Demand, Supply and Policy; A quantitative analysis of the business- premise and land market

The Creation of a Decision Support Tool

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Preface

After five years of recession, a lot of initial anticipations and aspirations were negated. Among these, the exploitation plans for the expansion locations of municipalities. The poor housing, retail and office markets are ruining private and public parties, but in the market of business locations, there is only one big loser, the municipality. In my thesis I have studied the causes, consequences and opportunities of this social problem. I set out on a venture to find out what to do with the land surpluses and the political tensions around it. By identifying and analysing large datasets, I searched to uncover the real extent of the problem and tried to quantify it in a model.

The purpose of this thesis is to help the government of the Netherlands to create a sustainable policy. An attempt is made to create a model which gives a holistic view of the problem, including feedback loops that give insight in the consequences of policy. It results in some conclusions that are intuitive, however are misconceived by many governments. Therefore this thesis is meant to be read by governmental policy makers to give them insight in the feedback loops in their line of work. Municipal councils can see if their plans to drop the land prices have the desired effects and provincial officials can oversee the consequences of local policy on a larger scale.

Now in front of you I present the results of this search; my graduation thesis for the master Construction Management and Urban Development at the Eindhoven University of Technology. The Brink Groep joined me in my research and provided me with a practical point of view, which hugely benefitted its applicability. They were a great source of inspiration and pushed me beyond my limits. Also the thesis was conducted as part of the KENWIB initiative, to improve the built environment from a sustainable point of view.

The topic was complex and versatile but with the help and guidance of my supervisors, family and friends, I was able to finish it in six months. The final product is more than I hoped for in the beginning. Therefore, I would like to thank some people, for their time and help.

First of all I would like to thank Michel van Rhee and Tristan Kunen for the day to day guidance at the Brink Groep. Their experience and sagacious views were a complement to my aspirations. Secondly I would like to thank, Wim Schaefer, Paul Masselink and Brano Glumac, who guided me at the university. Wim guided with metaphorical profundities and kept me on the right track. Paul helped with the insights in the realities of governance and connections. Brano was always open to my slightly unorganised presentations on my methodology and his experience with these methods. Thirdly I would like to thank the interviewees for their time and knowledge: Teun Brands, Jos Luijten, Joris Knoben, Huub Ploegmakers, Gertjan Harder and especially Erwin Daceir. Lastly I would like to thank my family and friends. My friends for all the good memories and the best years of my life. My girlfriend Nathalie, for being there with the ups as well as the downs, her patience and help. My father, mother and sister, for their support, love and enabling me to get where I am now. I couldn't have done it without you!

1 Thesis Outline

In this chapter the outline of the thesis will be sketched and the problem specified. After drafting this outline the research questions and the purpose are defined. The chapter will conclude with a reading guide to help the reader to fathom the process and streamline the experience.

1.1 Introduction

In the beginning of 2011 a headline in a newspaper proclaimed: ‘15% of the municipalities in financial danger due to losses on land reserves’. At that time the municipalities of the Netherlands had lost 2,9 billion euros on speculative purchasing of land. This is a major blow to the municipalities because the municipal fund had also been reduced drastically the year before (Allers 2010); leaving municipalities with a dry bank account and budgets they could not maintain. This only hinted the real scale of the disaster; at the end of 2011 the estimated losses had risen to around 3,9 to 4,4 billion euros (Ten Have et al. 2012). Now just before printing this thesis, in 2014 the losses allegedly have risen to between 4,0 and 6,0 billion euros. These figures are in stark contrast to the expected profits of 3,6 billion euros. This results in a total deficit between expected income and expenses of at least 7,6 billion euros; as large as the three quarters of the budget cuts in 2012 of the Dutch government due to the economic crisis (10 billion).

“Buy land, they’re not making it anymore”

- Mark Twain

Dutch municipalities have acquired, over the last eight years, an abundance of land destined for business. Based on optimistic prognoses and conceit, municipalities believed until around 2007 that they had a shortage of land in supply for business purposes (Olden 2010). However the demand for all this ground never truly developed as predicted. Now all across the Netherlands there are plots of land that have been made ready for construction, may never be used and the plots that are to be sold will leave a vacant building in the region (Planbureau voor de Leefomgeving 2009). This abundance is probably caused by the profitability of new developments. Municipal budgets are depending on the profits that are made from city expansion, causing a ‘two hats dilemma’. Municipalities must choose between (1) financial or economic considerations and (2) spatial planning goals. Dutch municipalities failed to distinguish properly between their different ‘hats’ with respect to business-land policies in the past three decades, clearly demonstrating what can go wrong with municipalities wearing two ‘hats’ (Van der Krabben and Jacobs 2013).

The land market is, as the name suggests, a system of supply and demand. The surpluses of acquired land have led to a mismatch between this supply and demand. This would not be a problem in any other market, though the land market has some imperfections, which differentiates it from a standard market. The institutional context for land ownership, exchange and development, combined with high governmental involvement and public funds differs the market as well from a normal market.

Land is a scarce and valuable resource and should therefore be managed in a sustainable way (Ferber et al. 2006). Nonetheless a mismanaged abundance of new, peripheral land prepared for development, can lead to the decentralisation of the urban environment. Currently companies buy the newly offered plots for a low price and leave a vacant building in the region (Planbureau voor de Leefomgeving 2009). Municipalities want to sell their acquired land for the financial benefits and so urge for city expansion. This is a typical example of urban sprawl. Persky en Wiewel (1996) concluded that deconcentration of development to outer suburban areas brings few or no net gains while presenting significant inequities in the distribution of costs and benefits. Firms locating in outer suburban areas reap most of the benefits, while most of the costs (or benefits foregone) are borne by unemployed city residents and commuters who bear the cost of congestion, accidents and pollution; as well as by taxpayers who foot the bill for subsidies for transportation, home-ownership and other public subsidies, offering an exuberance of land stimulates the urban sprawl and decreasing the social benefits in the long run.

This mismatch in supply and demand leads to the question: “What to do with the land supply?”. Granting the land as usual will lead to vacancy in inner cores and deconcentration, while granting less land will hurt the municipalities financially in the short term. It creates a tension between societal and financial interests (Vereniging van Nederlandse Gemeente 2011). The purpose of the research is to create a decision support tool to aid regional governance to simulate the consequences of policy by combining future demand and supply. The goal is to ultimately develop a decision making tool to identify weak and strong locations for business parks.

1.2 Problem Definition

In this section the problem is defined and the scope is discussed. Eventually this will result in a set of research questions, which will be answered throughout the rest of the research.

The mismatch in supply and demand considering the business -land and -property market generates tensions between societal and financial interests. Municipalities had anticipated profits on land development, but are now losing money on the projects. This leads to a decrease in budget of the municipalities, which will have to cut on societal projects, decreasing the quality of living for the residents. Municipalities want to provide a stable employment rate and thus want to attract companies. Companies on business parks are an essential part of the employment provision (Weterings, Knoben, and Van Amstedam 2008). Local governmental responsibilities are limited to their territory and as a result the relatively high supply, creates a competition between municipalities to attract companies. Competition is caused not only by the boundaries of local government, but as well as by interdependence between companies and municipalities. This competition does not only reduces the income for the municipalities trough price drops, but also leaves an obsolete and derelict area at the location of the company's origin. Vacancy and obsolescence has risen since the start of the millennium (Olden 2010) resulting in an actual need for more brownfield redevelopment instead of instigating the continuation of the problem.

The national government has picked up on this trend and developed, out of concern, a continuation of the 'SER-ladder'. The SER (Social Economic Council) introduced the 'ladder' in 1999 as a reaction to the Note Spatial Economic Policy (Dutch: Nota Ruimtelijk Economisch Beleid). The SER-ladder's successor, namely the 'sustainable urbanisation ladder', should have a central role in the control of urban sprawl caused by business parks.

However this ladder does not provide the provinces the power to compel municipalities to redevelopment and regional cooperation is not mandated but advised (Ministry of Infrastructure and the Environment et al. 2009). This results in a relatively large amount of freedom in decision making for municipalities. With an oversupply of land, rising vacancy and obsolescence, the environmental quality will drop and in the long run the municipal budgets will come under pressure. This has serious consequences for its inhabitants, since their quality of life will drop because budgets on social benefits will have to be cut, striking at the most vulnerable groups of our society; the elderly and infirm.

All of this leads to the problem definition, which has been formulated as follows:

> ***There is an oversupply of land purposed for business activities, which instigates vacancy and urban sprawl and strains the budgets of municipalities, which leads to a wide variety of social security problems.***

For a more detailed description of the scope of the problem see 'Appendix 1'.

1.3 Problem Owner

For taking on a relevant viewpoint the central question of this section is: "Who is responsible for the problem?" The municipalities caused the over-supply, but who is ultimately the problem owner? There are three perpetrators which are the victims as well; the national government, the provincial government and local governments.

"Let us never forget that government is ourselves and not an alien power over us. The ultimate rulers of our democracy are not a President and senators and congressmen and government officials, but the voters of this country."

— Franklin D. Roosevelt

Municipalities are the first degree problem owner; their plans for city expansion and initial preparations are the ones that are negated. Nevertheless the Dutch governmental hierarchy causes the provincial and national government problems as well. In the Netherlands municipalities cannot go bankrupt, they come under the title of an ‘article 12-municipality’. The twelfth article of the financial relation law (Dutch: Financiële-verhoudingswet) states that municipalities with long term shortages come under supervision of the province. The province covers the shortage on the condition that the municipality improves its financial situation and the municipality loses some of its independence. Dutch municipalities have large debts for purchasing and servicing land and need to pay interest over this. This brings a lot of municipalities in trouble. Fifteen percent of the municipalities is balancing on the edge of being given an article 12 status (Vakberaad Gemeentefinanciën 2012). Because the province has to supply all these municipalities with their deficits, it is becoming a problem for them as well. The national government will not profit from decentralisation and carries the burden of the overcrowding infrastructure and degradation of its business locations.

This same hierarchical domino effect can be seen in the cause of the problem. The municipalities are not the root of the problem. Estimations on how much land is needed for business areas is determined by the provincial government. These estimations are however closer to reality as the ones found executed by the municipalities, which is a result of the Dutch law. The province cannot directly dictate the land use plans and the municipalities are allowed to heighten the estimations of the province with their own ambitions. Hence it can be said that the Dutch laws are not capable of dealing with the matter. The amount of municipalities involved in this problem hint that the Dutch system was deficient in constraining municipalities.

If a single problem owner and cause should be defined these would depend on the time scale. First in the chain are the municipalities. The domino effect kicks it up the hierarchy as provinces have to supply the municipalities with fees. For this thesis the viewpoint of the municipality is chosen because it owns the immediate problem as well as the direct instruments to deal with the problem. The scope of the problem suggests nonetheless, that there is something fundamentally wrong and the problem is now owned by the province. The aspect of competition between municipalities is also not negligible and calls for a higher level of governance. The province will therefore be seen as the problem owner.

1.4 Purpose of the Research

The overall objective is to create a decision support tool to aid municipalities in sustainable spatial planning specified for business parks. Contributing to the search for finding an appropriate solution for the municipal dilemma, between profitable developments and sustainable redevelopments, is a step in the direction of efficient spatial-use. By comparing the demand and supply in both quantities as qualities, a sustainable decision can be made.

Despite the high attention to the problem in a lot of papers and articles (Ploegmakers, Van der Krabben, and Buitelaar 2013; Ploegmakers and de Vor 2013; ten Have et al. 2012; Vakberaad Gemeentenfinanciën 2012), there have been some crucial exclusions. None of the articles consider the current stock in their equation for the amount of land needed. In most papers it is assumed that the land grants will be originating from areas outside the current stock. This is however not the case (Weterings, Knoben, and Van Amstedam 2008). Another omission is the incorporation of qualitative aspects in the demand and supply. Just ascertaining the fact that there is an oversupply, will not suffice to help make a decision of what to do with it. By identifying high-growth or high-shrinkage branches one can compare the supply with these branches' preferences. This research attempts to not only create a model which quantifies the problem for municipalities, but the model will also try to predict the qualitative demands and how to best cope with these. Thus the purpose of the research is defined as follows:

> ***Creating a micro economic model which quantifies the relations of policy on business-land grants on the total supply and demand.***

To aid their decisions, the information generated by the model must cover the following aspects: (1) The real scope of demand corrected for business cycle effects. (2) What are the demands per business-branch and what are their requirements concerning the land use plans. (3) Analysis of where to absorb the abundance (4) and where to change the land use plans. This analysis should consider the greenfield development versus existing business park redevelopment and consequences for the municipality.

1.5 Research Questions

To guide the research in the right direction and test the hypothesis, the following research questions are proposed to help achieve the purpose of the research.

> ***Can demand and supply of business-land be modelled; quantifying policy influence on vacancy and losses?***

- *What caused the surpluses of business-land and what are the consequences?*
- *What is the financial structure behind business-land development?*
- *What constitutes supply and demand for business-land and can it be quantified?*
- *Can a decision support tool be created and validated?*
- *What are the influences of supply and can the model help create a sustainable policy towards business purposed land?*

1.6 Reading guide

For this research a detailed flow chart of the research is shown in Figure 1.1. A literature review will identify models and estimation methods for supply and demand of land and will define the conditions and motivations for the location choice of companies. All together it will create the theoretical framework for the methodological approach. Simultaneously data must be gathered and inventoried so that the methodical approach can be determined. After all data and approaches are identified, the data of a case study will be processed to find the relations and input the decision support tool will need. The decision support tool will then be shaped and tested on the same case. In the conclusion, it will be possible to advice the policy maker in the case study area on how to approach their over-supply and review the model application as well as validation and proofing of the model.

