 'race to the bottom' that induces an over-supply of industrial sites that in turn results in loss of open space.

We illustrate this situation with a simple framework for modelling strategic policy making in the case of the supply of industrial sites. It is assumed that municipalities attempt to maximize their local welfare by a policy of expanding the amount of industrial land in order to attract employment within their borders. Analogous to Brueckner (2003), who studies the competition for mobile resources, we have adopted the resource-flow-type of framework. Given this framework, we assume that the amount of (mobile) labour and firms that locate within the borders of a municipality is affected by the area of available industrial sites. Accordingly, the distribution of labour among municipalities is affected by a vector of choices with regard to the level of industrial-site area of all municipalities; the supply decision of each municipality thus depends on the supply decisions of other municipalities. The corresponding objective function of a municipality reads as:

$$G(y_i, l_i; X_i), \tag{5.1}$$

where municipalities are indexed by i; y_i is the amount of industrial-site area available; l_i is the amount of labour; and X_i is a vector of municipality-specific characteristics of i. As the distribution of labour between municipalities depends on the entire vector y as well as on municipality's own characteristics, the labour available to i is given by:

$$l_i = f(y_i, y_j; X_i), \tag{5.2}$$

where y_j is the vector of y's for other municipalities. In order to derive the reduced form, Equation (5.2) is substituted into Equation (5.1) yielding:

$$G[y_i, f(y_i, y_j; X_i); X_i] \equiv G(y_i, y_j; X_i). \tag{5.3}$$

Hence, municipality i chooses y_i to maximize Equation (5.3), setting $\partial G/\partial y_i \equiv G_{y_i} = 0$. As a result, we get the following reaction function for the supply of industrial-site area of a municipality:

$$y_i = R(y_j; X_i), \tag{5.4}$$

which exhibits municipality's *i* best response to the decisions of other municipalities with regard to their industrial-site supply, taking into account the specific characteristics of municipality *i*. Estimation of the slope of the municipality's reaction function, which is hypothesized to be positive, is the main goal of the subsequent empirical analysis.

5.3 Institutional setting

Firm relocations and expansions are important targets for local economic policy (Louw, 2000). A principal objective of Dutch municipalities is to spur employment growth in their local economy. In order to meet this objective, the incentive offered by Dutch municipalities is primarily oriented to the provision of new industrial land to accommodate new businesses, or to retain incumbent businesses (SER, 2004). As industrial land generates high direct and indirect benefits, most municipalities are inclined to expand their supply of industrial land rather than preserve open space or intensify the use of existing industrial land. Direct benefits are revenues associated with the development of new industrial land and the growth of the local tax base, whereas indirect benefits may be generated as a result of increased employment.

Considering this instrument of local economic policy, we first look in more detail at the institutional setting concerning the provision of industrial land in Dutch municipalities. The Netherlands has three tiers of government: the national government, provinces (twelve), and municipalities (418 in 2011).[3] Each governance level covers the entire country, and the provinces and municipalities have basically the same responsibilities and the same tax options. Dutch municipalities are relatively large compared with those in other countries. In 2010, the average municipality had 38,279 inhabitants. Dutch municipalities finance their spending through general and specific appropriations of the national government (30 and 37 per cent of the total budget, respectively).

Each of the levels of government has a role in spatial planning. New residential and industrial areas are planned by national, provincial and municipal governments and require lengthy decision making procedures.[4] National and regional plans, which define location,

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[3] The number of municipalities varies, but on 1 January 2011 it was 418. In 2010, for instance, twenty-one municipalities were abolished, and six new ones created. The Netherlands is the only country in Europe which reduces its number of municipalities annually (Statistics Netherlands, 2010).

[4] The amount of time it takes for a municipality to plan and realize an industrial site varies roughly from six to eight years (Louw, 2000; SER, 2004).

size and type of future land use, are prepared years in advance. In assessing whether these plans create sufficient space for future economic development, an important task has been assigned to the Business Location Monitor (BLM).[5] The BLM is an applied model which provides provincial planning authorities with estimates of future demand for new business areas, and monitors whether in the twelve Dutch provinces this demand complies with current plans (Schuur, 1999; Knoben and Traa, 2008). This analysis of future supply and demand for industrial areas is predominantly based on the procedure known as the 'land coefficient method' (Louw, 2000). Based on the sectoral employment scenarios for the Dutch economy,[6] and assuming that the use of industrial land is proportional to employment size, the level of demand for land is calculated by taking a fixed number of square metres of land for each future employee. The number of square metres in use per person employed is fixed within given combinations of industry sectors, types of industrial sites, and regions. Subsequently, the calculated level of demand is compared with the available capacity in existing spatial plans for the development of industrial sites. If the capacity is found to be insufficient, the regional spatial plans may be adjusted to comply with the estimated demand for industrial land. Municipalities accordingly translate these adjustments into land-use plans, specifying the use of land in detail (Louw, 2000).

The use of the above described method of estimation for the demand for industrial land is widely criticized because planning authorities tend to overestimate the real demand for industrial land (e.g., Louw et al., 2004; Knoben and Traa, 2008). Planning authorities typically employ estimates based on the most optimistic long-term growth scenario. This results in a generous reservation of industrial land for future economic growth. Realistic, generally less optimistic, growth prognoses are not taken into account. Additionally, municipalities are inclined to enhance this generous reservation by a supplementary buffer of land to attract extra firms. It is often maintained that a minimum amount of industrial land should always be available for immediate sale to interested firms (Louw et al., 2003). So, in spite of the (centralized) policy instruments, the amount of industrial sites provided at the local level is generally not determined in the most efficient and effective way because municipalities have a high degree of autonomy to apply the instrument of new industrial-site development to stimulate local economic growth. As a result, the lack of

[5] Since 1 January 2006, the BLM has been prepared by the Netherlands Environmental Assessment Agency (PBL).

[6] The four long-term sectoral employment scenarios for the Dutch economy, which are produced by the Netherlands Bureau for Economic Policy Analysis (CPB), are called 'Strong Europe', 'Global Economy', 'Regional Communities' and 'Transatlantic Market', and represent alternative future environments with different demographic, political, and socio-economic contexts. Each scenario affects the sectoral composition of employment growth differently. The most recent scenarios refer to the period 2002–2040 (Schuur, 1999; Arts et al., 2005).

regional coordination may give rise to strategically competitive behaviour between municipalities in determining their amount of new industrial-site area.

5.4 Data set

Our empirical analyses are based on a data set containing information on the total net area of industrial sites,[7] the amount of industrial-site area that has been converted into utilized land, and an array of each jurisdiction's characteristics. Utilized land corresponds to the net area of industrial land which has already been utilized for industrial use.[8] The jurisdiction's characteristics comprise, for instance, demographic structure, sectoral composition and land-use features. The data relate to the year 1996, and in the case of the provided industrial-site area also to 2006, and they are collected at the level of Dutch municipalities. The data referring to industrial-site area come from the Dutch Industrial Sites Database (IBIS).[9] The remainder of the data, concerning the municipalities' characteristics was acquired from Regional Key Figures (*Regionale Kerncijfers*), produced by Statistics Netherlands.

Models of strategic interaction are often estimated using spatial panel data to control for unobserved fixed local characteristics. However, since municipalities in the Netherlands are subject to an ongoing process of mergers and amalgamations, the number of municipalities fell over the period of investigation, 1996 to 2006, from 625 to 458 municipalities. This change of the number of spatial units over time is problematic in a spatial model, as it not only limits the number of observations, but it also hampers the specification of the spatial weights matrix used as point of reference for each observation (see Section 5.5). We therefore use cross-sectional data.[10] For the sake of comparability, we consider the municipal division of the Netherlands according to the 2006 classification, and we apply it using 1996 data.[11] In other words, the data originate from 1996, but are moulded by the municipal classification of 2006.

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[7] The net area of an industrial site is defined as the total area designated for industry minus the area which is used for infrastructure, water, green space, and other forms of public open space.

[8] The counterpart of utilized land is vacant land: land which has been designated for industrial use, but which has not yet been brought into use by any firm(s) or organization(s).

[9] The IBIS database provides an inventory of formal industrial sites, with annual information on numerous characteristics of which geographical location (viz. municipality) and the amount of provided and utilized land are the most relevant for the purpose of this chapter.

[10] Similar studies, such as Brueckner (1998), Brueckner and Saavedra (2001), and Allers and Elhorst (2005), have also used cross-sectional data.

[11] We refer to Statistics Netherlands (available at: http://www.statline.cbs.nl/) which provides a detailed history of each Dutch municipality in terms of its creation, merger, amalgamation, and abolition.

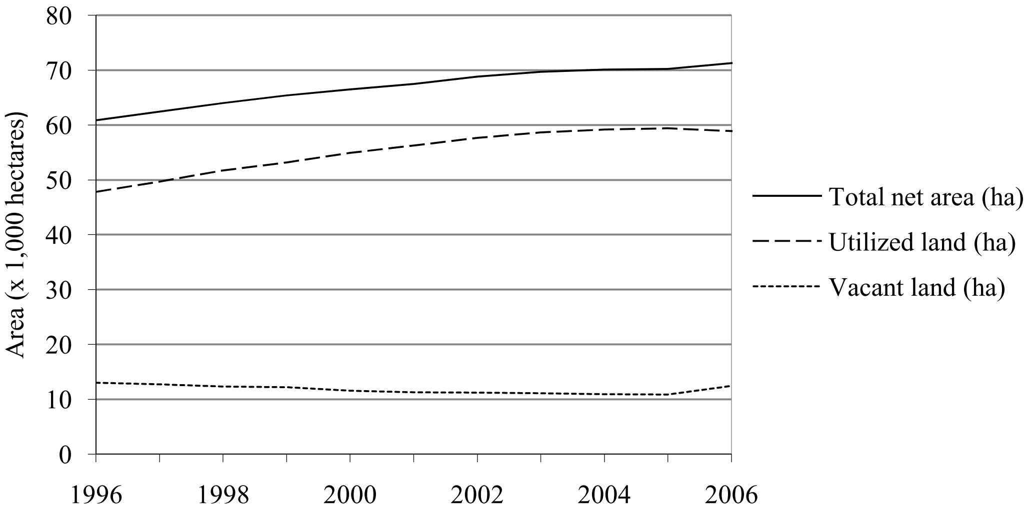
Furthermore, in contrast to the vast majority of the existing literature dealing with inter-jurisdictional competition, which uses budgetary data to proxy local policy, we use data concerning the output of a certain local policy, specifically hectares of industrial-site area provided per municipality. The provided industrial-site area is an accurate indicator of local industrial-site policy, as it reveals the effect of this policy on industrial-land availability in the municipality.[12]

5.5 Spatial clustering in the supply of industrial sites

To obtain insight into the Dutch situation concerning local supply of industrial sites and potential strategic policy interaction, we investigate local spatial autocorrelation of industrial-site provision between Dutch municipalities. More specifically, we perform an analysis to identify patterns of spatial clustering in the municipal supply of industrial sites. Since, in their effort to stimulate local economic growth, it is assumed that municipalities are competing with each other to attract (or retain) firms within their borders, our variable of interest is, therefore, the change of area of industrial-site supply by municipality, in the period 1996 to 2006.