While reading this thesis, keep in mind that business land is defined as land destined by the municipal land-use plans for business activities within the boundaries of a business park. Also when referred to a surface area (m^2 or ha.) it will be parcel area unless otherwise indicated. Also growth can be read as discrepancy and can either be growth or shrinkage. When unfamiliar with the topic, it is strongly recommended to read the appendices closely for elucidation when mentioned. A list of abbreviations is given on the last page

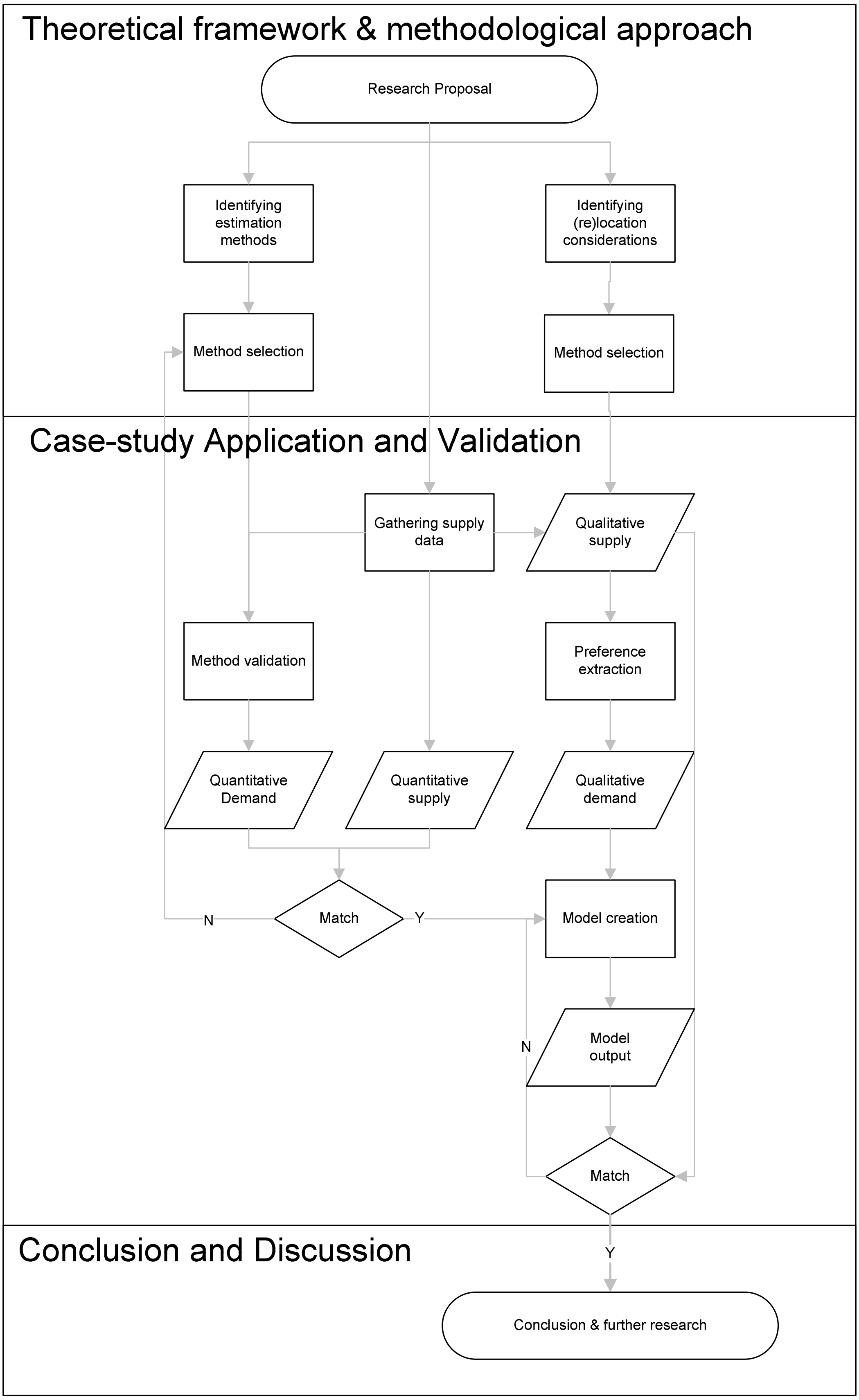

Figure 1.1: Research Flowchart

2 Theoretical Framework

In this chapter, literature on the subject will be reviewed to form a framework for the research. Firstly a background sketch of the structures of the development and spatial planning in the Netherlands can be found in 'Appendices 2 & 3'. This section focusses on answering the research questions that do not require any data analysis.

2.1 Business-Land Development

Business-land development in the Netherlands is highly focused on new developments. More as other markets in which re-use and redevelopment are more prominent options. Municipalities are responsible for the lion's share of the industrial land development (see Figure 2.1). More than 75 percent of the land predestined for industrial granting is owned by the municipalities (Ministry of Infrastructure and the Environment 2012a). This process is governed by the municipal service: 'het grondbedrijf' (Olden 2010). Municipalities have been able to service a new hectare for each hectare sold since the 1970's, resulting in a steering position for them.

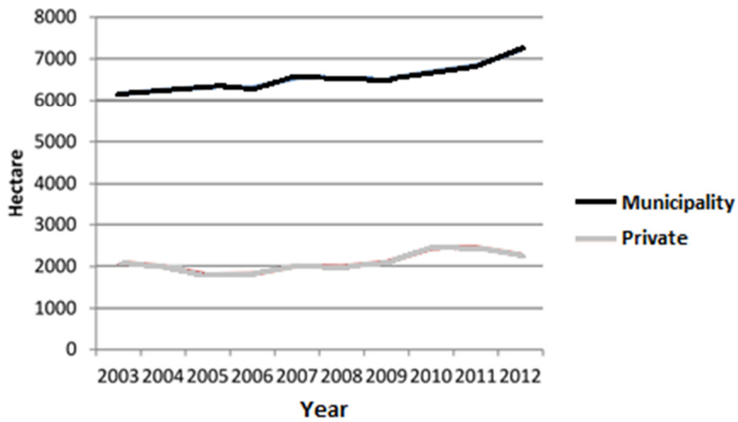

Figure 2.1: Division of land ready for granting in the industrial sector (Ministry of Infrastructure and the Environment 2012a)

This supply of land owned by municipalities is called the 'iron supply', a business economical understanding for the minimum of supply necessary for guaranteeing continuity. This supply is dependent on the time needed for production. In the case of land development the amount of land in supply is compared to the time needed for servicing the land. It is stated that twice the amount of land granted each year, should be in the reserve prepared to grant for guaranteeing continuity (Olden 2010; Traa and Declerck 2007). This is however a rule of thumb, more complex methods are available and will be discussed in 'Chapter 4'. The 'iron supply' as it is called in supply chain management, is divided into two types of land. The first of these is land ready to grant, which has already been serviced, this reserve is called 'land in development' (LID). The second form of iron reserve is the amount of land which is not yet serviced but is reserved in planning, which should be, including serviced land, around eight times the annual grant (Olden 2010). This reserve is called 'land not in development' (LNID).

The hierarchy of the Dutch government divides the estimations of the iron supply over the governmental layers; national, province and municipality. The involvement of the state is limited to the broad outlines of the policy and national estimates of employment. The provinces are mainly aiming at estimation of the demand, the designation of sites and encouraging regional coordination in planning and programming. Most of the tasks are focused on the municipalities, which are responsible for a large part of the planning, programming and the development and distribution (Gorter and Olden 2007). This gives municipalities the last call in the process of business-land development and the sense of responsibility.

2.2 Land Grant Protocol

In between the land development and the property development, the ownership of the land has to be transferred. The policy for selling LID to developing parties is handled by municipalities themselves. Because this is a delicate procedure and land is a 'scarce' commodity, the municipalities have a 'land grant protocol'. In the Netherlands each municipality has its own land grant protocol. It functions as a guideline and is a set of rules to determine whether or not a plot of land will be sold to a particular buyer.

As the land grants started to drop after 2009; the national government turned its attention to the land grant protocol. To prevent municipalities from haphazard land grants and to inhibit the urban sprawl, the national government introduced the 'sustainable urbanisation ladder'. The sustainable urbanisation ladder is a guideline which dictates three steps a municipality must consider when choosing new grounds for a company (Figure 2.2). Firstly, the demand for the new function should be there before trying to accommodate new functions. Secondly there should be no land, which is currently in use, as an option for redevelopment before deciding to build on a greenfield. Thirdly make the most of the opportunities to multiple use of space in this new developed area. This sustainable urbanisation ladder creates a motivational obligation for the municipalities towards the government, and is thereby superior to its predecessor the 'SER ladder'.

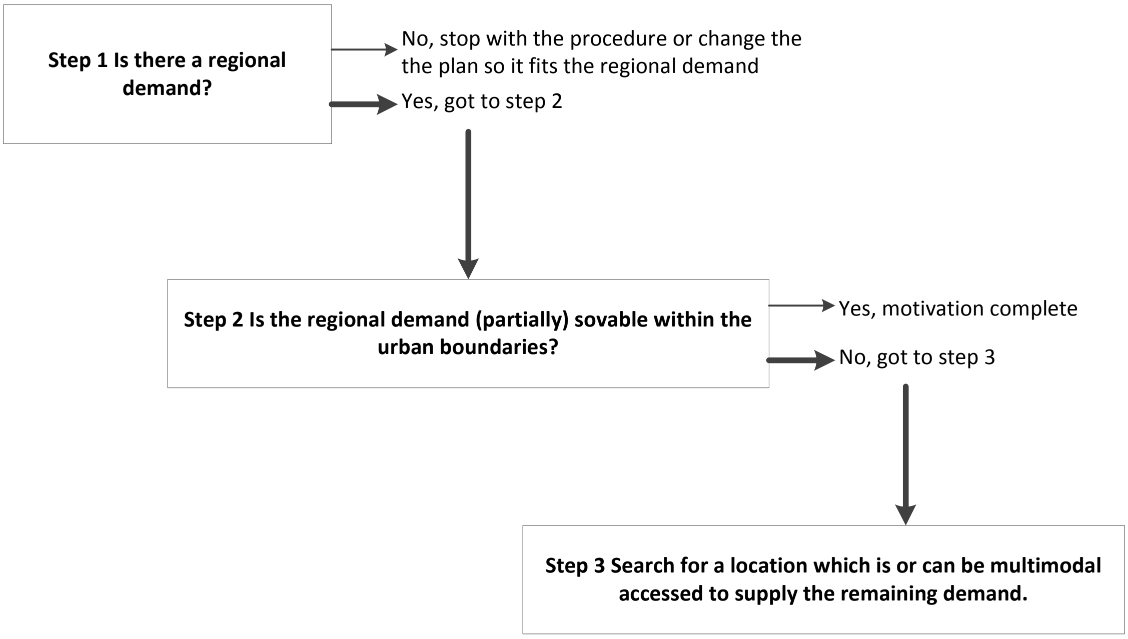

Figure 2.2: The sustainable urbanisation ladder (Ministry of Infrastructure and the Environment 2012b)

The characteristics and suitability mentioned in this ladder remain free for interpretation nonetheless (Ministry of Infrastructure and the Environment 2012b). Municipalities in the Netherlands have considerable political autonomy in their decisions to develop new schemes. Planning constraints are absent since higher governments (i.e. provinces) hardly impose them upon the municipalities. In general, provinces allocate a generous amount of land for industrial use (Ploegmakers, Van der Krabben, and Buitelaar 2013; Province of North-Brabant 2008; Court of Audit 2008). In 2009 the Ministry of Infrastructure and the Environment composed the 'covenant business parks' in which it states that provinces should take control over the 15.8000 hectares of brownfields to be redeveloped in a sustainable way. The 'SER-ladder' should have a central role in this. However the same list of statement dictates that the provinces should not compel municipalities to redevelopment and regional cooperation is not mandated but advised (Ministry of Infrastructure and the Environment et al. 2009). So the land grant protocols of municipalities are still the most influential factors in industrial land granting. And thus the land-regime is subject to a cooperation-regime, caused by the interdependence between companies and municipalities; undermining the sustainable redevelopment and allowing the centrifugal forces to instigate the urban sprawl.

2.2.1 Land Grants in Practice

There seems to be a large gap between documentation and reality as Ploegmakers et al. (2013) showed in an empirical research. They showed that only one out of three municipalities uses the formal code for calculating the land needed on reserve to guarantee continuity. None of their municipal interviewees used the land coefficient method, for it did not take into account economic conjuncture. The demand in practice is predicted by waiting lists and informal discussion. It was brought to light that, despite that almost all municipalities claim to monitor the existing stock, only one in four municipalities adjusted their demand by considering the current stock and vacancy rates.

Upon interviewing some municipal officials it became apparent that the practical application of the ‘sustainable urbanisation-ladder’ was even worse than in theory. The ‘ladder’ is lacking power, data and cooperation. As mentioned before, municipal officials are still able to evade the ladder by lack of power. The ladder urges cooperation between a redevelopment-team, company-relations and the economic planners. However municipal communication structures and hierarchies do not easily allow or adapt to these cross-disciplinary documents. One department does not know what the other is doing and vice versa. Next to lack of power and cooperation is the lack of data and communication; e.g. one of the interviewees mentioned unfamiliarity with the ‘ladder’. Small municipalities do not have the man power to keep an eye on the existing stock and accompany entrepreneurs in their search for a suitable location within the current built environment. Also are they not capable of predicting an accurate demand. This results in an ungrounded decision in the first two steps of the ladder.

2.3 Business Premise Market in the Netherlands

The main distinction in land development is that business land development is based upon speculations of municipalities instead of private developers. This is reflected in the premise development. As private developers do not take up a large part of business land development, they are not likely to develop business premises. As can be seen in Figure 2.3; after land is developed by the municipality, it is mostly sold to the end-user instead of a developer. The private end-user will commission a contractor to build his premise for own use.

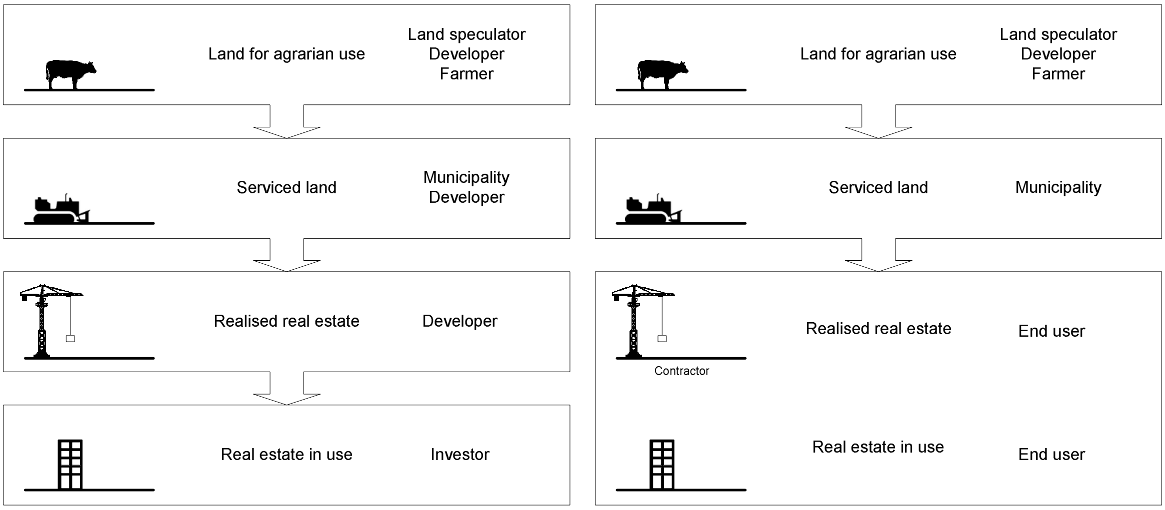

Figure 2.3: Property transitions in regular developed real estate (left) and business park developed real estate (right)

The existing real estate market of business premises differentiates itself from the other markets because of the small amount of speculation. Property developers hardly come into play in the business premise development. Therefore the supply of speculatively built industrial properties is extremely small (Louw, Krabben, and Priemus 2003). Institutional investors show only minor interest in acquiring industrial properties (Ploegmakers, Van der Krabben, and Buitelaar 2013). The share of business properties in real estate portfolios, of investors, amounts only to 2,5 percent against 43 percent residential, 28 percent retail, 24 percent offices and more than 2 percent mixed use (Krabben and Buitelaar 2011). This stands in stark contrast to the land development market, where the business-land market is dominated by speculation of municipalities as well as private developers. The business premise market is dominated by owner produced real estate. As much as two thirds of the current stock is owner produced and only 34 percent is commercially bought or rented. Within this commercial market, 85 percent originated as previously owned, resulting in a percentage of only 5 percent market share of speculatively produced real estate (Olden 2010), in contrast to the office space and housing market, which are dominated by commercial real estate. The division is shown in Figure 2.4.

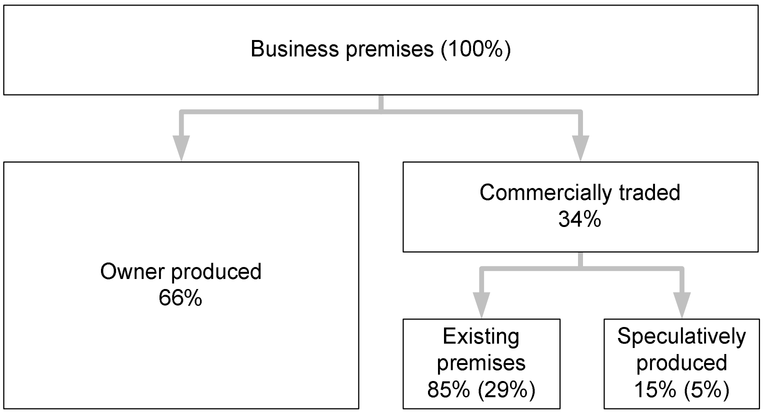

Figure 2.4: Division of business premises in the Netherlands

As a result, it can be concluded that the business premise market consists of specialised and tailored premises. As only 29 percent of business premises have been previously owned, it is possible to conclude that the market is dominated by 71 percent first time use. The relatively large share of the commercially traded properties, are 'second-hand' properties and are quite often still owned by the firm that used to have the property previously in use. Krabben & Buitelaar (2011) speculate that these second hand properties are almost all leased because the sale of second hand business property rarely occurs. The owner then reverts to the second best option and leases the property instead of selling it. The transference of industrial properties is even limited to only 600 transactions per year.

2.4 Financial Considerations

To get a better understanding of what drives the business-land market, the financial structure of firm relocation is discussed here. The financial considerations of business –land and -premise development are two sided. On the one hand municipalities have their financial stakes and on the other hand the developer (as concluded before almost always the company itself) has his own stakes. Therefore both sides of this aspect are reviewed.

2.4.1 Municipalities

The financial stake of the municipalities can be divided into the classic costs and benefits. As the municipalities are the main developers in this market, they carry the costs of acquisition and servicing, as well as the benefits of selling. The height of their income from development is determined by the amount of land sold and the land value. In theory land valuation in the Netherlands is mostly performed by of one of these four methods: the residual land value method, land quote method, comparison method and cost method. In practice, according to the land price policy (2009), the financial system used in most of the municipalities, is the functional land price politics. This method closely resembles the residual land value method. The price of the land is determined by the function to be realised in the land-use plan and the given parameters of the plan. The commercial value of the function, subtracted with the total investment costs, is assumed to be a realistic land value for future use (ex ante). The method seems objective but is not as water tight as it seems. Land-use values are defined in a pre-contractual phase and are thus based on estimated costs and revenues. These components are topic of negotiation between market parties and the municipality, in which the two evidently have conflictive objectives. This method is exclusively applicable to all developments where the costs and revenues are estimable and the real residual land value can only be determined after construction. However it is not possible to settle the prices post construction, because this would cause the municipality to become the risk bearer of the project. The market party is supposed to bear the risk for the development, tender, realisation and sales. The municipality is the risk bearer of the land-use plan and its exploitation value.

As land in development (LID) has been tagged with a price tag by the municipality, prior to selling, it is considered as an asset on the balance sheet. The price asked per square meter of the LID is used as the book value in municipal financial balances. Accounting rules make it possible to use this value in the budget of the municipalities before the plots are actually sold. The value used in the balances anticipate a certain market value. However if the real market value is lower as the book value, it should be changed to the market value (BBV 2012); or as it is called in accounting: 'depreciation' (Dutch: afboeken). Doing so brings the municipalities in financial difficulties because the previous budgets were based on the initial book value.

The parameters in the land valuation differentiate per province (e.g. height of the rent) and thus the land prices differentiate per province (see Figure 2.5). These prices are set in municipal land grant protocols after careful evaluation, nevertheless municipal officials are allowed to bargain with companies about the land price and do not dread to do so (Planbureau voor de Leefomgeving 2009). Because municipalities are allowed to develop greenfields and sell the land parcels for a profit, they start to speculate and calculate their budgets on these profits. This structure allows municipalities to make a profit on development projects if they own the land. However this is not their primary motivation for greenfield development, but the assumption of control is (Ploegmakers, Van der Krabben, and Buitelaar 2013).

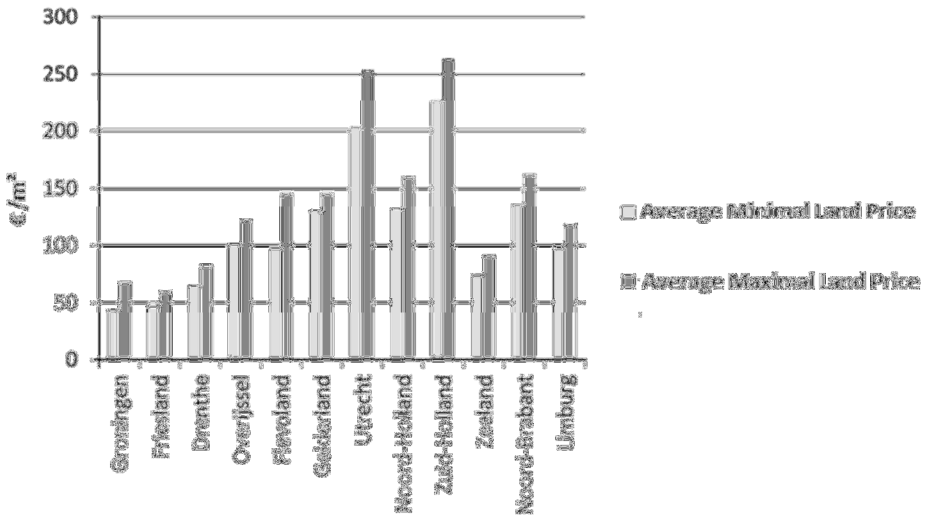

Figure 2.5: Land prices per province (Ministry of Infrastructure and the Environment 2012a)

2.4.2 Companies

The financial aspects are highlighted in a publication of van Dijk & Pellenbarg (2000). They describe that the decision making process of individual firms on the micro level can be mathematically calculated. The idea behind this approach is that each firm constantly makes a present value calculation, weighing the investment of moving against the benefits of that new location. These benefits can be anything from: enabling a cramped business with more space or moving closer to a specific transport hub, as long as the result is beneficial to the profits. This approach is based on the economic theorem of profit maximisation, but because firms possibly choose to locate for non-economic motives, such as place of birth and recreational opportunity, the accuracy of this assumption is arguable. However, as van Dijk & Pellenbarg rightfully argue: whether the present location is chosen for reasons of good luck or judgement, to survive in the long run firms need to attain a certain profit rate.

The relocation of a company has several financial consequences. These can be categorised into building costs, furnishing costs and relocation cost. This implies there are two sides to premise development; the shell and the furnishing. Harder (2013) pointed out the big differences between branches in appreciation of, and spending on both sides. As for more office-like firms, they will be more focussed on the shell than the furnishing, since furnishing will not differentiate much within office-like buildings. However companies with more production-like businesses are more dependent on the furnishing of their hall and will focus on those costs. As for the actual relocation costs, they are minimal and the building costs and furnishing costs compose the bulk of the costs (Harder 2013).

As it comes to costs when developing greenfields, they can be separated into land price and construction costs and fees. As Ploegmakers (2013) and Luijten (2013) stated in their interviews, municipalities wrongly assume the land price is the determining factor for location choice. Land price is only a small part of their decision, however it plays a role. One can assume that a company that wants to build a huge storage hall will weigh the land price more in the consideration as a company that wants to build a small stacked office, since the land price will take up a large portion of the total bill. For this thesis the differentiation has been made between dominant hall premises, balanced hall and office premises and dominant office premises. The calculations are made for these three types of firms who settle on business parks under a common land use plan. The results are shown in ‘Appendix 4’.

3 Methodological approach

To try to fathom the complex mechanisms involved in the system of supply and demand of business-land, the creation of an Agent Based Model is proposed (ABM). Agent-based Modelling (ABM) is a modelling technique for complex systems composed of interacting, autonomous decision makers. It will combine the macro economic developments and the micro economic decisions made by companies. All the factors will have to be quantified to serve as input for the ABM.

3.1 Marco Economic Estimation

First the demand for business land needs to be quantified by a macro economic method to supply the ABM with the total demand for business land. For this, several methods will be reviewed and one will be chosen and tested for reliability and relevance by comparing its performance to past developments.

3.2 Micro Economic Decisions

To quantify the qualitative aspects of this demand, random utility theory is applied. Random utility theory suggests that every alternative is rewarded with an unobservable utility for an entity. In the land market, the chosen piece of land rewards the buyer with a utility. It can be assumed that each buyer tries to maximise his reward with their choices, which is called utility maximisation. The utility is composed of valuation of involved attributes. In reality there is a limit to the amount of variables that can be observed. Therefore there will always be unobserved attributes. Random utility theory distinguishes between explainable and unexplainable components of the utility. Formula (1) is used to describe this theory mathematically.

$$U_{in} = V_{in} + \epsilon_{in} \quad \textbf{(1)}$$

In this formula U_{in} is an unobservable utility that for entity n, associates alternative i. V_{in} is the explainable utility and ϵ_{in} is the unobserved error (Hensher, Rose, and Greene 2005). V_{in} can be composed of multiple (k) variables, which all have a different functional form ($f(x)$) and weighting (β) of these forms. This is mathematically expressed by formula (2):

$$V_i = \beta_{0i} + \beta_{1i} f(x_{1i}) + \beta_{2i} f(x_{2i}) + \cdots + \beta_{ki} f(x_{ki}) \qquad \textbf{(2)}$$

Most models of location decisions of firms are based on the principle of utility-maximizing behaviour from the Random Utility Maximisation (RUM) theory (Mcfadden 1980). Random utility considers, as the name suggests, random utilities. These random utilities will not directly represent the real demand, as the research has to select a finite amount of utilities.

To quantify the appreciation of the attributes form a static dataset, a Bayesian network analysis is proposed. Bayesian networks (BN) are based on the Bayes' theorem, a method of mathematical manipulation of conditional probabilities. Bayes' rule can be described as a result that is derived from the more basic axioms of probability. Mathematically, Bayes' theorem gives the relationship between the probabilities of A and B, $P(A)$ and $P(B)$, and the conditional probabilities of A given B and B given A, respectively $P(A|B)$ and $P(B|A)$. The rule in its most common form (3) is:

$$P(A|B) = \frac{P(B \mid A)\, P(A)}{P(B)} \qquad \textbf{(3)}$$

This statement describes the adjustment of the belief that proposition A is true for proposition A and given the evidence B. Prior to the observation of B, $P(A)$ is the initial degree of belief in A. $P(A|B)$, is the posterior degree of belief in A, having accounted for B.

Because in this research it is not possible to observe the actual relocation of firms and their actual choices, it is only possible to have to base the assumptions on the given evidence. This is why the BN is used. It allows the adjustment of probabilities when evidence is combined. For instance it can be determined that the probability that a company will have paid 200€/m² for their land is one in four. But if evidence is introduced that this company is a chemical production plant, it could be the case that this statement can be refined. If it is known that the frequency of chemical production plants on 200€/m² is less than one in four, Bayes' rule will enable the adjustment of the probability.