Considering the development of aggregate industrial-site area of Dutch municipalities, we see that during the period of analysis the total amount of industrial land has increased by about 1,000 hectares per year (see Figure 5.1). In Figure 5.1, it is also shown that the number of hectares of vacant land has remained relatively stable. However, there are substantial regional differences in the availability of industrial sites, which is shown in Figure 5.2. Generally, the urbanized Western (viz. the Randstad) and the Southern part of the Netherlands has a relatively high presence of industrial sites, as compared with the less urbanized regions, which can mainly be found in the North and East of the country.

[12] On a more pragmatic note, another reason for choosing provided area is related to data availability: the Dutch Industrial Sites Database (IBIS) provides an extended data set containing detailed industrial-land provision data on the municipal level.



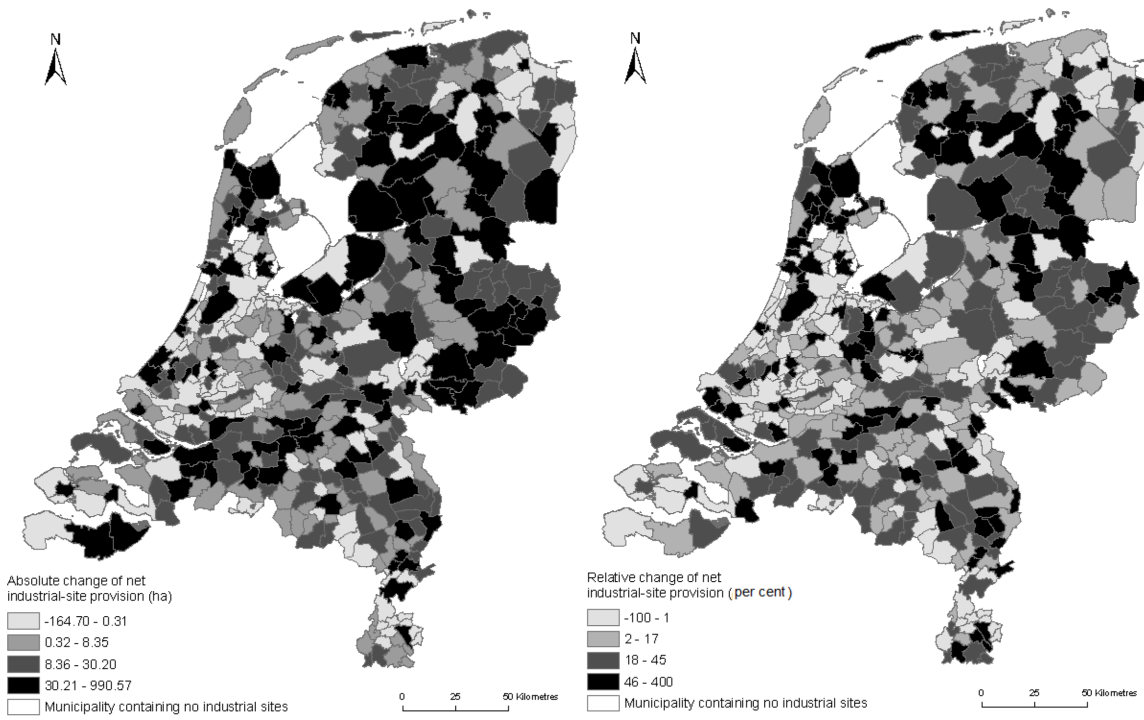
Source: Dutch Industrial Sites Database (IBIS).

Figure 5.1 Aggregate area of industrial sites in the Netherlands, 1996–2006, in thousands of hectares

Source*:* Dutch Industrial Sites Database (IBIS).

Figure 5.2 Distribution of industrial sites in the Netherlands, 2006

In Figure 5.3 we show quartile maps of the absolute and relative change in the net area of industrial-site provision by municipality in the period from 1996 to 2006. The figure shows a certain degree of spatial clustering in both the absolute and relative area change. Compared to the spatial clustering of supply of industrial land in 2006 (Figure 5.2), the clustering of change of industrial land reveals an opposite picture. Spatial clusters with large growth in industrial-site provision are mainly located in the Northern part of the Netherlands, while clusters with lower growth levels (or even decline) are mostly located in the Western part. The latter is among other things caused by the transformation of industrial into residential land, which mostly occurred in urbanized regions (Renes et al., 2009).[13]



Source: Dutch Industrial Sites Database (IBIS).

Figure 5.3 Quartile maps of the absolute (left) and relative (right) change in net industrial-site provision by municipality during the period 1996–2006

Since Dutch municipalities are not isolated islands, the spatial clustering of the change of provided net industrial-site area, may point to the existence of spatial autocorrelation for

[13] The municipalities of Bloemendaal, Bennebroek, Landsmeer, Laren, Noorder-Koggenland, Rozendaal, and Schermer do not contain any industrial land that has been formally designated as industrial site (Arcadis and Stec Groep, 2007). Accordingly, no change in the industrial-site area can be observed for these municipalities.

local authorities' industrial-site provision policies.[14] Calculating the associated Moran's I statistic yields a significant value (at the 1 per cent significance level) of 0.09, which indicates the presence of an overall spatial pattern in the data.[15,16] In order to identify local spatial patterns of industrial-site provision, we follow the Local Indicators of Spatial Association (LISA) approach (Anselin, 1995). This procedure enables us to detect spatial autocorrelation at a local level by portraying the local version of the Moran's I statistic. Figure 5.4 presents the associated local Moran's I statistics, irrespective to the significance level.[17] Positive autocorrelation is indicated by values classified as: 'high-high' for those municipalities with high levels of change in their industrial-site area, and which are surrounded by municipalities with high levels of change in their industrial-site area; and 'low-low' for those municipalities with low levels of change, and which are surrounded by municipalities with low levels of change. In the case of negative spatial autocorrelation, the values are classified as 'high-low' and 'low-high', indicating, respectively, municipalities with high values which are surrounded by municipalities with low values, and vice versa.

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[14] Spatial autocorrelation is present when the values of a certain variable observed at nearby locations are more similar than those observed at more distant locations.

[15] The (standardized) Moran's I statistic of overall spatial autocorrelation, for each variable of interest, is defined as follows:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2},$$

where the value of a continuous variable x at location i is compared with the value of the same variable x at location j.

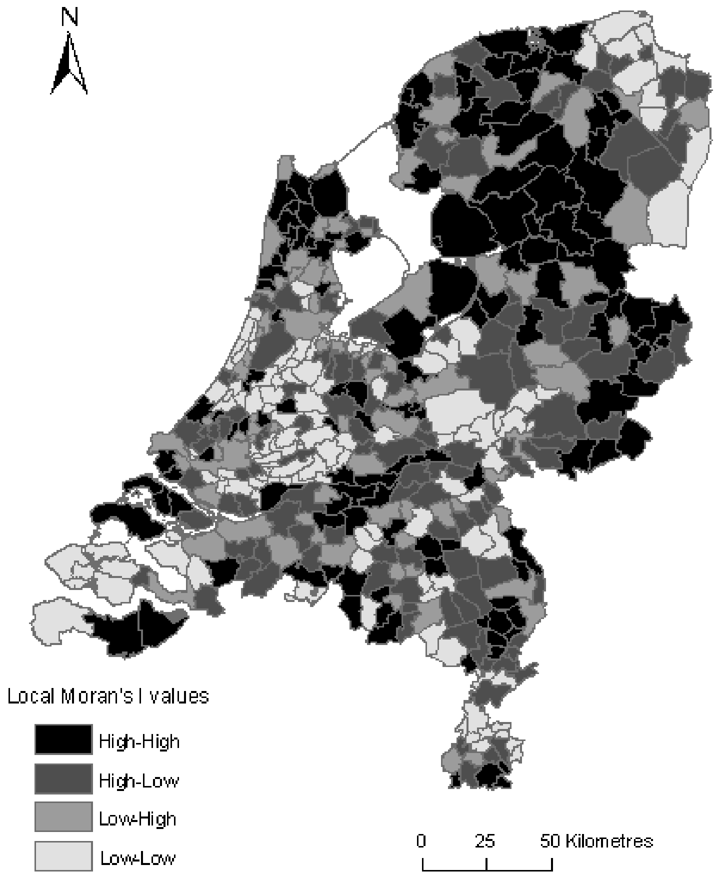
[16] The Moran's I statistic is computed for the change of industrial-site area per municipality in the period 1996 to 2006. The spatial structure of the data is expressed in a spatial weight matrix W with generic elements $w_{i,j}$ (with $i \neq j$) (Anselin, 1988). We employ a 'queen' weight matrix defined by a first-order contiguity, such that $w_{i,j} = 1$ if municipality i and j are neighbours, i.e. they share a common border or node, and $w_{i,j} = 0$ otherwise. In addition, the weights $w_{i,j}$ are row standardized and $w_{i,i} = 0$.

[17] The local Moran's I statistic decomposes the traditional Moran's I measure, into a measure of spatial autocorrelation for each individual location. It is designed to test whether the distribution of values around that specific location deviates from spatial randomness, and it takes into account the potential coexistence of different types of spatial autocorrelation (positive or negative) (Anselin, 1995). The local Moran's I statistic for a location i is defined as follows:

$$I_i = \frac{(x_i - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2 / n} \sum_{j=1}^{n} w_{i,j}(x_j - \bar{x}),$$

where x_i and x_j are the corresponding values for the locations i and j (with mean $\bar{x}$).

To ensure the contiguity of the spatial weight matrix, we have removed the Wadden Islands from the original data set.[18]



Note: The Wadden Island are not shown since these are not included in the analysis.

Figure 5.4 Local Moran's *I* values of the change of net industrial-site area per municipality, in the period 1996–2006

Once we inspect the local Moran's *I* map, it reveals some well-defined clusters in space, suggesting the presence of related policies of industrial-site provision between the municipalities concerned. Municipalities with high levels of change in their industrial-site area, which are surrounded by municipalities with high levels of change in their industrial-site area as well, are mostly concentrated in the North-Western part of the Netherlands (Province of North-Holland) and in some areas of the Northern provinces of Friesland and Drenthe, whereas clusters of low levels of change mostly emerge in the Randstad region and the South-Western periphery (Province of Zeeland).