In BN's more evidence is introduced so that the probability can be further refined; the amount of evidence can be numerous. For adjusting the belief in A in a network, given the evidence $x_1, x_2, \dots, x_n$, the following formula (4) is used.

$$P(A|x_1, x_2, \dots, x_n) = \frac{P(x_1, x_2, \dots, x_n \mid A)\, P(A)}{\sum_{x_1, x_2, \dots, x_n} P(x_1, x_2, \dots, x_n \mid A)\, P(A)} \qquad \textbf{(4)}$$

If a characteristic has a high frequency for a certain branch compared to other branches, it can be assumed that this branch has a preference for this particular characteristic. This analysis requires a huge set of data because of the different branches that show completely different characteristics. Each of the branches must be analysed and each attribute must be categorised into levels.

After the attributes and levels are identified, the structure of the network, must be determined. This structure is called the directed acyclic graph (DAG), and can be derived by structural learning from the survey data. Structural learning automatically searches for statistical inferences among variables. Though, purely statistical interdependence does not always reflect real causal relationships. The direction of the links cannot be determined by the computer. The solution is a supervised learning strategy that draws on rational thinking (Marcot 2012).

Afterwards the model will be validated for its accuracy. To test probabilistic forecasts there are several methods for measuring its accuracy. Pearl (1978) proposes a Brier test (Brier 1950), which scores the outcomes of the model against a set of realised outcomes, resulting in a hit rate. This hit rate is then used in a quadratic loss function, resulting in the accuracy of the model.

The probabilities found by the best DAG are transformed into the utilities used in the choice model by using the multinomial logit model. This is represented in its simplest form in formula (5).

$$P_{i|A} = \frac{expV_i}{\sum_{i\epsilon j} \exp V_j} \quad \textbf{(5)}$$

By rewriting this formula we can deduce formula (6), which can be seen in 'Appendix 5'.

$$V_i = \ln\left(P_{i|A} * MI\right) \quad \textbf{(6)}$$

This is done by scaling the probabilities for choosing an attribute with a sensitivity analysis. The attributes are tested for explanatory information and entropy reduction. The sensitivity is found through a mutual information (MI) formula (7).

$$MI = \sum_{a\epsilon A} \sum_{i\epsilon j} P(i,a) \ln\left(\frac{P(i,a)}{P(i)\ P(a)}\right) \quad \textbf{(7)}$$

The formula describes the mutual information between the query variable A for $a\ \epsilon\ A$, towards an attribute j. This is equivalent to the expected reduction in entropy of A due to a finding at j. This done by summing the probabilities of mutual occurrence of all states i of j and query a, multiplied by the natural logarithm of Bayes inference. The outcome is a set of utilities for all level of the location attributes.

4 Land Supply Management

As was stated in the introduction, a rule of thumb says: “Twice the amount of land, that has been granted the previous year, is needed in supply”. According to this rule, the municipalities of the Netherlands have an oversupply of land destined for business use. A rule of thumb in this case simply will not suffices and to really understand the size of the oversupply, the supply management of LID and LNID needs to be elaborated. In this chapter the aspects of supply and demand are discussed, tested and processed to try and define constitutes supply and demand for business-land.

“If desire for goods increases while its availability decreases, its price rises. On the other hand, if availability of the good increases and the desire for it decreases, the price comes down.”

- Ibn Taymiyyah (1263–1328 CE)

4.1 Supply and Demand

Since this thesis is specified to land with the function business, supply as well as demand are defined as the amount of land (in hectare) with the function business; named ‘business-land’. The demand is further refined to the amount of business-land needed for the proper functioning of a healthy entrepreneurial environment. The supply is defined as the offered amount of land composed of the ‘iron reserve’, considering LID as well as LNID and the current stock. The demand is dependable on a wide variety of variables, since each entrepreneurial activity demands a different amount of land and has a different efficiency.

The supply of business-land in the Netherlands, concerning working locations, is closely monitored by the ‘IBIS Werklocaties’. These working locations are categorised into three types: harbours, economic zones and business parks. IBIS makes an annual inventory assessment of all of these locations. It keeps track of all 3.505 business parks in the Netherlands, which cover an area of 81.748 hectare. IBIS ascertained that the grants show a descending trend since 2007, specifically business park grants have dropped from 915 hectare in 2007 to only 334 in 2012 (Ministry of Infrastructure and the Environment 2012a).

The existing terrains constitute the first part of the supply the other half of the supply are composed of the land in development and the pipeline supply; land not in development. The LID amounts in total to 4.905 hectares (Dutch: harde plannen). This is only the tip of the iceberg; there is a total of 4.844 hectares in planning pipelines (Dutch: zachte plannen). This is a total of over 14.000 hectares of extra working land, which is almost the size of Amsterdam. In 2012 a total of 334 hectares was granted, while the LID reserve reached an amount of nearly fourteen times as much. The amount of LNID (land in the pipeline) upped this to almost thirty times the annual amount of land granted. These amounts are disproportioned; suggesting we could last at least thirty years with the current rate. The rule of thumb dictates; “The land in supply must be twice the land granted that year”, already suggests the relation between supply and demand from a time perspective. Because of pipeline delays, the amount of land in reserve needs to be higher than the actual demand. But there are much more complex and accurate methods for indicating what the demand will be. These will be discussed after an introduction to indicators for demand.

4.2 Employment as an Indicator for Demand

The future demand of business-land is unmistakeably connected to employment developments (Beckers and Schuur 2012). Employment is an important economic factor and is closely monitored. Quarterly and yearly reports are produced on many scales and regions and careful estimations for employment developments have been made over the past few years. This makes it possible to extrapolate the relations between employment developments and the demand for business-land and project them onto the future as a prognoses.

Probably the most widely used prognoses, for the Netherlands are the WLO scenarios by Huizinga and Smid. In 2004 they created a fourfold of scenarios for the Dutch welfare and living environment (Dutch: welvaart en leefomgeving: WLO). These WLO scenarios are based on two key uncertainties which form the four possibilities. The uncertainties are (1) the willingness for international cooperation and (2) the reform of the collective sector. These scenarios are used to calculate long term predictions of the economy and employment.

The predictions result in a set of growth coefficients for a set of business branches. The branch division is shown in 'Appendices 6 & 7' and the growth coefficient in 'Appendix 8'. With these four scenarios in hand, the employment growth of business-branches is framed within a set of parameters, which allow a prediction to be made of the demand for land (Traa and Declerck 2007). For this translation from employment growth to demand for land, a translational method is needed. These methods are discussed in 4.3.

The demand for land can also be extracted from employment in another way. Van Oort et al. (2007) analysed another aspect of the employment market; the proportion of new businesses and existing businesses. In Figure 4.1 the origin of employment is displayed over time in the Netherlands. On a yearly basis a small share is held by the new companies, followed by a minute share of moved new companies. Though on the long run it can be seen that new companies hold a large share of the employment market on business locations. But the largest share is mainly composed of current employment and relocated current employment. New and relocated employees compose the potential demand for new business land.

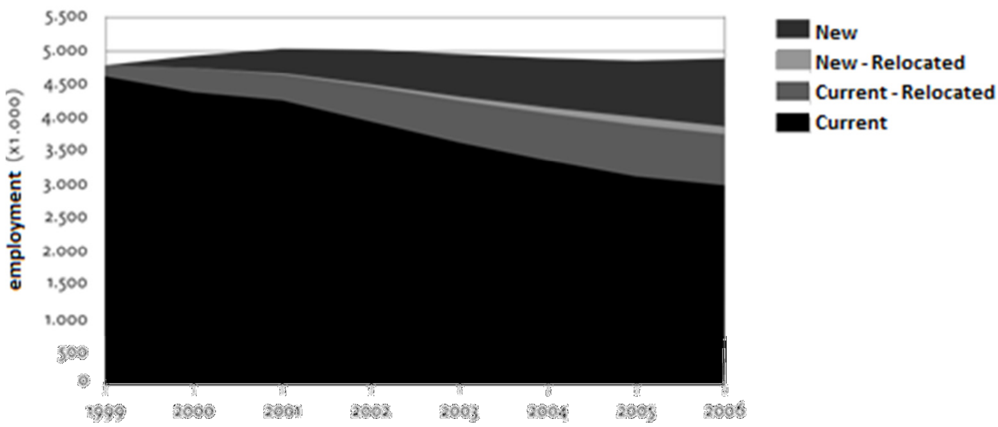

Figure 4.1: Shares of employment by origin (Oort et al. 2007)

4.3 Estimating the Demand

Ploegmakers et al. (2013) did extensive research on the subject on how municipalities estimate their demand for land. In their research it became apparent that there is a large gap between theory and practice. Most municipalities seem to lack the capacity to form a team with understanding of markets and supply chain management and invent their own rules of thumb to provide a method for estimating the demand. Knoben & Traa (2008) created an overview of all the possible estimation methods and reviewed them for applicability. In this section a review is given on the theories currently existing for land reserves.

There are a variety of methods that are used to estimate the demand for business-land. The methods are divided by Knoben & Traa (2008) into two main categories; methods that either use a terrain quotient and those that do not. A terrain quotient is a standardised indicator for the amount of area surface needed per employee. The methods that use a terrain quotient are divided into demographic methods and economic orientated methods. This is an important factor in defining the amount of land compared to changes in employment. The subdivision and the methods can be seen in Table 4.1. A short description of their mechanics is given in 'Appendix 9', as well as the advantages and disadvantages of the methods. The used methods are described in the next few paragraphs.

Table 4.1: Estimation methods (Knoben and Traa 2008)**.**

Category	Subcategory	Method
Terrain quotient methods	Demographic methods	Population method
		Demographic method
		Protrusive method
		Corrected demographic method
	Economic methods	Mixed method
		Industrial method
		Economic method
		Confrontation method
		Granting / Industrial method
		BLM
Meso/Micro -economic methods		Granting method
		Company consultation method
		Demographic company simulations
		Building stock method
		Physical production method
		Timeline analysis

4.3.1 The BLM Model

The Spatial Planning Bureau of the Netherlands (Dutch: Ruimtelijke Planbureau) has created a business-housing location monitor (Dutch: Bedrijfslocatiemonitor; BLM) for the Dutch market. The goal of this model is to help governmental bodies with estimating the demand for working locations (Traa and Declerck 2007). This model is the official method prescribed by the national government; however it is not an obligatory method. The BLM distinguishes itself into three sub models because the demands of these categories behave significantly different. The BLM considers three location types; harbour locations, business locations and offices. For the business locations and the harbour locations it uses the IBIS data to calculate the demand. The demand for business locations is calculated per branch, region location type and year.

In the BLM, the employment per branch is defined by long term scenario estimates made by the government. The employment per location type is derived from historical data. Combined, these two data sets can estimate the future employment per branch and location type. Location type preference is defined as the share of employment, on a location type per region and branch, in the total employment per region and branch. The terrain quotient is defined as the amount of square meters parcel area per net area per employed person for each combination of region, branch and location type. A simplified scheme for the formula is given in Figure 4.2. By applying it to a fixed region (for this thesis: South-east Brabant) and only one location type (business parks) it can be drawn as follows.

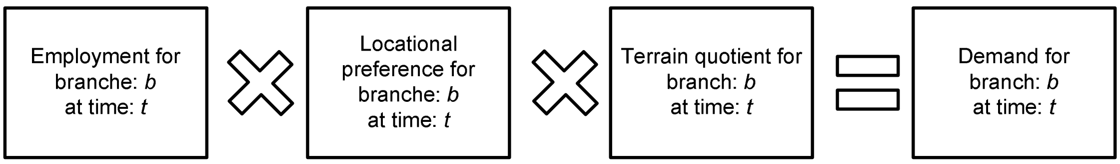

Figure 4.2: BLM for business parks in the south-east of Brabant

A more detailed description of the actual formulas of the model is given in 'Appendix 10'.

The BLM is by far the most sophisticated method for estimating the demand for industrial land due to its incorporation of almost all involved macro-economic trends (Knoben and Traa 2008; Beckers, Schuur, and Traa 2012). The BLM is subject to criticism nonetheless. According to a report of van Dinteren et al. (2007), it does not pay any attention to meso-economic trends in sectors. Also because of its long term period, it is hard to anticipate the effect of economic cycles. Knoben & Traa argue that the BLM is designed to estimate the trend, not the deviation-cycle. It also needs refinement for use on lower scale levels and needs additional tools to have a more qualitative approach to the locations (Van Dinteren, Posthuma, and Bruin 2007). By combining the BLM with agent-based modelling it is possible to introduce this business cycle effect, locational preferences and policy restrictions. The BLM is chosen as the quantitative estimation method for this thesis, because it is found to be the most effective and is the most applied by professional governmental agencies (not municipalities). Some adaptions must be made to apply it on a smaller scale and it must therefore be validated. In '6.2 Validation and Adaptation of the Input' the BLM is adapted to a smaller scale.

4.3.2 Timeline Analysis

A 'timeline analysis' is a method which uses recent development to look a little into the future by extrapolating the relevant relations. It does not use terrain quotients, locational preferences or business branches, which simplifies the approach. It only considers the land that is going to be granted in the upcoming years. By doing a multiple regression analysis over a large dataset, it determines the most influential factors and determines the coefficients for these. The suspected coefficients are:

β_1= Land granted in $t = -1$
β_2= Land granted in $t = -2$
β_3= National employment growth $t = 0$
β_4= National employment growth $t = -1$
β_5= Business cycle indicator $t = -1$
β_6= Business cycle $t = -2$

Resulting in the regression formula (8), with $LG_{t,i}$ being the amount of land granted in year t for region i, it is the dependent variable and β_n are the independent variables.

$$LG_{t,i} = C_0 + C_1 * \beta_1 + C_2 * \beta_2 + \cdots + C_6 + \beta_6 \qquad \textbf{(8)}$$

Knoben and Traa (2008) conducted an experiment with this method and concluded the following: it is possible to make limited business land predictions with timeline analysis. The limit of reliability is five years and the method is applicable on provincial level. It loses reliability on smaller scale levels, which is due to two causes: (1) employment growth is more accurate at the provincial level and (2) politics are more involved on smaller scales. Political plans can be incorporated with a dummy in the timeline method and it will become more reliable on smaller scales. This incorporation of a political dummy in a regression shows there is more of influence than just the macro-economic developments. For example local politics will sometimes exclude branches from settling in the land-use plan.

A timeline analysis will be used to validate the use of the BLM on a smaller scale and to explain the assumptions and deviations.

4.4 Location Theory as an Indicator for Demand

As mentioned before, the theories of supply in the land market should take in account the distinctiveness of land as a commodity (Adams et al. 2001). Land is not an interchangeable bulk product and thus other aspects need to be taken into account for the supply and demand of the market. Land is unique because of its location and allocation which makes the location theory is an indispensable aspect of the estimation of demand.

In the considerations concerning the location or relocation of a company, one of the factors is generally standing out as the most important; location factors. Many researches reviewed the locational preferences for firm relocation (Krabben and Buitelaar 2011; van Dinteren, Posthuma, and Bruin 2007; Oort et al. 2007; Pellenbarg, Wissen, and Dijk 2002; Dijk and Pellenbarg 2000; Pen 1999; Louw 1996). Van Oort concluded that the variables were not changing, but over time their position strengthened or weakened. All papers mention the research of Louw (1996), which determined which factors were of influence in the decision and weighted them for three different stages of the relocation process. The most important factor are shown in

Table 4.2. This thesis will focus on the most significant factors in the process; ‘location factors’ and ‘financial factors’.

Table 4.2: Consideration factors in relocation (Louw 1996)

Phase:	Orientation	Selection	Negotiation	Total
Building factors	15,30%	12,30%	7,10%	**11,90%**
Functional factors	15,30%	18,40%	7,10%	**16,10%**
Technical factors	3,10%	4,20%	2%	**3,40%**
Financial factors	12,20%	14,20%	52,50%	**22,50%**
Location factors	43,90%	36%	12,10%	**32,30%**
Other factors	6,10%	14,60%	19,20%	**13,80%**
Total:	**100%**	**100%**	**100%**	**100%**

Since the sixties many studies have been executed about the amount, direction and underlying motives of firm migration in the Netherlands. Already in 1970, it was found that 60 percent of the establishments migrated, because there was no space for them to expand their area (Pen 1999). Another theory focusses on the locational qualities business locations have to offer. The location theory focusses on the so called pull factors which attract businesses to certain locations. Later, the relocation theory was introduced and push factors were included into the research to identify what made businesses leave their old location (Pellenbarg, Wissen, and Dijk 2002). The researches of the eighties and nineties still form the foundation of the current relocation theory.

Table 4.3: Push & pull factors in relocation by occurrence (Van Steen 1998)

Push	%	Pull	%
No possibility of expansion	77,0%	Possibility of expansion	61,0%
Premise not representative	31,6%	Representative premise	50,4%
Parking possibilities	29,4%	Parking possibilities	46,7%
Transport of goods	25,7%	Accessibility by car	45,0%
Accessibility by car	17,5%	Transportation of goods	36,0%
Location of consumers and clients	10,4%	Too large premise	29,3%
Location of suppliers	4,8%	Location of consumers and clients	19,2%
Quality of living environment	4,3%	Accessibility by public transport	16,0%
Expropriation, fire, selling, of premise	3,6%	Location of suppliers	9,2%
Fusion/reorganisation	3,4%	Quality living environment	7,3%

These push & pull factors for the Dutch business locations were summarized by Pen (1999). His paper gives an overview of all research previously done with different approaches towards these push & pull factors. An example of a set made by van Steen (1998) is displayed in Table 4.3. Pen also mentions the research of the Ministry of Economic affair distinguished the pull factors per business sector, which implies that there is a difference per sector. Combining all of these researches, an overview will be created of the most influential factors for choosing a location as well as leaving another.

Not all the relevant reasons for relocation van Steen (1998) mentions, are qualified to be used for a quantitative analysis. For example; expropriation, fire, selling of premise and fusion/reorganisation are almost impossible to simulate. Also some other factors are composed of a number of indicators. In the next paragraph the most relevant factors of a location will be unravelled to its most basic indicators.

The financial aspects are highlighted in a publication of van Dijk & Pellenbarg (2000). They describe the decision making process of individual firms on the micro level with a profit maximisation formula. As described before in 2.4.2: each firm constantly makes a present value calculation of the investment costs of moving set against the benefits of the new location.

Another aspect which was long overlooked by municipal decision making was the relocation distance. Municipalities tried to draw as much companies to them as possible, not realising that new companies were coming from relatively close locations. Van Oort et al. (2007) compare the movements of companies and the distances over which these movements occur. He concludes out of a data analysis that most companies move within the municipality’s border (75 percent) and almost all companies stay within COROP region borders (94 percent). This finding instigated the debate if supplying ground will actually improve the employment in a municipality.

4.4.1 Attribute Identification

The desirability of a land plot is almost proportional with the price of the plot per square meter (Ploegmakers and De Vor 2013; Beckers, Schuur, and Traa 2012; Ploegmakers, van der Krabben, and Buitelaar 2013). Ploegmakers and De Vor (2013) analysed the land prices with a hedonistic regression and identified that (1) the nature of the business park (‘High-end’ or ‘Mixed-use’) (2) the visibility of the location and (3) the distance to the city centre, were of mayor influence. Another influence of the land price is not the location but the land use plan. The restrictions a land use plan entails, result in a limitation in possibilities, which drops the value of the land. Limitations that will be considered by companies are: building restrictions, environmental restrictions and branch restrictions.

Possibilities of the land use plan

The possibility of expansion is mostly determined by the restrictions of the land use plans (Dijk and Pellenbarg 2000; Pellenbarg, Wissen, and Dijk 2002). These will determine the flexibility of the current location. Sometimes a neighbouring plot, which is for sale, is bought for expansion however this is accidental. Mostly companies buy a plot with expansion in mind, thinking some years ahead with their current growth. The land use plan limits companies by dictating a minimal and maximal use of the surface in percentages. The difference in-between these is the flexibility the companies can use to build first and then expand later without acquiring new land. So the minimal and the maximal area required to be built upon are influential factors for the selection of a suitable plot. Another land use plan restriction of influence is the environmental category (Pellenbarg, Wissen, and Dijk 2002; Olden 2010). This limits the environmental impact by the activities on the location and thereby restricts its use. It is obvious that some more heavy industries will need to be allowed a certain degree of environmental impact and are themselves excluding locations which inhibit them. The other way around, there are possibilities in a land use plan which can refuse certain companies by their core business. In that case certain SBI08 (Standaard Bedrijfsindeling 2008) codes are not allowed on the terrain (or parts of it). This exclusion of SBI codes is taken into account in the proposed model but is not a specific attribute in the analysis.

Representation

The ambitions of the park are of influence as well; while some business parks get the stamp high-end-use, others get the stamp mixed-use (Oort et al. 2007; Pellenbarg, Wissen, and Dijk 2002). This is important for the land price as well as for the representation of the location. This influences the desirability for some companies. While somewhat more heavy industries would not care about a representative location, there are enough service companies that do.

Therefore this stamp is given weight in the selection procedure. Also as Ploegmakers and de Vor (2013) conclude, the view locations attract companies and increase the land value.

Transportation

Transportation is one of the most influential factors of plot selection (De Vor 2011; Manzato 2012; Olden 2010; Oort et al. 2007; Pellenbarg, Wissen, and Dijk 2002; Pen 1999). It returns in several forms several times on all location motivation lists. Whether it is called transportation or accessibility, it is based upon the ease of transportation of goods and persons to and from the location. This can be divided into several sub influences. Transportation can be achieved by car, bus, truck and plane. Each of these has a transport medium which is accessible with a rate of ease. Accessibility is determined by the amount of parking places and the amount of possibilities to reach the location. These two factors are monitored for each business location by IBIS. Access by public transport can be measured by the access by bus and train (Pen 1999). The same counts for the access to international plane traffic (Pellenbarg, Wissen, and Dijk 2002; Manzato 2012), by measuring the distance towards the nearest airport. Accessibility by truck is influenced by the distance to the nearest highway entrance/exit (Pellenbarg, Wissen, and Dijk 2002; de Vor 2011). This is also of influence on the accessibility by car and is available in the IBIS-inventory.

Suppliers & Clients

Some companies tend to move closer towards their suppliers or clients to reduce transportation costs or consumer barriers. These differ somewhat between companies and therefore is chosen to measure two possible relations; (1) the distance to the nearest living environment and (2) the clustering of the same branch (De Vor 2011; Pellenbarg, Wissen, and Dijk 2002; Pen 1999). The first can be explained by for example the wholesale industry. It is highly likely that they will try to increase their consumers by settling close to living areas or the city centre. The second measure is chosen to view thematic clusters. This will identify certain branches that will want to move close to other branch congeners. This identified vertical integration of branches on one terrain.

Land price

Lastly there is the land price, which influences companies in their decision. As Ploegmakers (2013) and Luijten (2013) stated in their interviews, municipalities wrongly assume this is the determining factor for location choice. Land price is only a part of their choice. The land price is partially determined by the type of companies that can build on it. A company that wants to build a huge storage hall will expect a different land value than a company that wants to build a small stacked office. This is determined by the amount of lettable floor area (LFA) and the price of one m² LFA. A small office has a high revenue per m² and can be stacked, while a business hall has a lower revenue per m² and is often not stacked. Residual calculations will differ per building type and this is incorporated into the financial considerations. However municipalities tend to set a fixed price for an entire terrain, which can limit the attraction for some companies. Therefore the land price is incorporated in the preferences.

The sum of all these preferences determines the appreciation of a location for a company. The total list of factors and variables is shown in Table 4.4.

Table 4.4: Attributes for relocation

Category	Attribute	
Possibilities of the land use plan	**1**	Minimally built percentage
	2	Maximally built percentage
	3	Environmental category
Representation	**4**	View location (Dutch: zichtlocatie)
	5	Terrain stamp (High-end- or Mixed-use)
	6	Park management
Transportation	**7**	Parking possibilities
	8	Highway accessibility
	9	Distance to city centre
	10	Accessibility public transport
	11	Distance to airport
Suppliers & Clients	**12**	Distance to living area
	12	Clustering of companies
Land price	**14**	Land price

4.4.2 Attribute Discretisation and Coding

For use in Bayesian networks, the attributes need to be discretised. The equal frequency method is used to determine the intervals for discretising the continuous or discrete variables. For some, the equal frequency method was not applicable. The distance to the city centre will result in a radius of ten kilometres, to include at least half of the companies, but a range of ten kilometres has rationally no explanatory value therefore it was chosen to create three levels; (1) covering the area within the beltway of a city and (2) an area of three kilometres outside of the beltway (3) and the rest. The same rationality was used for accessibility to public transport and distance to the airport. Public transport was assessed with the average distance to a bus stop and train station. Train stations were not of influence since, none of the terrains were closer than 1,5 kilometres from a train station. Lastly the entropy reduction method was used for the attribute levels in clustering, because an equal frequency would create a false explanatory value since companies would be found to have no explanatory value for clustering. To find an explanatory value for clusters of companies on a terrain, it was found that two times the average percentage would be the best. In Table 4.5 the attribute levels and discretisation methods can be seen.

Table 4.5: Attributes and levels

	Variable	Type	State & Ranges	Discretisation Methodology
1	Minimally built percentage	Continuous	0-50%; 51-65%; 66-100%	Equal frequency
2	Maximally built percentage	Continuous	0-80%; 81-90% 91-100%	Equal frequency
3	Environmental category	Discrete	1-3; 4-6	Equal frequency
4	View location (Dutch: zichtlocatie)	Discrete	Yes; No	*
5	Terrain stamp	Discrete	Mixed-use; High-end-use	**
6	Park management	Discrete	Yes; No	*
7	Parking possibilities	Discrete	Sufficient; Insufficient	**
8	Highway accessibility	Continuous	0-500m; 500m-1km; 1km-2,5km; > 2,5km	Equal frequency
9	Distance to city centre	Continuous	0-2km; 2-5km; >5km	Logical
10	Accessibility public transport	Continuous	0-200m; >200m	Logical
11	Distance to airport	Continuous	0-2km; >2km	Logical
12	Distance to living area	Continuous	0-200m; >200m	Equal frequency
13	Clustering of companies	Continuous	Above 2x average; Below	Entropy reduction
14	Land price	Continuous	0-140€; 141-170€; >170€	Equal frequency

* = Boolean
** = Supplied by IBIS

In ‘Appendix 11’ the codings can be found for all attribute levels to use in the analysis and in ‘Appendices 12 & 13’ the frequencies of all attributes can be seen.

5 The Model

In this chapter an attempt is made to create a decision support tool in the form of a model. The workings of the model are abstractly described in this chapter. Before the model is presented, it should be noted that the model will try to describe the reality in a simplified mathematical and statistical way and in no way it is a representation of the reality. To avoid misinterpretation of model outcomes, it is chosen to present the outcomes in a distributed way, so it will always be visible that the model is based upon mathematics and statistics. It should also be noted that companies are programmed to behave in a rational way and based on statistical preferences. Therefore it is assumed companies have perfect information and will base their decisions on the observed utility maximisation. The exogenous variables that designate preferences to irrational behaviour are deemed non-existent.

"One of the most insidious and nefarious properties of scientific models is their tendency to take over, and sometimes supplant, reality."

— Erwin Chargaff

5.1 Agent-based Modelling

Agent-based Modelling and Simulation (ABMS) is a modelling technique for complex systems composed of interacting, autonomous decision makers. The decision makers are called 'agents'. Agents act based upon the rules of interaction and relationships with their environment and/or other agents. ABMS allows the crossing of the macro and micro levels. In these simulations an understanding can be formed of the influence of high-level structures on low-level agent interactions and vice versa. This method is ultimately well fitted for the bridge between macro-economic developments, as employment growth, and micro economic decision making, like the relocation of a company. A more extensive description of agent based modelling is given in 'Appendix 14'.

5.2 Model Description

Because NetLogo is written in a computer programming language, it will be incomprehensive to use the algorithms in this thesis, therefore the model is described in an abstract way. The model explores business land-usage patterns from an economic perspective, using the socioeconomic development of the past to predict future developments. It models the growth of businesses. As businesses grow, they become less and less content with the location and eventually will have to take a course of action. This action can either be investing in their current location or move to another location. These businesses are divided into several branches according to their own behaviour. The model ultimately shows the moving streams of businesses that can be expected within the simulated world, Eindhoven in this case. This policy intervention can be simulated with manipulation of the environment. Land use plans can be changed and terrains can be set on hold.