We have revealed clear patterns of spatial clustering in the municipal supply of industrial sites. In order to explain these patterns, in Section 5.6 we employ a model which

[18] The Wadden Islands are located just to the North of the Dutch mainland, and consist of the following separate municipalities: Texel, Vlieland, Terschelling, Ameland, and Schiermonnikoog.

tests whether, and to what extent, the spatial autocorrelation between the municipalities concerned may be attributed to spatial dependence, i.e. whether the supply of industrial sites is subject to strategically competitive behaviour.

5.6 Regression analysis

5.6.1 The econometric model

To examine whether, and to what extent, the provision of industrial-site area by Dutch municipalities is associated with neighbouring municipalities' provision of industrial-site area, we construct an empirical model which is based on the theoretical framework discussed in Section 5.2. We follow the typical format for modelling spatial interaction, which functions as a vehicle for detecting strategic interaction: spatial dependence enters the model in the conditional mean of each municipality's reaction function, implying that geographically-specified weight matrices define the nature of the interdependence between jurisdictions (Anselin, 1988).

In accordance with the above, we estimate a reaction function as characterized by Equation (5.4). Inspired by Brueckner (1998; 2003) and Borck et al. (2006), we use the following empirical model which hypothesizes the shape of the reaction function for the dependent variable, and the average annual growth rate of industrial-site area, y_i, in a municipality i (=1,2,…,n) over the period 1996 to 2006:[19]

$$y_i = X_i \beta_i + \lambda \sum_{j \neq i} w_{ij} y_j + \varepsilon_i , \tag{5.5}$$

where the matrix w_{ij} represents a set of weights that aggregate the industrial-site provision decisions of other municipalities into a single variable, which has a coefficient λ. This coefficient describes the slope of the reaction function. The spatial weights matrix is defined by first-order contiguity, such that $w_{i,j}$ = 1 if municipality i and j are neighbours, i.e. they share a common border or node, and $w_{i,j}$ = 0 otherwise. The spatial weights matrix is typically standardized, so that the sum of each row equals 1, which implies that the spatially-lagged variable, Wy, contains the value of the average annual growth rate of industrial-site area (y) of the neighbours. The vector β comprises municipality i's own characteristics, which represents preferences and other factors that affect the level of

[19] The average annual growth rate in a municipality i, over the period 1996 to 2006 is defined as:
y_i = 100 · (*Ln* Net industrial-site area in 2006_i – *Ln* Net industrial-site area in 1996_i) /10.

industrial-site area provision. The error term, ε_i, is assumed to be normally distributed with constant variance, and independent across observations.

Two main issues have to be addressed when estimating Equation (5.5): endogeneity of the y_j's, and possible spatial error dependence (see Brueckner, 2003). This can be illustrated by rewriting Equation (5.5) in matrix form:

$$y = X\beta + \lambda Wy + \varepsilon , \tag{5.6}$$

where W is the weight matrix; X is the matrix of the municipality's own characteristics; and ε is the error vector. A model such as Equation (5.6) is known as a 'spatial autoregressive', or 'spatial lag', model. In this case, λ is the lag parameter which denotes the slope of the reaction function. Additionally, y on the right-hand side is endogenous since the dependent variable in each cross-sectional unit depends on a weighted average of that dependent variable in neighbouring cross-sectional units (viz. municipalities). As a result, ordinary least squares (OLS) estimates of the parameters will be affected by simultaneity bias. To avoid this problem, Equation (5.6) can be solved for the equilibrium values of y, yielding the following reduced form equation:

$$y = (I - \lambda W)^{-1} X\beta + (I - \lambda W)^{-1} \varepsilon . \tag{5.7}$$

Additional problems arise if the assumption of independence of the errors across municipalities is violated, i.e. the errors exhibit spatial dependence, satisfying the relationship:

$$\varepsilon = \rho W \varepsilon + \nu , \tag{5.8}$$

where W is the weighting matrix; ρ is the parameter to be estimated; and ν is a random error term typically to be assumed independent and identically distributed (i.i.d.). Solving Equation (5.8) yields:

$$\varepsilon = (I - \rho W)^{-1} \nu , \tag{5.9}$$

which shows that each element of ε is a linear combination of the elements of v, implying that ε_i is correlated with ε_j. If spatial error dependence is not taken into account, estimation of Equation (5.5) may yield a biased estimate of the reaction function slope λ.

In order to deal with the aforementioned sources of spatial correlation, we use the generalized spatial two-stage least squares (GS2SLS) estimation procedure. Kelejian and Prucha (1998) have introduced this technique which consists of a three-step procedure. In the first step, Equation (5.6) is estimated by 2SLS.[20] In the second step, the residuals obtained via the first step are used in a generalized moments procedure (GMM) to estimate the autoregressive parameter ρ in Equation (5.8). And finally, Equation (5.6) is re-estimated by 2SLS, after transforming the model via a Cochrane-Orcutt type transformation to account for spatial correlation (see Kelejian and Prucha, 1999).

Furthermore, there is a potential problem with heteroskedasticity of the error terms, which may lead to consistent but inefficient estimates. By adopting the GS2SLS-procedure, however, this issue can be solved, as the estimated GMM-parameter allows for heteroskedasticity. The latter is thus a positive by-product of this estimation procedure for cross-sectional spatial models, which contains a spatially-lagged dependent variable, as well as spatially-correlated error terms. [21]

We employ a cross-section data sample consisting of 453 Dutch municipalities classified according to the 2006 municipal division. Similar to the investigation of the local spatial autocorrelation of industrial-site provision between municipalities (Section 5.5), we have removed the Wadden Islands from the original data set.

5.6.2 Municipality characteristics

In the aforementioned, X is denoted as the matrix of municipality i's own characteristics. Inclusion of these local characteristics helps to eliminate spatial error dependence, which may arise when spatially-clustered variables are omitted from the model. Accordingly, we include local control variables which refer to the municipalities' industrial-site, demographic, land-use restrictions, accessibility, and political characteristics.

The net industrial-site area per municipality in 1996 is included to control for the initial amount of industrial-site area. We expect that the higher the initial amount, the lower the provision of extra industrial-site area. Another included industrial-site characteristic is the amount of utilized industrial-site area per municipality in 1996. In contrast to the former variable, the relationship with regard to industrial-site area growth is assumed to be positive. An increased level of utilized area suggests an increasing urge to create supplementary industrial-site area in order to be more attractive for potential newcomers (see Louw et al., 2003).

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[20] The basic idea is to use instruments H in a first step to estimate the model (Equation (5.6)) by 2SLS, where H consists of the linearly-independent columns of (X, WX, W^2X). This implies that one regresses Wy on X and WX, and uses the fitted values $\hat{Wy}$ as instruments for Wy (see Brueckner, 2003).

[21] An alternative way of estimating Equation (5.6) is to use a maximum likelihood approach (see, e.g., Brueckner, 1998). This approach does not, however, correct for heteroskedasticity of the error terms, and in the case of spatial error dependence it yields biased estimates.

Municipal demographic characteristics may affect efforts to promote local economic growth because of the needs and preferences of the population with respect to additional employment (Borck et al., 2006; Šťastná, 2009). In view of that, the provision of industrial sites may be influenced by the municipality's population, and, more specifically, by its structure. Therefore, we include the number of inhabitants categorized as being potentially productive in 1996 (viz. those aged between 20 and 65 years) as a fraction of the total population. Additionally, we take into account the size of the municipalities concerned by controlling for the corresponding population density (number of inhabitants per hectare). As industrial-site provision is an instrument of local employment promotion, we expect that both a relatively low fraction of working-age population and a relatively low population density may spur the development of industrial-site area, yielding a negative sign.

Population density also reflects the way land is used, i.e. when a municipality is characterized by a high population density, it implies that land, available for housing, is relatively scarce. With regard to the scarcity of land, industrial-site development is assumed to increase if there is ample availability of land, or a lack of restrictions on industrial-land development. As such, the availability of agricultural land can be considered as an important natural resource for the construction of industrial sites, as industrial sites are mainly developed by converting land which was originally used for agricultural purposes into industrial land (Dekkers, 2010). Conversely, the available amount of land occupied by nature and forest is assumed to curb industrial-site development. Because of the negative externalities associated with industrial-site presence, legislation is, amongst other things, dedicated to both open space and biodiversity conservation. Therefore, the fraction of agricultural land of the total land area in a municipality is included as a measure of potential industrial-site area expansion per municipality, whereas the fraction of land which is occupied by nature and forest controls for potential restrictions on industrial land use. We expect that the signs of the corresponding estimated coefficients are, respectively, positive and negative.

Additionally, the availability of land and the restrictions with respect to industrial-site growth is dependent on the geographical location of the municipalities. Taking this aspect into account refers to the issue of spatial heterogeneity as potential explanation of the clustering of industrial-site supply (Van Oort, 2007). In this respect, we distinguish the municipalities concerned according to the following three national zoning regimes: the Randstad core region, the intermediate zone and the national periphery (see Van Oort, 2007; and Appendix 5.B of this chapter).[22] The different zoning regimes indicate the attractiveness of a region in terms of its economic performance. As the provision of industrial-site area is assumed to be an important instrument of local economic growth stimulation, we expect that the more peripheral a municipality is, the higher are the investments in municipal industrial-site development. Additionally, the level of urbanization is obviously lower in the intermediate and peripheral zones than in the Randstad. Therefore, relative to the Randstad, the more distantly located municipalities, are subject to less physical restrictions concerning the possibilities of industrial-site development.

In Chapter 2 we have shown the importance of accessibility, in terms of connectivity to infrastructure, for economic growth on industrial sites. In accordance with these findings, we expect that easily accessible municipalities are more inclined to increase their industrial-site area than less accessible municipalities. The accessibility of a municipality is operationalized by taking the road distance from the midpoint of the municipality concerned to the nearest highway ramp. Inclusion of this proxy for overall accessibility of a location (Rietveld and Wagtendonk, 2004) is expected to yield a negative sign, indicating that the growth of land used for industrial purposes within a municipality declines with increasing distance from the nearest highway.