Each business is member of a branch and has an amount of space it needs to execute their business. This space is supplied by a premise, which offers approximately that amount of space. These premises are located on business parks and have a certain age and space. The terrains own certain qualities for which companies have preferences. Each branch has different locational preferences and growth factors. These location preferences quantify their appreciation of their current location. The companies will grow less content with their current location because of ageing, space discrepancy and better locations that become available. Eventually it will become more attractive to relocate or invest in their current premise. Evidently this must be possible within the land use plan. If this is not possible, the company will have to relocate and refurbish or build a premise, suited for their current spatial needs and some future growth.

5.3 The Workings of the Model

Before the description of the model is given, first a set off assumptions on which the model is based is stated. Next to the previously found considerations, these are the assumptions made:

- Businesses act only based upon the spatial discrepancy and the best other option.
- Businesses choose the best option only based upon financial and locational preferences.
- New companies come in at a constant rate determined by van Oort et al. (2007).
- Vacancy is evenly spread (due to lack of detailed data) according to DTZ data.

- All other unknown variables are normally distributed within found parameters.

The model is made in NetLogo. An abstract flowchart of the algorithm is given in Figure 5.1, followed by a short description of the overall workings of the model. For a more elaborate description see ‘Appendix 15’.

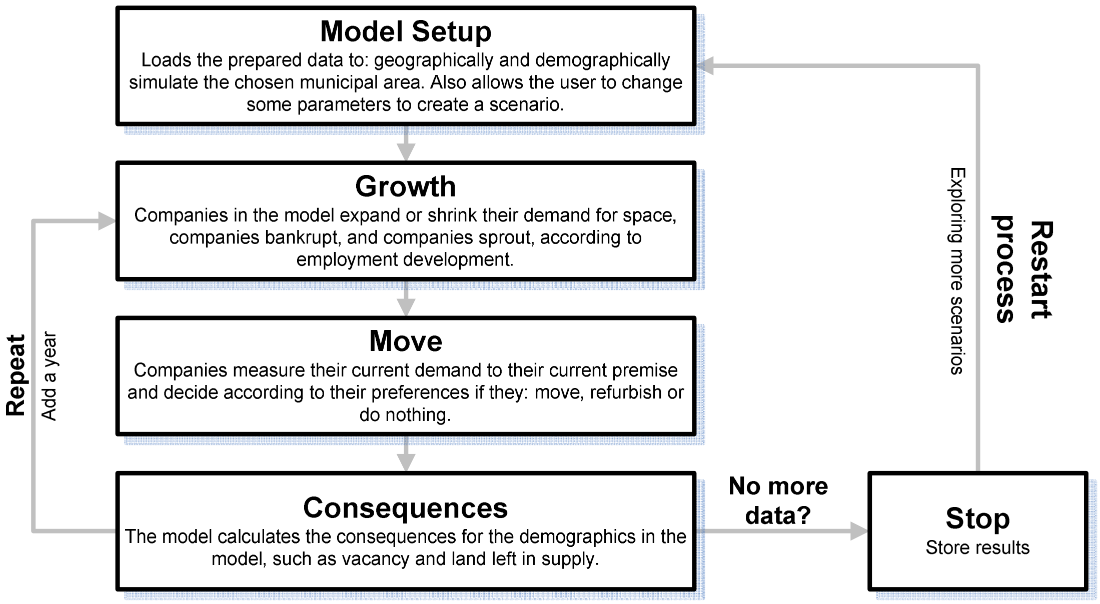

Figure 5.1: Model structure

The Setup

In the setup phase the ‘world’ is created. This world is the simulated area, with the included characteristics. These are loaded from prepared GIS-shapefiles. These files contain (1) the geographical shapes of the terrains and their characteristics and (2) the companies with their branch, location and size. The uncertainties of how the companies are fitted to their locations is absorbed by a normal distribution and vacancy is evenly spread due to lack of detailed data for this. Now the model is set up for a single simulation. After each simulation the normal distributions are re-distributed in the setup phase and the model is ran again; ceteris paribus.

Growth

As the model is initiated, the simulation will begin each step with a growth command. In this command the companies add or subtract an amount of demand based upon the findings of the quantitative demand analysis. This factor differentiates for each branch. This growth (or shrinkage) will enhance (or reduce) the discrepancy between the demand for space and the space of the premise for each business. This will lead to some sort of dissatisfaction, which is used as input for the 'move' algorithm of the model. As described above, the companies within a branch, will all grow at the same rate. This is obviously never the case and this will result in a too homogenate landscape. Therefore a randomiser is added upon the growth, which lets the companies grow with a normally distributed growth factor with the mean being the branches growth prediction.

Another factor is that not all the companies that will settle come from a location on the created world map. Some companies have not yet settled themselves in a business park before and some are native to a municipality outside of the model borders. To compensate this, calculations are made for every bit of growth occurring within a municipality and three percent of it will be from newly acquired companies as found by van Oort et al. (2007). These are spawned in the growth command, adapting a random size acceptable within the branch's boundaries.

Move

As a result of the growth command, the model has a set of companies which have certain dissatisfaction with the space of their premise and a set of companies with no premise yet. The already settled companies have two causes for their dissatisfaction; their current premise is not spatially satisfying or their current premise is not qualitatively satisfying. Based on these factors combined with financial considerations, the companies will have to decide to take a course of action. The process of this command is visualised in Figure 5.2. The company weighs the costs, spatial discrepancy and the quality to make a decision on their course of action. Therefore four pay-offs have to be generated and are compared. However therefore the quality must be quantified for three locations. These locations are specified in the model as sub-terrains, which are postal code areas (PPC6). The locations are (1) the best available undeveloped patch, (2) the best suited developed patch with a suitable housing location and (3) the rating of the current location.

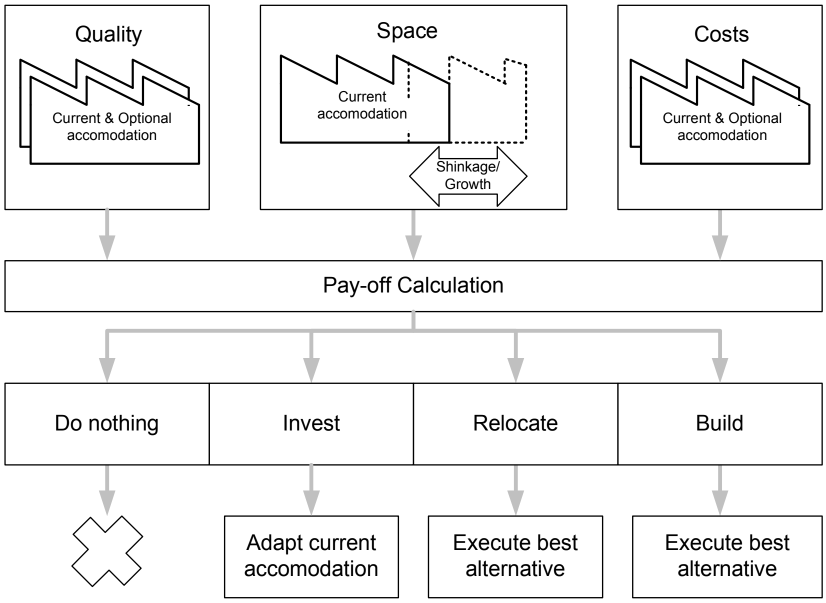

Figure 5.2: Course of action model for settled companies

The payoffs are generated based on satisfaction and are calculated with an algorithm. The company looks up its branch and then searches for the branch's weighting list. This list is compiled of the weights given to the location attribute levels. Then the company asks all sub-terrains to report their variables and the company multiplies them with their respective weights. This results in a list of scores for all sub-terrains and then the highest one is selected as the best option. To prevent that the best sub-terrain excludes a certain branch, all scores of for these branches are disqualified for this list. A schematisation of the scoring algorithm can be seen in Figure 5.3.

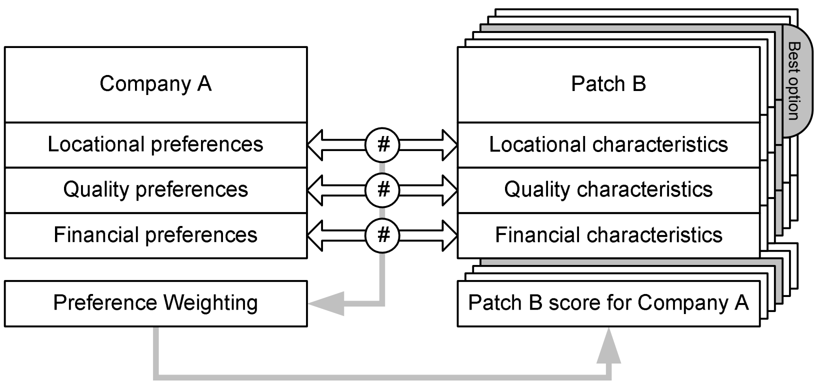

Figure 5.3: Plot scoring algorithm scheme

The scoring of these plots results into three sub terrains needed in the payoff calculation. With these sub-terrains' scoring and the financial consideration of this branch four pay-offs are generated as displayed in Table 5.1.

Table 5.1: Pay-off composition overview

	PO_x	PO_i	PO_m	PO_b
Spatial Need	$PO_x = -(\Delta R * \alpha)$	$-$	$-$	
Financial Aspects	$-$	$PO_{if} = \Delta R * -F_i * \beta$	$PO_{mf} = R * -F_m * \beta$	$PO_{bf} = R * -F_b * \beta$
Spatial Quality	$-$	$-$	$PO_{mq} = \Delta Q * \gamma$	$PO_{bq} = \Delta Q * \gamma$

The first of the payoffs is the payoff for doing nothing (PO_x). If a company does nothing it will have to take up the dissatisfaction for another year and await next year's results of growth. Therefore the payoff is equal to their dissatisfaction with the location. This dissatisfaction is caused by ageing of the buildings and the spatial discrepancy (ΔR). These are multiplied with the weight of dissatisfaction (α) to calculate the payoff. The costs of doing nothing are zero.

The second payoff (PO_i), is the one for investing in its current premise. The payoff for this is the satisfaction they will have on their current location after expansion. However expansion is not always an option. Therefore a simple test must be done first. Is the size of the current premise, plus the needed extra space possible on the current lot according to the land use plan? In other words: is there enough space left for the company to expand? If this expression is true, the company will calculate the costs of investing in its current location. These costs are equal to the building costs per square meter (F_i) and differentiate among business branches.

The third payoff (PO_m) that is generated, is based upon the hypothesis that the company will be able to move to their best suited, already existing premise, which is available. The satisfaction created by the quality of the location, combined with a quality weight (γ) will represent the positive part of the payoff. Before moving towards this building, it will need a refurbishment. The costs for refurbishing (F_m) are just as the building costs different per branch. Multiplying them with the spatial demand (R) and then the cost weight (β) negatively influences the payoff.

Lastly the fourth payoff (PO_b) is calculated, this is based upon the company moving towards their best suited greenfield and building a perfectly fitted building. This will require the acquisition of the new land, building the new premise and relocating all aperture. The total costs will be the building costs and the moving costs (F_b). The costs of the land are reduced to an expectation. A certain branch will expect a certain land price. The actual cost of the chosen location are subtracted by these and form a positive or negative discrepancy these cost are incorporated in the calculations of 2.4; see 'Appendix 4'.

After the course action has been selected, the company executes the corresponding hypothetical move, resulting in land grants and changes in vacancy. The coefficients α, β and γ, will be the adjustment parameters for the model. Because they are interdependent and solving the model with three unknown variables is almost impossible, the coefficient γ is chosen a stationary value, leaving two adjustment parameters.

Alternatively, companies which are new to the system face a similar choice. After generation of all payoffs and costs, they will be compared to each other and the highest of them will be executed. The process uses the same payoff algorithm as the settled companies, with the exception of the do nothing option, which is replaced by the leave option that is only chosen if all the other options are excluded.

Consequences

In this phase the model is prepared for the next cycle. Buildings age and companies that have shrunken to an unsustainable small size are declared bankrupt. This threshold is the minimum area a single employee uses. Bankruptcy leads to 'death' of the agent. Each of these micro-economic actions has consequences for the macro-economic dynamics. For this, the macro-economic averages need to be updated. Afterwards the view is update to let the user see the progress of the model. and then the model restarts the procedure and enters the next year.

Distributions

In the model description some unknown variables or uncertainties are given. To deal with these uncertainties they are normally distributed around a known mean and when available in literature a known standard deviation. These distributions give the differentiation to the outcomes and call for a Monte Carlo approach to the simulation. When the model is in Monte Carlo mode, the simulation will keep running an indefinite amount of time and will reset the world every given amount of years and store the results. The averages of the simulations will be categorised and counted to form a normal distribution of the possible results of the land developments in the future. A list of the distributions is given in Table 5.2 from which the model repeatedly samples random.

Table 5.2: Input uncertainties in the model and their parameters

Uncertainty	Mean	Standard Deviation	Source
Fitting of the current accommodation	0%	18 - 22%	(Oort et al. 2007)
Growth per individual company	SBI specific trend	8,9%	Timeline analysis
Newcomers	3%	1%	(Oort et al. 2007)

6 Case study: Metropolitan Agglomeration Eindhoven

A model of only one municipality will not suffice to simulate the complexities of land development. Therefore is decided that more than one municipality should be characteristically defined. This will enable regional covenants to align their policies and view the consequences. A good match for this scale and activities to test the model and make it feasible within the given time frame, are conurbations. These are large metropolitan areas in morphological sense. These are contiguous urban areas with buildings in which most human activities take place, most jobs are present and most public facilities are located (Vliegen 2005).