The tax-competition literature is replete with empirical studies which take into account the political regime in the local administrations. These studies demonstrate that featured strategic jurisdictional interaction is influenced by political calculations (e.g., Allers and Elhorst, 2005; Šťastná, 2009). In the case of the Netherlands, municipalities are not headed by a single person, but are governed by the 'mayor and municipal executive', consisting of the (appointed) mayor and the aldermen, and the municipal council, which contains elected members from the various political parties.[23] Given the role of the municipal council as a parliamentary legislative body with powers of policy determination, the prevailing political regime in a municipality is reflected in the composition of the municipal council (viz. the political partition of the council). The system of proportional representation means that the composition of a municipality council is a reflection of the election results of the corresponding local elections. Since the data on local elections are only available for recent years, we use the election results of the national elections by municipality as a proxy for

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[22] Distinguishing between macroeconomic zones in the Netherlands is based on a gravity model of total employment concerning data from 1996. The Randstad region in the Netherlands historically comprises the economic core provinces of North-Holland, South-Holland and Utrecht; the intermediate zone mainly comprises the growth regions of Gelderland and North-Brabant; and the national periphery is composed of the Northern and Southern regions of the country.

[23] In the Netherlands, aldermen always represent a coalition of political parties; there is no municipality in which one party has an absolute majority on the municipal council (Allers and Elhorst, 2005).

the political regime of a municipality. This pragmatic decision is to a great extent legitimized by the proliferation of local political parties in the 1990s. These parties do not exist at the national level and have a typical local political agenda, which makes it difficult to categorize them according to the classic left-right division. In this respect, we assume that a voter has similar political preferences, irrespective of the type of election (national or local). Using the results of the 1994 and 1998 national elections per municipality, we employ the average proportion of left-wing votes as a proxy for the political nature of the municipality.[24,25] A higher proportion of left-wing votes is associated with lower industrial-site development growth, as the proportion of left-wing votes measures the progressive attitude of municipality residents, and thus their willingness to preserve nature and landscape (as opposed to their conservative counterparts, right-wing voters, who are typically inclined to stimulate (local) entrepreneurship rather than to protect nature and landscape). Additionally, we include a dummy to distinguish those municipalities which have been going through a process of merging and amalgamating during the period 1996 to 2006. Merging implies decline of the emergence inter-jurisdictional interaction between the municipalities concerned, which may give rise to a less generous supply of industrial-site area. In accordance with this, we expect that merged municipalities, relative to non-merged municipalities, induce a negative influence on industrial-site provision growth per municipality. Variable names, definitions, sources and descriptive statistics are listed in Appendix 5.A.

5.6.3 Estimation results

Table 5.1 reports the empirical results. Before proceeding with the discussion of these results, several points should be considered. First, the explanatory variables referring to industrial-site characteristics – population density and accessibility – are in natural logs. Second, column 1 reports the results of a non-spatial model estimated by OLS. From the residuals of the OLS-estimation, the indicator of the presence of spatial patterns, Moran's I, is calculated to be 0.09. Since this outcome is statistically significant, the hypothesis of no spatial autocorrelation is rejected. We have reported the corresponding standard Lagrange Multiplier (LM-)test statistics, which indicate the most appropriate estimation approach for dealing with spatial autocorrelation. We have also reported the robust forms

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[24] Elections take place every four years at a nationally uniform date. As no elections were held in 1996, we decided to use the election results of 1994 and 1998.

[25] The following Dutch political parties, which took part in the 1994 and 1998 national elections, were categorized as 'left-wing': PvdA, D'66, Groen Links, SP, NWP (Natuurwet Partij), Groenen, NCPN, Sol'93 (Solidair '93), PSP'92, DNP (De Nieuwe Partij), SAP (Socialistiese Partij-Rebel), and Idealisten/Jij. The data on the elections of 1994 and 1998 are taken from www.nlverkiezingen.com.

of the respective tests and the LM ARMA test. The latter relates to the higher-order alternative of a model with both spatial lag and spatial error terms. The test outcomes indicate that both LM-lag and LM-error statistics are highly statistically significant, with the former slightly more so. Note that the LM ARMA statistic is also statistically significant. The test outcomes incline towards the adoption of a spatial lag model, even though spatial-error dependence has been detected. Therefore we have adopted the GS2SLS-procedure, instead of, for instance, maximum likelihood estimation, as it addresses spatial lag, as well as spatial error dependence. The corresponding estimates are presented in column 2 of Table 5.1. And finally, the statistically insignificant value of the Bruesch-Pagan test statistic points to serious problems with heteroskedasticity of the error terms of the model. As we decided to use the GS2SLS-estimation, the outcomes meet the assumption of homoscedastic errors, and so it brings us more accurate estimates than, for instance, its maximum likelihood counterpart. As a result of this, we focus on the GS2SLS-estimators by making inferences.

The most important finding from Table 5.1 is that the estimate of λ, the spatial lag parameter, is positive and statistically significant (at the 1 per cent significance level). The positive coefficient indicates that municipalities' reaction functions are upward-sloping, so that municipalities' decisions concerning the amount of industrial-site area to be provided are interrelated. More specifically, the estimated coefficient reveals that an increase of 1 per cent of neighbouring municipality j's average annual growth rate of industrial-site area, in the period 1996 to 2006, leads to a 0.67 per cent increase of municipality i's average annual growth rate in the same period, ceteris paribus. In addition, the statistically significant estimate of ρ points to the existence of spatial dependence of the errors across municipalities. The negative sign indicates that the errors are negatively correlated, so disregarding this correlation may lead to underestimation of λ.

Considering the remainder of the results, the majority of the estimates are, in terms of sign, consistent with our expectations. Only the estimate referring to the effect of merged municipalities yields an unexpected sign, but it appears to be statistically insignificant. We see that among the covariates only the initial amount of net industrial-site area (at the 1 per cent significance level), the amount of utilized industrial-site area, and the population density are statistically different from zero (both at the 5 per cent significance level). Additionally, we see that coefficients referring to intermediate zone and national periphery become non-significant when estimated by the GS2SLS, instead of OLS. This indicates that patterns of spatial clustering, as observed in Section 5.5, are not caused by spatial heterogeneity, i.e. industrial-site supply is not subject to forces referring to geographical context-specificity.

Table 5.1 Estimation results for the average annual growth rate of industrial-site area between 1996 and 2006

Variable	OLS (1)	GS2SLS (2)
λ		0.669***
		(4.85)
ρ		–0.464**
		(–2.47)
Constant	8.639*	7.605*
	(1.77)	(1.77)
Ln Net industrial-site area in 1996	–2.914***	–2.217***
	(–3.40)	(–2.99)
Ln Net utilized industrial-site area in 1996	2.220**	1.681**
	(2.55)	(2.31)
Fraction of inhabitants between 20–65 yr. in 1996	–1.183	–2.217
	(–0.18)	(–0.44)
Ln Population density in 1996	–0.378	–0.376**
	(–1.33)	(–2.00)
Fraction of agricultural land in 1996	0.627	1.193
	(0.48)	(1.03)
Fraction of nature and forest in 1996	–2.356	–0.844
	(–1.13)	(–0.48)
Intermediate zone (dummy)	1.483**	0.452
	(2.20)	(0.69)
National periphery (dummy)	1.918***	0.613
	(2.60)	(0.92)
Ln Distance to nearest highway ramp in 1996	–0.405	–0.434
	(–1.29)	(–1.43)
Proportion of left-wing votes (average of 1994 and 1998)	–0.593	–0.171
	(–0.22)	(–0.08)
Municipality merger from 1996 to 2006 (dummy)	0.558	0.435
	(1.05)	(1.32)
Number of observations	453	453
Adj. R^2	0.07	
Breusch-Pagan	184.158***	
	(0.00)	
Moran's *I*	0.087***	
	(0.00)	
LM spatial lag	9.529***	
	(0.00)	
Robust LM spatial lag	1.084	
	(0.30)	
LM spatial error	8.556***	
	(0.00)	
Robust LM spatial error	0.110	
	(0.74)	
LM ARMA	9.639***	
	(0.01)	

Notes: *t*-values are given in parentheses, except for the LM-test diagnostics where *p*-values are reported; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Special attention, however, should be paid to the interpretation of the estimated coefficients of the spatial model, regarding the nature of the corresponding marginal effects. From the reduced-form Equation (5.7) we see that the marginal impact of a unit change in X on y is not simply the partial effect, denoted by β, as it would be in the OLS model. The model specification modifies the impact, β, of X on y through the matrix inverse term $(I-\lambda W)^{-1}$. The matrix $(I-\lambda W)^{-1}$, the spatial multiplier, ensures that spatial spillovers travel through the entire system, and are not restricted to the immediate neighbours, i.e. the model suggests that spatial spillovers are present in all modelled effects (not just y, but also the control variables X) and in the errors. Thus, the estimated coefficients in the spatial model are consistent estimates of the marginal effects of a change in X on equilibrium growth rates, whereas the full effect is a multiple of the marginal effect (Anselin, 2003; Chen at al. 2009).[26]

For the correct interpretation of the coefficients, the effect of the spatial multiplier should be taken into account as follows: $\partial y/\partial X' = (I-\lambda W)^{-1}\beta$. This can be rewritten as: $\partial y/\partial X' = I\beta + \lambda W\beta + \lambda^2 W^2\beta + \lambda^3 W^3\beta$, etc. As such, the marginal effects can be decomposed into direct, indirect, and induced effects. The direct (marginal) effects are represented by β. The indirect effects, indicated by $\lambda W\beta$, are spillovers of the direct effects. These effects refer to the impact on the municipalities j, defined as the neighbours of municipality i. The indirect effects are spillover effects of the direct effects, and both effects are local, in the sense that only those municipalities in which there has been an exogenous shock and their neighbours are affected. The induced effects, $\lambda^2 W^2\beta + ...$, refer to spatial spillovers induced by the direct and indirect effects on all neighbours. Note that these induced effects comprise impacts on the higher-order neighbours, as well as feedback effects on municipalities which are already experiencing direct and indirect effects. This implies that in the model all municipalities in the system are spatially linked, so that the spatial effects in the model are global in nature (see, e.g., Abreu et al., 2005; Mobley et al., 2009). So, the marginal effects of changes in the explanatory variables depend on the spatial location of the municipalities, relative to other neighbouring municipalities, and on the resulting spillover and feedback effects between municipalities. β in the OLS model will be biased upward in magnitude whenever the variable X for municipalities is spatially correlated with the X variables for their neighbouring municipalities (Anselin, 2003). In the empirical results given in Table 5.1, the magnitude of this bias (on average, $(1-\lambda)^{-1}$) is illustrated by comparing the OLS and GS2SLS model estimates.

For the sake of completeness, we have computed the associated marginal effects.[27] We follow Abreu et al. (2005), who consider a change of a variable at one location, and then compute what happens in all other locations as a consequence of this change. This results in a vector of impacts, the magnitude of which varies with the location of the

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[26] Spatially correlated errors arise owing to omitted spatially-correlated variables.