Out of the 22 metropolitan Dutch agglomerations, Eindhoven was chosen as case study area, since all necessary data was available at the time of the research and the municipality has recently commissioned a research on the topic of its ‘iron reserves’. The Eindhoven metropolitan agglomeration has over 330.000 residents and supplies them with 190.000 jobs. It has 53 business parks, which supply businesses with over 1.300 hectares of business-land. It has a total 180 hectares of land for sale and 4 more large projects in the pipeline. Land grants in this area have dropped from 35 hectares in 1997 to 6 hectares in 2013. It is a dynamic market for a case study.

6.1 Required Data

For the creation, validation and use of the model, a lot of data must be gathered and prepared. This data is available from local governments, such as municipalities and provinces as well as some real estate companies. The required data is not found purely in the prepared form usable for Agent Based Modelling and must be prepared through a series of preparations. The incipient models, the BLM and the Bayesian Network will combine rough data and extract the data needed for the ABM. In Figure 9.6 the flowchart of the data preparation is given and the processes are described below.

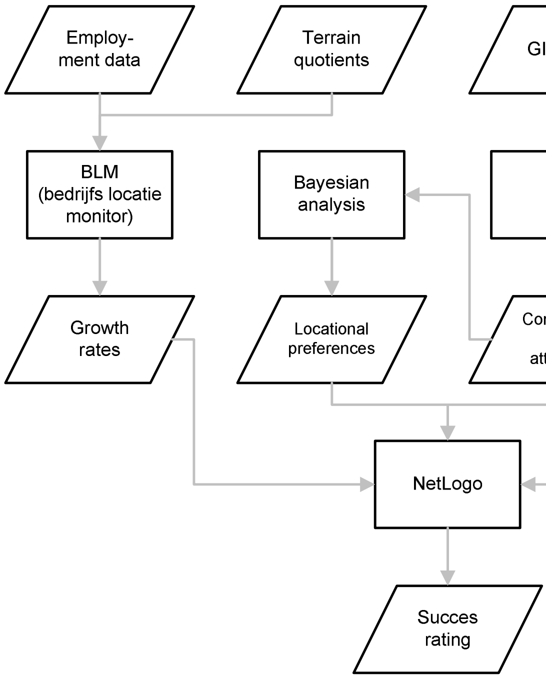

Figure 6.1: Flow chart of the data flows

An overview of all data needed for the model is shown in 'Appendices 16 & 17', with the conditions of the data, where to find it and how it is prepared.

6.2 Validation and Adaptation of the Input

Because a model for long term predictions cannot be validated on accuracy immediately, it is common to try to reconstruct the past as a validation method. This chapter will try to validate the input from the incipient models as well as the final ABM. An overview of the validation process is given in Figure 6.2.

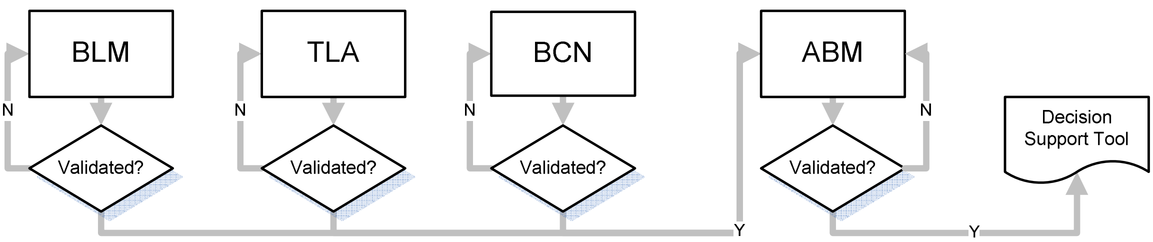

Figure 6.2: Validation process for BLM, Time Line Analysis (TLA), Bayes Classifier Network (BCN) and the ABM

6.2.1 BLM Validation

To validate the BLM's core, it needs to be tested against the realisation of demand for land. The demand for land is an abstract concept, there is no data describing the actual need for business land, so it has to be deduced from other data. The method devised for this subtracts the vacancy rate from the current surface absorbed by the market to find the need for business land. Then these results are compared with the BLM results. The results can be seen in Figure 6.3.

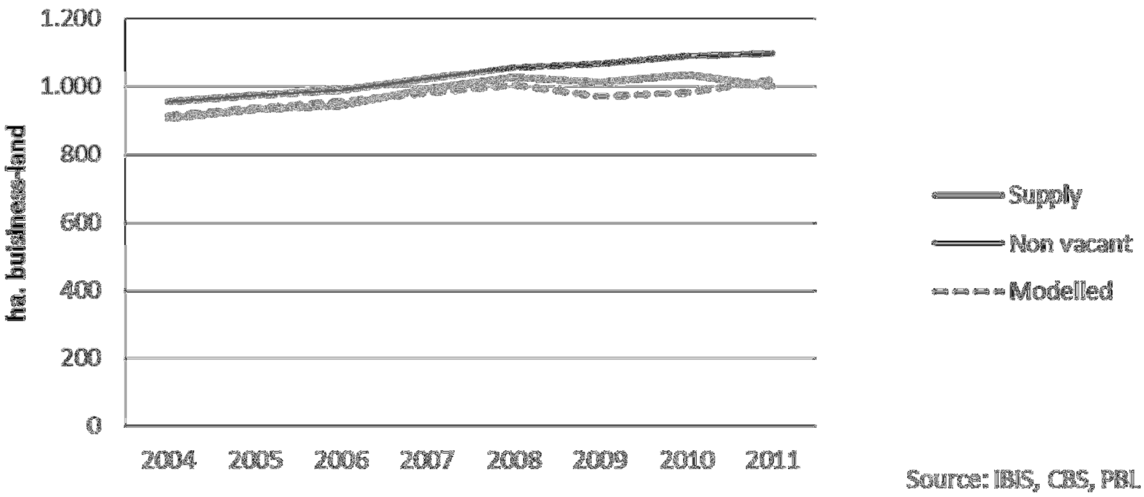

Figure 6.3: The actual demand for business-land compared to simulated results with the BLM

It can be seen that the non-vacant line follows the modelled line quite closely, though there are some distinct course differences. When the modelled demand line overshoots the non-vacant line, it takes the non-vacant line some time to react. This can be explained by the fact that as soon as the employment changes, it takes some time for the vacancy to react. This could be the effect of contracts and management delays. Nonetheless the core of the BLM method is able to closely follow the line of non-vacant land and deviations are intuitively explainable, but these will need more explanation. This is done with a regression analysis in '6.2.3 Timeline Validation'. For now it is assumed that employment combined with the BLM is a good indicator for estimating demand.

6.2.2 WLO Validation

For estimations of business land with the BLM, accurate employment predictions are necessary. Therefore the WLO prediction framework needs to be tested on accuracy as well. Centraal Planbureau (2012) reported on the actuality of the scenarios and concluded no adaptations are needed. However the WLO predictions were made nationally and can be translated to provincial level. The use of it at conurbation level is uncertain. Therefore the scenarios were tested on accuracy on past developments. The test can be seen in 'Appendix 18'. Agglomerated, the results look accurate, however on branch-level the results are highly inaccurate. Local developments are deviating heavily from the scenario predictions. It was therefore decided that the WLO scenarios were dismissed as input for the BLM predictions; at least at this scale level. In 'Appendix 19' is explained how new growth parameter were extracted from the large employment database of Eindhoven.

Now that the WLO has been declare unusable, but new trends have been identified for the coming few years, it is possible to estimate an annually granting rate. But in reality the growth of the macro economy is heavily subjected to business cycles. This is especially evident in the land grants which have a strong correlation with the business cycle indicator (see 'Appendix 20'). These tidal waves in the business cycle are hard, if not impossible, to predict. The national bank tries to anticipate these waves with a lead business cycle indicator. To anticipate this, a second method is used so that a short term forecast can be made with a high accuracy. The 'timeline analysis' is made on inter-municipal level.

6.2.3 Timeline Validation

A timeline analysis is based on a regression analysis of possible indicating variables with correlations with the amount of land granted. These variables may show some lag and thus lag variables could have a stronger or more probable influence than the real variables. With this in mind the variables (β_n) are eliminated on the basis of improbable relations. For this analysis a regression is done with $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$, as described previously in 4.3.2. After looking at the outcomes of the regression, some factors must be eliminated due to unaccountable relations and high P-values. Variables β_1, β_2 and β_5 can be eliminated for having such unreliable relations. The land grants of the last few years (β_1) are not reliable according to this test. This implies one or two things; (1) the current method is depending on unreliable input and or (2) is not applicable on this scale level. Nonetheless these variables are not representable. The business cycle indicator $t = -1$ (β_2) has a negative relation in the regression, which is unexplainable; it namely forces a cyclical effect within the system itself. The indicator of two years of lag (β_3) has a very low P-value which indicates a low chance of a random relation. This could be explained as followed: when companies will increase the production as a result of a good economy, it will take them some time to hire new people and expand until they will need a new location. This coincides with the results found by the deviation with the BLM test with the vacancy rates as well as the publication of Oort et al. (2007). All of this indicates a two year delay from business growth to moving or expansion.

With the remaining $\beta_3, \beta_4, \beta_6$ a new regression is done resulting in a 85 percent correlation with reality. The results are visible in 'Appendices 21 & 22'. A forecast can now be made using the formula (10):

$$LG_{t,i} = C_0 + C_3 * \beta_3 + C_4 * \beta_4 + C_6 + \beta_6 \qquad \textbf{(10)}$$

In which:

$\beta_3 =$ National employment growth $t = 0$

$\beta_4 =$ National employment growth $t = -1$

$\beta_6 =$ Business cycle $t = -2$

The predictions with the timeline analysis the same problem as the BLM, they depend on predictions to estimate. The reliability in the first estimation (2013) is very high since only the national employment growth is the unknown factor and the forecasts can be done accurately with minimal influence on the outcome. However in the second year (2014), two out of three factors consist out of forecasts and the accuracy will drop drastically. As for the third year (2015) the estimations is based solely on forecast. The results are shown in Figure 6.4.

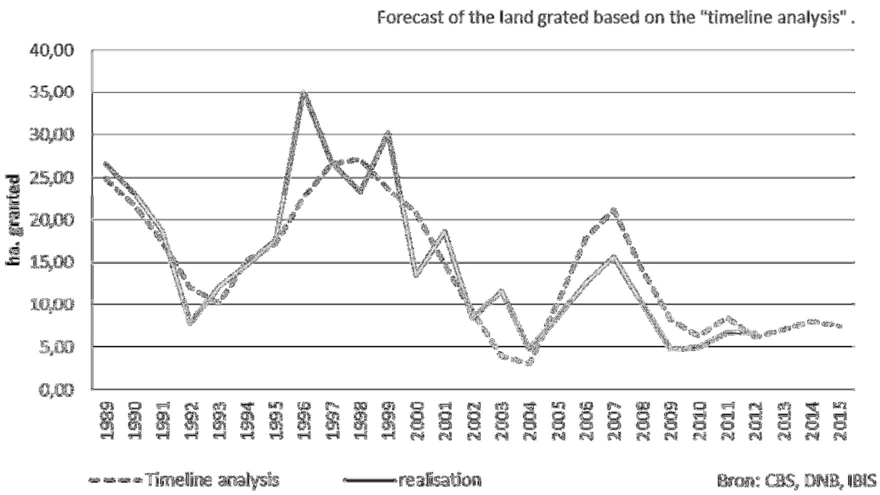

Figure 6.4: Time line analysis compared with realisation for Eindhoven (GA)

The result is a line with a correlation of 85 percent, which has a prediction value R^2 of 0,73. These predictions show an estimate for the upcoming few years. The land granted will lie around 7-8 hectares a year till 2015. The extremely high coefficient of the employment growth coincides with the assumption of employment as an indicator for land granting. The regression value of the business cycle from two years lag is a good indicator for how much the demand for land deviates from the trend. By using a coefficient sensitivity (CS_j) analysis (11), it can be determined that the standard deviation of the land grants, by chance of business cycle impact, is 8,9 percent in spatial growth. This is solely caused by the national business cycle indicator. This will be used as a deviation parameter in the model.

$$CS_j = \frac{C_j * \mu\beta_j}{\sum_{i=0}^{n} C_i * \mu\beta_i} \quad \textbf{(11)}$$

6.2.4 Bayes Belief Network Validation

The construction of a network starts with building the structure (the DAG). The way a Bayesian network is constructed has an impact on the results and therefore several forms must be tested (Manzato 2012; Heckerman 2008). For this research several structures were tested for optimisation. The structures suited for this research were the Bayes Classifier (BCN), Bayes Classifier Naïve (BCNN) and the Bayesian Augmented Naïve (BANN). From these the BCNN structure only allows for one layer of hierarchy. This implies all factors are assumed to have a direct cause on the location choice and assumes they are not interdependent. The BANN and BCN structures allow multiple levels in the network hierarchy, resulting in chains of influence and divergent and convergent relations.

Structural learning is conducted via data mining that automatically searches for statistical relationships among variables. This was performed by the software package ‘Power Constructor’. However, purely statistical interdependence do not reflect realistic causal relationships and the direction of the influences between variables cannot be determined by machine learning (Frayer et al. 2014). By using a lower sensitivity, only the correlations above 0,05 were incorporated. Relationships in BNs do not have to be causal but can also assert non-causal statistical association (Nadkarni and Shenoy 2004). Therefore some relations must be prohibited.

Next to the DAG, another issue that needs testing is the incorporation of the company size. It is possible that the smaller companies of one to four employees distort the image of company relocation choice. As a result all the models are tested with the dataset including or excluding companies of 1-4 employees.

To actually validate a probabilistic forecast, there are several methods for measuring its accuracy. Pearl (1978) proposes a Brier test (Brier 1950), which scores the outcomes of the model against a set of realised outcomes. The formula for calculating this is originally (12).

$$B = \frac{1}{n}\sum_{j=1}^{r}\sum_{i=1}^{n}(F_{ij} - E_{ij})^2 \qquad \textbf{(12)}$$

Norsys (1995) proposes incorporating this test with a iterative sampling approach. It lets the model predict the outcome given the evidence and counts the correct and incorrect predictions ($X = x$). Because the there is only one dataset available, the set must be separated into a training set and a test set. This is to prevent the test being prejudiced because it was already in the training set. The dataset is randomly divided into two portions. 75 percent of the dataset is used for training the beliefs and 25 percent is used to test the beliefs. The results of the tests are shown in Table 6.1.