[27] We have used the statistical software package *R* for this purpose.

municipalities concerned. Applying this method means that all observations are treated as unique locations, i.e. 453 locations have been created with 453 associated impacts per explanatory variable. Table 5.2 presents the corresponding mean direct, indirect, and total effects, i.e. summary measures of direct and indirect impacts (and the cumulative total effects) resulting from the effect of the estimated spatial multiplier. Additionally, the difference between the GS2SLS coefficient estimates and the associated direct effect estimates represent the induced effects that arise as a result of impacts passing through neighbouring municipalities and back to the municipality itself. Since the differences between the GS2SLS coefficients and the direct effect estimates are very small, we can infer that feedback effects are small and not likely to be of economic significance.

Table 5.2 Marginal effects of the average annual growth rate of industrial-site area between 1996 and 2006

Variable	Mean direct effect	Mean indirect effect	Mean total effect
Ln Net industrial-site area in 1996	–2.53	–4.17	–6.70
Ln Net utilized industrial-site area in 1996	1.92	3.16	5.08
Fraction of inhabitants between 20-65 yr. in 1996	–2.53	–4.17	–6.69
Ln Population density in 1996	–0.43	–0.71	–1.14
Fraction of agricultural land in 1996	1.36	2.24	3.60
Fraction of nature and forest in 1996	–0.96	–1.59	–2.55
Intermediate zone (dummy)	0.52	0.85	1.37
National periphery (dummy)	0.70	1.15	1.85
Ln Distance to nearest highway ramp in 1996	–0.49	–0.82	–1.31
Proportion of left-wing votes (average of 1994 and 1998)	–0.19	–0.32	–0.52
Municipality merger from 1996 to 2006 (dummy)	0.50	0.82	1.31

If we consider the direct effects, we see that these are close to the associated GS2SLS model coefficient estimates. In contrast to the similarity of the direct effect estimates and the GS2SLS model coefficient estimates, there are large discrepancies between the indirect effects estimates and the GS2SLS model coefficient estimates. Apart from pointing to the presence of strategic interaction between Dutch municipalities' industrial-site provision policies, the estimated lag parameter causes each explanatory variable X to have a multiplier impact on y, depending on the degree of connectivity between municipalities, which is governed by the weight matrix in the model.

5.7 Conclusion

The main aim of this chapter was to test whether the provision of industrial-site area by Dutch municipalities is subject to strategic interaction. By means of the techniques of spatial econometrics, we have estimated the associated reaction functions of municipalities concerning the growth of available municipal industrial-site area.

In the period 1996 to 2006, the various model specifications employed have clearly indicated the presence of strategic interaction between Dutch municipalities' industrial-site provision policies. A 1 per cent higher average annual growth rate of available industrial-site area in neighbouring municipalities leads to a 0.66 per cent higher average annual growth rate of the municipality concerned, ceteris paribus.

Given that the municipal provision of extra industrial-site area may be considered as an instrument of local economic growth stimulation, our findings are consistent with the empirical tax-competition literature which examines the interdependence of local tax rates. Tax rates are set with the aim to create attractive local business conditions. The amount of industrial-site area also acts as an instrument for local policy makers. Assuming that the allocation of employment depends on available industrial-site area in all municipalities, local authorities tend to set their local amount of industrial-site area strategically by taking into account other, nearby, local industrial-site provision policies.

While our results are consistent with the tax-competition literature, the results cannot prove that the applied model is correct as a description of how the amount of industrial-site area to be provided is actually chosen. In other words, the presence of spatial interaction has been proven but the question remains: to what extent this can be attributed to mechanisms which have been defined as inter-jurisdictional competition? Further research may elaborate on this issue.

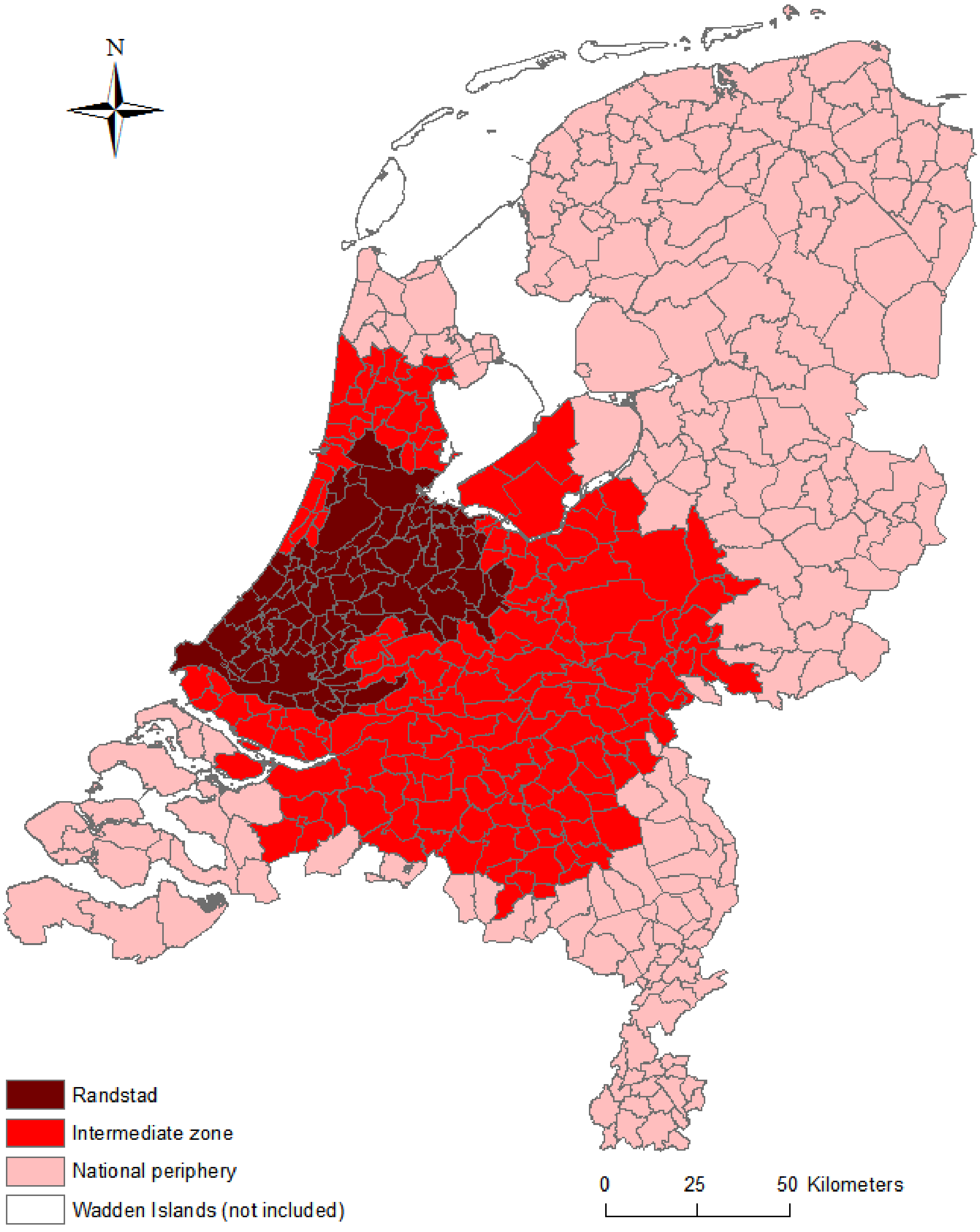
Hence, the findings have provided us with insight into the determinants of local industrial-site provision policy. In particular, it addresses to what extent the amount of industrial-site area provided annually is interrelated with the amount of industrial-site area provided in surrounding municipalities. It is interesting to note that our findings confirm that, hitherto, central industrial-site planning efforts appear to be rather ineffective. Given the theoretical considerations and the corresponding positive association found between municipal industrial-site provision policies, it is plausible that the current practice of industrial-site planning leads to an overprovision of the overall amount of industrial-site area, inducing a high degree of inefficient land use and other distortive landscape effects. Therefore, the outcomes of this analysis are a useful input for (regional) spatial planning authorities in order to assess, and to optimize, their reservations of industrial land for future economic growth.

Appendix 5.A Definitions, sources and descriptive statistics

Variable	Description	Source	Mean	Standard Deviation
Average annual growth rate of industrial-site area	The annual growth rate from 1996 to 2006 of total net industrial-site area per municipality	IBIS	2.25	4.86
Municipality characteristics				
Net industrial-site area	Total net industrial-site area per municipality in 1996 (hectares)	IBIS	134.16	327.95
Net utilized industrial-site area	Total net utilized industrial-site area per municipality in 1996 (hectares)	IBIS	105.45	261.92
Working-age population	Fraction of inhabitants within the age category of 20 and 65 years per municipality in 1996	CBS	0.62	0.03
Population density	Number of inhabitants per hectare per municipality in 1996	CBS	10.79	63.76
Agricultural land	Fraction of the total municipality area (incl. water surface) which is assigned to agricultural land in 1996	CBS	0.62	0.23
Nature and forest	Fraction of the total municipality area (incl. water surface) which is assigned to nature and forest in 1996	CBS	0.11	0.13
Randstad	Dummy variable: equals 1 if the municipality is located in the Randstad	Van Oort (2007)	0.19	0.39
Intermediate zone	Dummy variable: equals 1 if the municipality is located in the intermediate zone	Van Oort (2007)	0.37	0.48
National periphery	Dummy variable: equals 1 if the municipality is located in the national periphery zone	Van Oort (2007)	0.44	0.50
Accessibility	Euclidean distance from the midpoint of a municipality to the nearest highway ramp in 1996 (metres)	ABF	5,316.43	4,570.19
Left-wing votes	The average proportion of voters per municipality who voted for a left-wing party during the 1994 and 1998 national elections	NL Verki-ezingen	0.43	0.09
Merged municipality	Dummy variable: equals 1 if the municipality has been merged during the period 1996 to 2006	CBS	0.26	0.44

Notes: The abbreviations stand for: ABF – ABF Research Real Estate Monitor; CBS – Statistics Netherlands; IBIS – Dutch Industrial Sites Database; NL Verkiezingen – Online database containing Dutch election results from 1918 to 2010 [www.nlverkiezingen.com]; The sample size is 453 observations.

Appendix 5.B National zoning regimes in the Netherlands



Source: Van Oort (2007).

Chapter 6

Conclusions

6.1 Research findings

This thesis was motivated by the need to enhance our empirical understanding of the performance and impact of industrial sites in the Netherlands. Based on quantitative methods of empirical research, we have provided evidence on different major issues concerning industrial sites in the Netherlands. In this chapter, we draw attention to the most important conclusions, and discuss their policy implications, as well as suggested directions for further research.

The first part of the thesis addressed the external effects (i.e. externalities) associated with the spatial concentration of economic activities on industrial sites. In Chapter 2, we investigated the positive externalities involved with the economic performance of industrial sites by answering our first research question: *To what extent is the performance of industrial sites affected by their local economic structure and accessibility?* Positive externalities related to the clustering of firms, i.e. agglomeration economies, are supposed to promote local economic growth. Using a quantitative method, inspired by Glaeser et al. (1992), we explained the economic performance of industrial sites in the municipality of Amsterdam, in terms of local employment growth, as a function of the sectoral composition of the industrial sites concerned. As such, the sectoral composition provided us with indicators of the level of specialization, diversification and competition, with respect to the associated agglomeration externalities: Marshall-Arrow-Romer (MAR), Jacobs and Porter externalities. Additionally, we explicitly considered the importance of the accessibility of industrial sites as a growth-promoting factor. By using industrial sites located within the area of the municipality of Amsterdam, we showed to what extent the economic structure, in terms of specialization, diversity, and competition, affected site-industry employment growth between 1998 and 2006. The outcomes of our analysis provided substantial empirical evidence of a negative relationship between the degree of specialization and growth. This implies that an overrepresentation of similar economic activity does not generate localization economies. In the same chapter we confirmed that location matters, or at least the particular position of an industrial site, as indicated by the revealed spatial pattern of the fixed effects associated with unobserved industrial-site characteristics in the initial model. As we were mainly interested in the importance of accessibility, we focused on location by adding (non-contiguous) indicators of spatial heterogeneity – ease of accessibility and presence on a harbour site – to the initial model. We subsequently found that industrial sites which are easily accessible from the highway grow relatively fast, as well as sites located in the Amsterdam harbour area.

In Chapter 3, we have investigated the impact of negative externalities generated by industrial sites by providing an answer to the following research question: *What is the impact of the presence of industrial sites on their immediate vicinity?* Applying a hedonic pricing model, we valued the negative externalities generated by activities located on industrial sites in the Randstad region and the Province of North-Brabant, in the year 2005. The effect of these negative externalities is proxied by estimation of the distance-decay of house prices in the vicinity of industrial sites. Our results clearly showed that the presence of an industrial site has a statistically significant negative effect on the value of residential property. Relatively close to a site, externalities have a strong negative effect on house prices which convexly decreases up to a certain distance. Beyond that point, in our case about 1 kilometre, the negative effect on house prices concavely decreases till it fades out with increasing distance. Furthermore, we found that the effect of industrial-site size intervenes with the effect of distance on house prices, in the sense that this interactive effect affects the maximum variation of the distance effect: the larger the site, the larger the range of houses which are affected by the presence of the industrial site concerned. Our outcomes have demonstrated that the impact of negative externalities is largely localized, implying that the perception of the spatial quality of the neighbourhood is affected by the presence of an industrial site, and to a certain extent by the size of an industrial site.

The second part of the thesis focused on the determinants of local industrial-site provision, in terms of location and size. In Chapter 4, we investigated the relationship between various spatial location characteristics and the outcomes of land-use policy, with respect to industrial-site development, by answering the following research question: *What is the role of spatial location characteristics as determinants of the location choice of industrial-site area provision, and the resulting intensity of land use in terms of employment?* By applying various econometric techniques, we analysed the distribution of industrial sites, and employment on industrial sites, across the Province of North-Brabant. During the period 2000 to 2008, we have seen that the growth of industrial-site area (11.5 per cent) has exceeded the growth of employment on industrial sites in North-Brabant (7.1 per cent). Regression of the growth rate of employment on the growth rate of the industrial-site area demonstrated, ceteris paribus, that employment on industrial sites grows at a decreasing rate of industrial-site area growth. This questions the urgency of the provision of industrial sites as an instrument of local employment stimulation. Looking in more detail at the relationship between various spatial location characteristics and the realized industrial-site development, we found that industrial-site supply and the level of employment is positively associated with the residential land value of the location (4-digit ZIP-code area) concerned. This points to the importance of job availability with respect to the attractiveness of a location. Considering the role of accessibility of location, with respect to the size of industrial-site area and employment, we found mixed results. The level of industrial-site area is positively associated with accessibility by road, in contrast to accessibility by rail. But locations which are easily accessible by rail are positively associated with the level of industrial-site employment. These results point to the relevance of sectoral composition with respect to industrial-site development. We have seen that industrial sites are accommodating an increasing number of labour-intensive activities, such as consumer and business services. These types of activities encompass, amongst other things, different location requirements in terms of accessibility, compared with the more capital-intensive activities which are typically found on industrial sites. As such, labour-intensive activities may benefit in particular from the availability of an intercity-railway station in the vicinity as it enhances the access to labour. However, the level of employment on locations which are easily accessible by rail is limited to a certain degree. Considering the growth of employment, we have found that locations which are easily accessible by rail appear to be negatively associated with employment growth, whereas accessibility by road is positively associated with employment growth. This points to the variation of availability of land across the locations concerned. Land near railway stations, and in particular intercity-railway stations, is used intensively, which gives rise to employment growth at more distant locations, where sufficient land is available.

In Chapter 5, we investigated strategic interaction as a driver of the supply of local industrial-site area by providing an answer to the final research question: *To what extent is the amount of supplied industrial-site area subject to strategically competitive behaviour between municipalities?* By means of spatial econometric techniques, we have tested whether, and to what extent, municipalities take into account the decisions of neighbouring municipalities regarding the provision of industrial land. For the period 1996 to 2006, the various model specifications employed have clearly indicated the presence of strategic interaction between Dutch municipalities' industrial-site provision policies. A 1 per cent higher average annual growth rate of available industrial-site area in neighbouring municipalities leads to, ceteris paribus, a 0.66 per cent higher average annual growth rate of the municipality concerned. Our finding confirmed that the allocation of employment in a certain municipality depends on available industrial-site area in other municipalities, i.e. local authorities tend to set their local amount of industrial-site area strategically by taking into account other, nearby, local industrial-site provision policies.

6.2 Policy implications

Throughout the thesis, several policy implications have already been discussed. Chapters 2 and 3 arrive at outcomes which may provide useful tools to policy makers and urban planners for prioritizing and assessing the development of industrial sites, taking into account potentially relevant positive and negative externalities. In Chapter 2, our approach enabled us to gain insight into the extent to which the performance of an industrial site is affected by its local economic structure and accessibility. For instance, in order to benefit from positive externalities, a local planning authority can impose restrictions on the degree of specialization of the sectoral composition on an industrial site. In a similar fashion, Chapter 3 provided empirical evidence for the negative relationship between proximity to industrial sites and the values of nearby house prices. We found that the impact of negative externalities is largely localized, implying that the perception of the spatial quality of the neighbourhood is affected by the presence of an industrial site, and to a certain extent by the size of an industrial site. These findings indicate the social costs associated with the presence of an industrial site. As such, they may contribute to the assessment of the transformation of land into an industrial site, or vice versa, in terms of social costs and benefits (see, e.g., De Groot et al., 2010).

Chapters 4 and 5 have yielded insights into the determinants of local industrial-site provision policy. In particular, they addressed to what extent the amount of industrial-site area is associated with, respectively, spatial location characteristics and the amount of industrial-site area provided in surrounding municipalities. The outcomes of quantitative analyses point to the weakness of industrial-site provision as an instrument of economic growth promotion. The current practice of local industrial-site planning, in terms of location choice and size of industrial-site development, appears to result in an oversupply of the overall amount of industrial-site area, inducing a high degree of inefficient land use and other distortive landscape effects. Consistent with, amongst others, THB (2008), the empirical results call for a review of the current spatial planning of industrial sites. For instance, using a quantitative approach (regional) spatial planning authorities may arrive at a recalibration of their reservations of industrial land for future economic growth.

At a more general level, our research has demonstrated that the use of refined spatial data, and corresponding quantitative methods, results in thorough empirical insights concerning the planning of industrial sites. We emphasize the importance of empirical evidence in order to infer liable input for spatial planning policy. The analyses provide support to policy makers in their efforts to make well-considered, transparent, policy decisions. Additionally, the empirical evidence may help to avoid the emergence of irrational sentiments which can obstruct the discussion.

6.3 Directions for further research

The analyses carried out in this thesis point at several directions for further research. In this respect, recurring topics in the chapters are the issues of the level of spatial aggregation and the aspect of time, which are associated with the transferability of our findings (i.e. the extent to which research results of one situation apply to other similar situations), and the changing nature of industrial sites related to developments of the structure of the economy.

The studies carried out in this thesis are built on a range of data sets. The data used cover different geographical areas and vary across different levels of spatial aggregation, which complicates the linking of data sets and the associated analyses. In particular, hardly any data on the disaggregated spatial level of industrial sites is available, since industrial sites are not considered as administrative entities. As a consequence, we have applied the various quantitative methods on a limited number of specific cases.

More specifically, the outcomes of Chapter 2, for instance, explicitly address the relevance of spatial aggregation. On the scale of industrial sites located in the municipality of Amsterdam, we have revealed a negative relationship between the degree of specialization and growth, indicating that an overrepresentation of similar economic activity does not generate localization economies. Additionally, we find that there are studies showing positive effects, but also studies showing negative effects.[1] It is argued that the level of spatial aggregation may matter for the strength with which agglomeration forces are operational, which in turn gives rise to other interesting questions. For instance: Do we find similar results for industrial sites located in other municipalities or regions? Or, are the effects explained by the specific characteristics of the location concerned, in this case the municipality of Amsterdam? These types of research question may be extended by taking into account contiguous elements of space. Most of the investigated relationships in this thesis do not allow for the effects of spatial autocorrelation between the spatial entities considered. As such, these analyses lend themselves to extensions by inclusion of spatially-lagged versions of the relevant explained and explanatory variables employed.

The time dimension of our analyses is another topic related to the issue of the transferability of our research findings. The studies carried out cover a relatively short time span. An interesting area for further research would be to take into account long-run trends which would provide us with, amongst other things, insights into the evolution of industrial-site supply related to economic development and the valuing of (negative) externalities over time. Besides the effect of the length of the period covered, the use of

[1] By means of a meta-analysis, De Groot et al. (2009) have indicated that both negative and positive effects of specialization exist. They point to the relevance of, amongst other things, spatial heterogeneity in terms of level of spatial aggregation as an explanation for the variation in effects.

panel techniques (as opposed to cross-section techniques which we have generally employed) may enlarge our understanding in this respect.

Throughout the several studies carried out, it is apparent that the nature of industrial sites in the Netherlands is changing in terms of economic structure. The share of manufacturing activities on industrial sites is decreasing in favour of small-scale companies and service providers. So, originating as a location for heavy, large-scale, nuisance-generating industrial activities, industrial sites have transformed into a location for all kinds of economic activities. In this respect, further research could be conducted at the firm level in order to investigate the choice between being located on an industrial site or outside an industrial site. Special attention should be paid to the land use of the individual firms, pointing to the aspect of the productivity of land as a factor of production (in addition to labour and capital). In addition, given the recent change in the industrial character of industrial sites, the classification of industrial sites has become outdated. The division of sites into heavy-industry sites, harbour sites, miscellaneous sites, high-tech sites, and transport sites needs revision. This holds in particular for the category 'miscellaneous', which comprises around 60 per cent of the industrial sites (Arcadis and Stec Groep, 2007). From a policy perspective, a more specific classification would contribute to the accuracy of the implications which can be inferred from associated empirical research.

Given the marked added-value of the insights from empirical research, but the limited number of cases studied available so far, further research initiatives should be undertaken to enlarge the spatial and temporal scope of the analyses. Extension of the scope may lead to an increased understanding of location specificities of the outcomes and a refinement of the methods concerned. But, such expansion of the study area is, as already mentioned several times, highly dependent on the availability of data. So, if policy makers and spatial planners aim to increase the use of empirical insights, as input for spatial policy, associated spatial data sets should be assembled, managed, and made available.

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Nederlandse Samenvatting (Summary in Dutch)

Bevindingen

Stimulering van de lokale economie is geworteld in het Nederlandse bedrijventerreinenbeleid. Bedrijventerreinen zijn het resultaat van beleid gericht op de geconcentreerde creatie van ruimte voor werkgelegenheid. Gedurende de afgelopen decennia zijn bedrijventerreinen de belangrijkste locatie geworden voor de uitgifte van grond voor bedrijvigheid. Hierdoor vestigen veel bedrijven zich op deze locaties en leveren ze een aanzienlijke bijdrage aan de lokale economie. Maar bedrijventerreinen hebben ook nadelen. Ze zijn de bron van allerlei soorten hinder, zoals geluidsoverlast, verkeersoverlast en horizonvervuiling. Dit heeft onder andere geleid tot discussies over nut en noodzaak van de aanleg van nieuwe bedrijventerreinen en de locatie van bedrijventerreinontwikkeling. Empirische inzichten over de positieve en negatieve effecten van bedrijventerreinen zijn echter schaars. Dit proefschrift heeft tot doel deze inzichten uit te breiden door gebruik te maken van verschillende kwantitatieve methoden van empirisch onderzoek.

Het eerste deel van dit proefschrift bestudeert de positieve en negatieve externe effecten die samenhangen met de ruimtelijke concentratie van economische activiteit op een bedrijventerrein. In hoofdstuk 2 is de rol van positieve externe effecten op het economisch presteren van bedrijventerreinen onderzocht aan de hand van de volgende onderzoeksvraag: *in welke mate wordt het economisch presteren van bedrijventerreinen beïnvloedt door de lokale sectorstructuur en bereikbaarheid?* Van positieve externe effecten ten gevolge van de ruimtelijke clustering van bedrijven (ofwel agglomeratievoordelen) wordt verondersteld dat deze de lokale economische groei bevorderen. Geïnspireerd door het werk van Glaeser e.a. (1992) is op kwantitatieve wijze, op het ruimtelijk aggregatieniveau van bedrijventerreinen, de variatie in werkgelegenheidsgroei op bedrijventerreinen in de gemeente Amsterdam (periode 1998–2006) verklaard als een functie van de sectorsamenstelling van de bedrijventerreinen. De sectorsamenstelling is geoperationaliseerd aan de hand van indicatoren voor de mate van specialisatie, diversiteit en concurrentie van de economische bedrijvigheid. Daarmee wordt invulling gegeven aan de theoretische inzichten van respectievelijk Marshall-Arrow-Romer, Jacobs en Porter over de aard van agglomeratievoordelen. De gehanteerde eenheid van observatie is een bepaalde sector op een bepaald bedrijventerrein. De economische activiteiten zijn opgedeeld in elf sectoren, verdeeld over 68 in Amsterdam gelegen bedrijventerreinen. Verder is expliciet rekening gehouden met het belang van bereikbaarheid van bedrijventerreinen als groeibevorderende factor. De analyse laat zien dat de sectorstructuur op een bedrijventerrein, in termen van specialisatie, diversiteit en concurrentie, invloed heeft op de werkgelegenheidsgroei binnen een bepaalde sector op het betreffende bedrijventerrein tussen 1998 en 2006. De uitkomsten leveren empirisch bewijs voor een negatieve relatie tussen de mate van specialisatie en groei. Dit impliceert dat oververtegenwoordiging van gelijksoortige economische activiteiten op een bedrijventerrein geen agglomeratievoordelen oplevert. Verder kan op basis van het verkregen ruimtelijk patroon van *fixed effects*, die de niet-geobserveerde bedrijventerreinkenmerken van het gebruikte model weerspiegelen, gesteld worden dat locatie ertoe doet – of ten minste de geografische positie van een bedrijventerrein. Op het aspect locatie is nader ingezoomd door aan het initiële model indicatoren van ruimtelijke heterogeniteit toe te voegen in de vorm van de mate van bereikbaarheid en de aanwezigheid op een haventerrein. Dit laat vervolgens zien dat bedrijventerreinen die eenvoudig te bereiken zijn via de snelweg een relatief hoge groei hebben doorgemaakt in de onderzochte periode, evenals de bedrijventerreinen in het Amsterdamse havengebied.

Hoofdstuk 3 gaat in op de negatieve externe effecten verbonden aan de aanwezigheid bedrijventerreinen. Deze zijn bestudeerd aan de hand van de volgende onderzoeksvraag: *wat is het effect van de aanwezigheid van bedrijventerreinen op hun directe omgeving?* Voor de waardering van negatieve externe effecten, veroorzaakt door activiteiten op bedrijventerreinen, is gebruik gemaakt van de hedonische prijsmethode. De omvang van de negatieve externe effecten is gemeten door de huizenprijzen te schatten als functie van de afstand tot het dichtstbijzijnde bedrijventerrein. De resultaten wijzen onmiskenbaar uit dat de aanwezigheid van bedrijventerreinen een statistisch significant negatief effect heeft op de transactieprijs van woningen. In de relatieve nabijheid van een bedrijventerrein hebben de negatieve externe effecten een sterk effect op huizenprijzen. Tot een afstand van ongeveer 1 kilometer heeft dit effect een convex afnemend verloop. Voorbij dit punt vlakt het effect af bij toenemende afstand. Verder blijkt uit de analyse dat er een wisselwerking optreedt tussen het effect van bedrijventerreinomvang en het effect van afstand op huizenprijzen. Dit interactie-effect is van invloed op de reikwijdte van het effect van afstand tot een bedrijventerrein: hoe groter het bedrijventerrein is, des te groter is het bereik aan huizen dat wordt beïnvloed door de aanwezigheid van het betreffende bedrijventerrein.

Het tweede deel van dit proefschrift is gericht op de determinanten van bedrijventerreinuitgifte, zowel in termen van locatie als omvang. In hoofdstuk 4 is met behulp van verschillende econometrische technieken de ruimtelijke spreiding van bedrijventerreinen en van werkgelegenheid op bedrijventerreinen in de provincie Noord-Brabant geanalyseerd. Het uitgangspunt was de volgende onderzoeksvraag: *wat is de rol van ruimtelijke locatiekenmerken als determinanten van locatiekeuze voor bedrijventerreinuitgifte, en de corresponderende intensiteit van grondgebruik in termen van werkgelegenheid?* Aan de hand van deze vraag is de relatie tussen verschillende ruimtelijke locatiekenmerken en de uitkomsten van grondbeleid verkend. Van 2000 tot 2008 is in Noord-Brabant het areaal grond in gebruik door bedrijventerreinen met 11,5 procent gegroeid, terwijl de werkgelegenheid op bedrijventerrein slechts met 7,1 procent is toegenomen. Regressieanalyse toont dat werkgelegenheid in afnemende mate groeit met uitbreiding van het areaal bedrijventerreinen. Als de relatie tussen verschillende ruimtelijke locatiekenmerken en de gerealiseerde bedrijventerreinontwikkeling op de betreffende locatie (4-cijferig postcodegebied) nader wordt bestudeerd, valt onder andere op dat werkgelegenheid positief samenhangt met de residentiële grondwaarde. Dit wijst op het belang van de beschikbaarheid van banen voor de aantrekkelijkheid van een locatie. Gekeken naar de samenhang tussen bereikbaarheid van een locatie en het areaal bedrijventerreinen en werkgelegenheid dan levert de analyse gemengde resultaten op. Het areaal grond dat in gebruik is door bedrijventerreinen hangt positief samen met de bereikbaarheid per snelweg van de locatie, in tegenstelling tot de bereikbaarheid per spoor. Maar locaties die eenvoudig te bereiken zijn per spoor worden gekenmerkt door bedrijventerreinen met een relatief hoge werkgelegenheid. Dit wordt onder andere verklaard doordat bedrijventerreinen steeds meer arbeidsintensieve activiteiten huisvesten, zoals financiële en zakelijke dienstverlening. Deze typen activiteiten hebben extra baat bij de nabijheid van een (intercity)station, ten opzichte van kapitaalintensieve activiteiten die van oudsher vooral te vinden waren op bedrijventerreinen. Echter, gekeken naar de groei van werkgelegenheid op bedrijventerreinen, dan blijkt deze negatief samen te hangen met de bereikbaarheid per spoor van de betreffende locatie, terwijl de groei van banen positief samenhangt met de bereikbaarheid via de snelweg. Dit komt doordat ruimte voor groei in de nabijheid van (intercity)stations beperkt is door het reeds intensieve gebruik van grond op dergelijke locaties. Op de meer perifere snelweglocaties is deze ruimte wel aanwezig.

Hoofdstuk 5 sluit af met een studie naar het effect van strategische interactie tussen gemeenten op de omvang van bedrijventerreinuitgifte. Hiervoor is de volgende onderzoeksvraag geformuleerd: *in welke mate bepaalt strategisch competitief gedrag tussen gemeenten het uitgegeven areaal bedrijventerreinen?* Door gebruik te maken van ruimtelijk econometrische technieken is getoetst of, en in welke mate, Nederlandse gemeenten rekening houden met de beslissingen van nabijgelegen gemeenten ten aanzien van de uitgifte van bedrijventerreinen. De periode 1996–2006 is onderzocht. Uit de verschillende modelspecificaties komt naar voren dat er sprake is van strategische interactie tussen het gevoerde bedrijventerreinenbeleid van gemeenten in Nederland. Zo blijkt voor de onderzochte periode dat een toename van 1 procentpunt van de gemiddelde jaarlijkse groeivoet van de oppervlakte bedrijventerrein in een gemeente tot gevolg heeft dat diezelfde groeivoet in de betreffende buurgemeenten met 0,66 procentpunt toeneemt, ceteris paribus. De allocatie van werkgelegenheid in een bepaalde gemeente is dus afhankelijk van de hoeveelheid grond in gebruik door bedrijventerreinen in andere gemeenten. Lokale autoriteiten zijn zodoende geneigd de oppervlakte uit te geven bedrijventerrein strategisch te bepalen, gebaseerd op het uitgiftebeleid van andere, nabijgelegen gemeenten.

Beleidsimplicaties

De uitkomsten van de in dit proefschrift uitgevoerde studies leveren bruikbare, *evidence-based*, inzichten op ten aanzien van verschillende aspecten van het bedrijventerreinbeleid. Het eerste deel van dit proefschrift verschaft instrumenten, waardoor specifiek rekening gehouden kan worden met het optreden van eventuele positieve en negatieve externe effecten en hun waardering bij de planning van bedrijventerreinen. Zo is gebleken dat sectorsamenstelling op een bedrijventerrein van invloed is op het economisch presteren van een bedrijventerrein. Een oververtegenwoordiging van gelijksoortige bedrijven levert geen agglomeratievoordelen op. Gekeken naar negatieve externe effecten en bedrijventerreinen, dan kan gesteld worden dat deze vooral in de nabijheid van een bedrijventerrein een sterk negatief effect op huizenprijzen hebben. Dit inzicht biedt aanknopingspunten voor het inschatten van de maatschappelijke kosten en baten verbonden aan de transformatie van een locatie in een bedrijventerrein, en vice versa.

Het tweede deel van het proefschrift verschaft inzicht in determinanten van lokaal bedrijventerreinbeleid. De kwantitatieve analyses wijzen op de zwakte van bedrijventerreinuitgifte als instrument ter bevordering van lokale economische ontwikkeling. De huidige manier waarop bedrijventerreinen worden ontwikkeld lijkt te hebben geresulteerd in een overaanbod van bedrijventerreinen, wat tot uiting komt in inefficiënt grondgebruik en andere verstorende landschapseffecten. Dit vraagt om een herziening van het beleid ten aanzien van de planning van bedrijventerreinen. In dit kader zouden regionale planningautoriteiten hun programmering aan kunnen passen, leidend tot een herijking van de hoeveelheid grond gereserveerd voor bedrijventerreinen.

Vervolgonderzoek

De studies waaruit dit proefschrift is samengesteld zijn gebaseerd op verschillende databestanden. Deze data omvatten verschillende geografische gebieden of regio’s en variëren in ruimtelijk aggregatieniveau. Dit compliceert de koppeling van databestanden en zodoende de verschillende analysemogelijkheden. In het specifieke geval van bedrijventerreinen is op het betreffende niveau van aggregatie slechts in beperkte mate data beschikbaar. Bedrijventerreinen worden namelijk niet beschouwd als afzonderlijke administratieve eenheden. Naast de geografische beperkingen kennen de data temporele beperkingen. De databestanden beslaan veelal een relatief korte periode. Deze databeperkingen hebben ertoe geleid dat de verschillende kwantitatieve methoden slechts zijn toegepast op een beperkt aantal specifieke cases. Dit heeft gevolgen voor de generaliseerbaarheid van de uitkomsten; de mate waarin de bevindingen gebaseerd op een bepaalde situatie geldig zijn voor andere, soortgelijke situaties. Om deze (externe) geldigheid van de verschillende empirische inzichten over bedrijventerreinen te vergroten is er behoefte aan uitbreiding van het aantal specifieke casestudies. Hierdoor wordt de ruimtelijke en temporele *scope* van de analyses vergroot. Dit is echter afhankelijk van de beschikbaarheid van verfijnde ruimtelijke data.

Verfijnde ruimtelijke data maken mogelijk dat ingezoomd kan worden op het ruimtelijk aggregatieniveau van bedrijven die gevestigd zijn op bedrijventerreinen. In de uitgevoerde studies is verschillende malen aangeduid dat de aard van Nederlandse bedrijventerreinen verandert in termen van sectorsamenstelling. Als oorspronkelijke locatie voor zware industrie, zijn bedrijventerreinen getransformeerd in een locatie voor allerlei soorten economische activiteiten. Vervolgonderzoek kan zich richten op empirisch onderbouwde verklaringen voor de keuze van de betreffende bedrijven om zich al dan niet te vestigen op een bedrijventerrein. In dit kader is het interessant om de intensiteit van het grondgebruik van de afzonderlijke bedrijven te bestuderen; nader ingaand op het belang van grond als productiefactor (naast kapitaal en arbeid). Maar dan dient duidelijk gedefinieerd te zijn wat een bedrijventerrein is. De huidige gehanteerde typologie behoeft herziening door het veranderende karakter van bedrijventerreinen qua sectorsamenstelling.

Het proefschrift biedt aldus verschillende empirische studies met waardevolle inzichten die als input kunnen dienen voor ruimtelijk beleid. Verdere uitbreiding van deze kennis, en overeenkomstige wenselijke *evidence based* beleidstoepassingen, is denkbaar, maar staat of valt bij de beschikbaarheid van voldoende ontsloten ruimtelijke data.

Nawoord

Lees het voor- of nawoord van een willekeurig proefschrift en grote kans dat het een reismetafoor bevat om het doen van promotieonderzoek te typeren. Het is in dit geval niet anders, een betere beeldspraak heb ik er simpelweg niet voor.

Iedere keer na een dag van noeste wetenschappelijke arbeid werd ik bij binnenrijden van Utrecht CS verwelkomd door C.C.S Crone:

en hoe verder hij ging
des te langer
was zijn terugweg

Nieuwsgierigheid, kennishonger en de illusie van volledigheid lieten me moeiteloos verder gaan. Een oneindige hoeveelheid tijd om na te denken, om te lezen en om die andere methode nog eens toe te passen – zo leek het. En voor de zekerheid nóg een keer de resultaten van de allereerste analyse checken. ‘Wetenschap is nooit af’, zoals mijn Alma Mater eens terecht verkondigde in het kader van een wervingscampagne. Maar dit proefschrift dan? Zonder heenweg geen terugweg. Ondanks de verlokkingen van het verder gaan is op een zeker moment toch de terugweg ingezet, loyaal gebleven aan waar het om begonnen was: een afgerond proefschrift. Het was inderdaad een forse terugweg, maar gelouterd ben ik teruggekeerd en het gestelde doel is bereikt. Terugblikkend kan ik constateren dat de kunst van het schrijven van een proefschrift niet het verder gaan is, het is het terugkeren.

Na vijfenhalf jaar geeft het me erg veel voldoening dat het af is. Dit was niet mogelijk geweest zonder de steun van anderen. Graag wil ik iedereen bedanken die op de een of andere manier heeft bijgedragen aan de totstandkoming van dit proefschrift. Een aantal mensen verdient echter een speciale vermelding.

Geen proefschrift zonder promotor(en). Ik had het geluk om begeleid te worden door Piet Rietveld en Henri de Groot én dat ook nog eens aan de afdeling Ruimtelijke Economie van de VU, een afdeling die al jaren meedraait in de Champions League van de ruimtelijke- en vervoerseconomische wetenschapsbeoefening. Piet en Henri wil ik bedanken voor de prettige en inspirerende samenwerking. Jullie gaven mij de ruimte en het vertrouwen om me te verdiepen in het onderwerp en om me te bekwamen in het doen van hoogwaardig academisch onderzoek. Piet, met je creativiteit, wijsheid en rust voorzag je me van nieuwe ideeën en werd de rode draad van het proefschrift bewaakt. Verder vond ik het telkens weer een feest om in de rol van Zwarte Piet te kruipen, om samen met jou als Sinterklaas op 5 december strooigoed en cadeaus uit te delen op de afdeling. Henri, ik denk met veel genoegen terug aan de vele gesprekken die we gevoerd hebben. Jij was altijd bereid om mee te denken als ik ergens tegenaan liep. Jouw kennis, geestdrift, enthousiasme en geduld zorgden ervoor dat ik grip kreeg op de verschillende methoden. Door mij steeds weer de data te laten 'martelen' werd ik uitgedaagd het maximale uit het onderzoek te halen.

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Onder de noemer afleiding mag ook de ruimtelijke economen whiskyclub 'RE-blended' geschaard worden. Aan de hand van connaisseur, fijnproever en verzamelaar Frank zijn Eveline, Olaf, Ron en ik menigmaal meegenomen langs de rijke single-malt smaken van onder andere de Highlands, de Lowlands, en de Speyside. Deze leerzame, maar vooral gezellige avonden zullen we in de toekomst nog vaak overdoen.

Het is al eerder gememoreerd: eenvoudig is het verder gaan, niet de terugweg. Hierdoor heb ik het laatste jaar van mijn onderzoek in 'mijn eigen tijd' uitgevoerd. Ik wil mijn nieuwe collega's van de Amsterdam School of Real Estate bedanken voor hun oprechte belangstelling in mijn promotieonderzoek. Ik waardeer de kansen die ik krijg om mijn opgedane kennis in te kunnen zetten in de verschillende opleidingen. Zo kan ik een beetje bijdragen aan het slaan van de brug tussen wetenschap en (vastgoed)praktijk.

Het in mijn eigen tijd werken aan het proefschrift betekende dat andere dingen erbij inschoten, zoals het bezoeken van een voetbalwedstrijd op zondagmiddag (hoewel dat afgelopen seizoen niet zo erg was). Gerrit en Caroline, nu het af is zal ik er weer regelmatig bij zijn op de Maas- of Olympiatribune. Wat ik minder vaak afzegde waren de avondjes in de kroeg of de maandelijkse popquizzen. Onvermijdelijk waren de discussies over theorie, empirie en natuurlijk de status van het onderzoek. Dit was niet merkwaardig in een gezelschap met nog twee, en soms drie promovendi. Uiteindelijk haal ik als eerste de eindstreep, maar binnen afzienbare tijd zijn we alle vier doctor – dat komt helemaal goed! Vijftien dagen na de verdediging van dit proefschrift moet zelfs de volgende al op voor zijn verdediging. Vincent, ik ben blij dat jij mijn paranimf wilt zijn en ik vind het een eer om twee weken na mijn verdediging jou terzijde te staan. Verheugd ben ik ook met mijn andere paranimf als secondant. Herman, als niet-wetenschapper zorg jij voor de nodige relativering van al dat wetenschappelijke geneuzel.

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Friso de Vor
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