Table 6.1: Accuracy of the tested 'directed acyclic graphs'

Structure	Smallest size	Training	Test	Logarithmic loss
BAN	1	13,56	12,56	2,461
	5	14,61	12,56	2,463
BCN	1	21,45	18,44	2,32
	5	21,76	17,9	2,423
BCNN	**1**	**31,15**	**29,78**	**2,12**
	5	32,03	30,55	2,178

The most accurate network is the Bayesian Classifier Naïve Network, displayed in Figure 6.5 and is used to derive the weights from all the tasks.

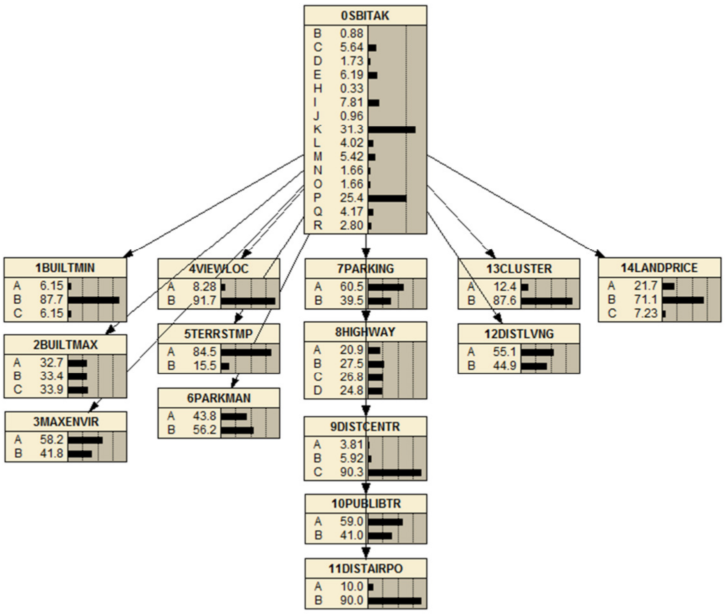

Figure 6.5: Bayesian (Naïve) Network for location choice

The 'sensitivity to findings test' views how much the entropy is reduced by the introduction of the evidence. In Table 6.2 the mutual information (sensitivity to findings) is presented for all branches combined. In 'Appendix 23' a full overview of the sensitivities is given.

Note that the percentages are low and in total only add up to ten percent explanation value; implying that these attributes only explain a tenth of the choice. This leaves a huge error term in the model and results should be used with caution. The model as a whole has a 29,17 percent prediction value which is significantly better as 6,67 percent in full entropy, but is not high. The utility calculations in the final model should be carefully analysed before interpreting the results of the model.

Table 6.2: Entropy reduction by mutual information

Variable	Mutual info	Percent	Variance of believes
Clustering of companies	0,05666	1,89	0,000969
Land price	0,03996	1,33	0,000454
Maximum built percentage	0,02846	0,95	0,000505
Terrain type	0,027	0,901	0,000493
Distance to airport	0,02193	0,732	0,000537
Distance to highway entrance or exit	0,01881	0,628	0,000264
View location	0,01519	0,507	0,000577
Maximum environmental category	0,01503	0,502	6,09E-05
Distance to centre	0,01454	0,485	0,000152
Park management	0,01319	0,44	0,000158
Distance to Neighbourhood	0,01296	0,433	0,000175
Accessibility by public transport	0,01159	0,387	0,000025
Minimally built percentage	0,01158	0,387	0,00014
Parking possibilities	0,00772	0,258	0,00016

6.3 The Input from Incipient Models

In the paragraph the output of the two models (BLM & BCN) prior to the created ABM is discussed. The output of these models will serve as the input of the ABM which will then indicate the relation between these two indicating models. Firstly we discuss the estimated quantitative demand predicted with the BLM and then the qualitative demand found by the Bayesian network.

6.3.1 BLM Output

The newly adjusted forecast is made, specifically for the area Eindhoven (GA). This is made with the local developments and branch focuses in mind. Slightly lower deviations of predicted trend lines are ignored due to the crisis, though large observed deviations are treated as developments and new trends. As a result, the demand for land per branch is summarised in 'Appendices 24 & 25'. In 'Appendix 26' a more detailed analysis is given of the results of the developments in Eindhoven (GA). The sum of these projections result in Figure 9.9, where the projected demand is shown with the WLO scenarios as reference. The new projections differ slightly from the projection in Figure 9.7. This is due to the dependence of the BLM variables on growth predictions. These are recalibrated without the WLO scenarios, resulting in a slightly lower projection.

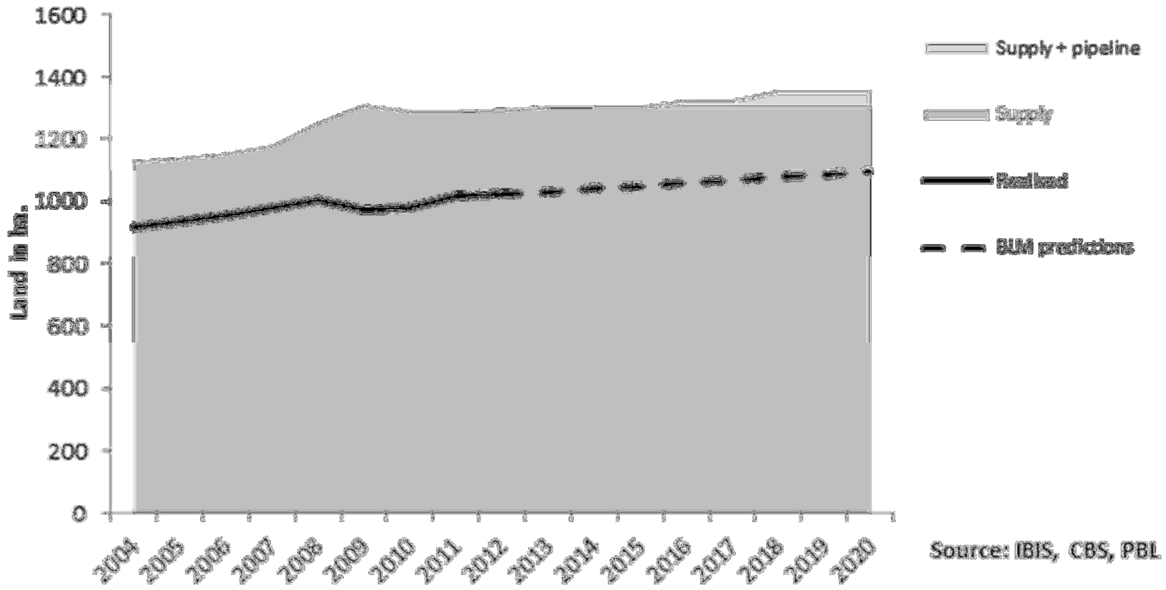

Figure 6.6 :BLM prediction for Eindhoven (GA) adjusted for local trends and the supply

6.3.2 Bayesian Model Output

The Bayesian Network supplies us with the probabilities of choosing an alternative given the evidence of the SBI branch. This is translated by the method discussed in chapter 0. The result is a large table with 15 weightings for 34 levels and it is presented in 'Appendix 27'. It is chosen to present the outcome of this data by creating a map which shows the scoring of the terrains on average for all branches. The map is scale coloured with the darkest areas representing the highest scores and is show in Figure 6.7. An overview of all different scores for each branch can be found in 'Appendix 28'.

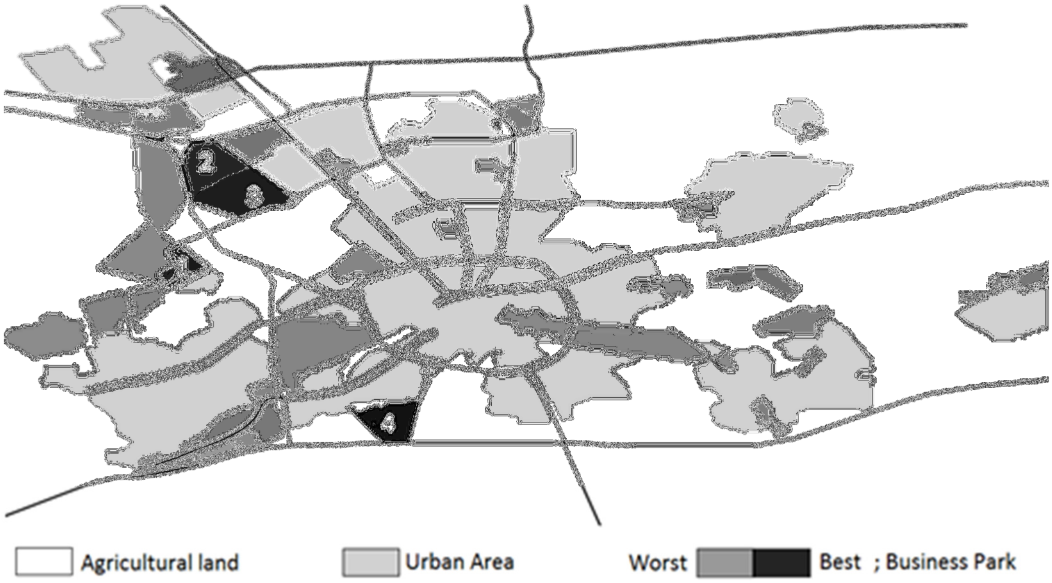

Figure 6.7: Map of case study area with all (colour scaled) business parks

Here it can be seen there are four very good terrains. These are: (1) Flight Forum, (2) GDC Acht Noord, (3) GDC Acht Zuid and (4) the High Tech Campus (4). It should be noted though, that these are the average scores and the scores vary between branches, so if we would specify a branch, the scores would change. Also the terrains in question are largely or completely in private hands and are highly focussed on one branch, implying that a focussed terrain benefits the attractiveness.

6.4 Model Validation

Verification and Validation of Computer Simulation Models is conducted during the development of the model with the goal of guaranteeing accuracy and credibility. This is addressed through verification and validation of the simulation model. The verification and validation of the model start when the initial model development has been completed and is an iterative process. The final validation is discussed here.

The model is validated by recreation of the events between 2004 and 2013. The data fed into the model and the data used for verification must be independent. This model has several independent variables as output, three were used as validation variables. These are (1) the land grants, (2) the location choice and (3) the vacancy. These variables are the only data not fed into the model and are merely a result of the interactions of the agent in the model. They need to be compared to the actual developments of these variables; the realisation. For the amount of land grants the IBIS documentation need to be equalled within statistical boundaries. These boundaries must be defined because the model is distributed itself.

6.4.1 Grants

In Figure 6.8 the results from the model and the realisation can be seen. The land grant outcomes of the model are distributed and are hard to interpret without mutation. The lose outcomes of this distribution resemble the realisation in documentation (a correlation of 0,9). As we take the averages it can be seen that they somewhat closer resemble reality with a correlation of 0,95. At the height of the business cycle (2008 & 2009) the realisation exceeds the averages of the model, though the model has covered the outcomes in some of its runs nonetheless, as it can be seen that outcomes surround the realisation on both sides. As the model progresses, the standard deviation increases, the lower limit shows stable behaviour but the upper limit increases fast. At year nine of the simulation, the standard deviation is 21,05 ha (26 percent). As a result of the employment growth as input, the model closely matches the outcome after nine years (78,3 ha. modelled versus 80,0 ha. realised) and is accepted.

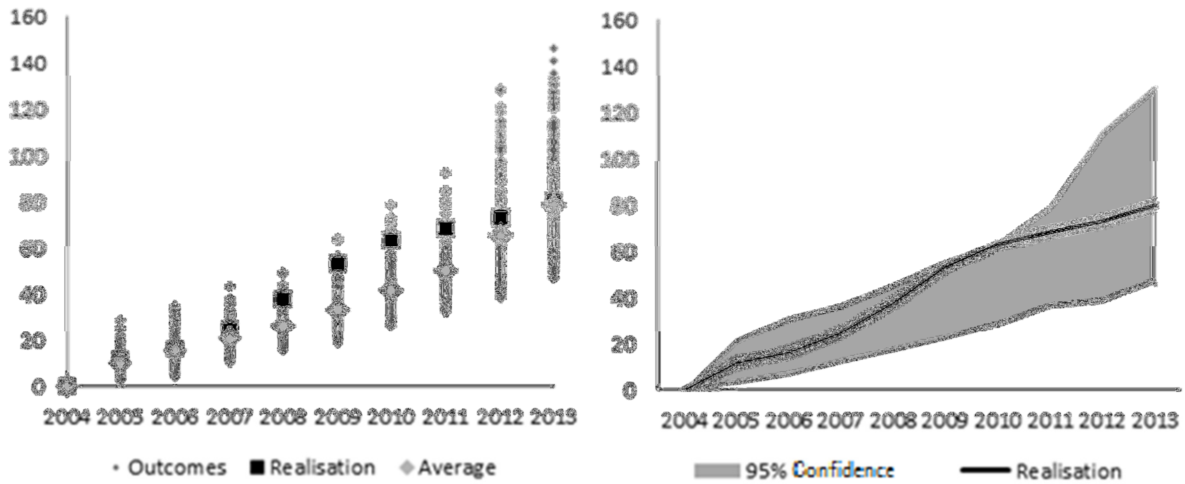

Figure 6.8: Model outcomes against realisation & confidence boundaries

6.4.2 Location Choice

In Figure 6.9 the location choice is shown for new developments against the realised developments between 2004 and 2013. The success of the location choice model is tested with a correlation test and a Brier test. The result of the correlations test is a score of 0,62. The Brier test is calculated by comparing the results of the model to the system in full entropy. When no information is given, the model would divide the randomly resulting in an evenly spread 5,3 ha. for each terrain. This model increases the information to a point that 60% of the terrains scores better as in full entropy. These scores are not very high but increase the accuracy of the location model by incorporation of financial factors from 29,8% to 60% and are thus accepted.

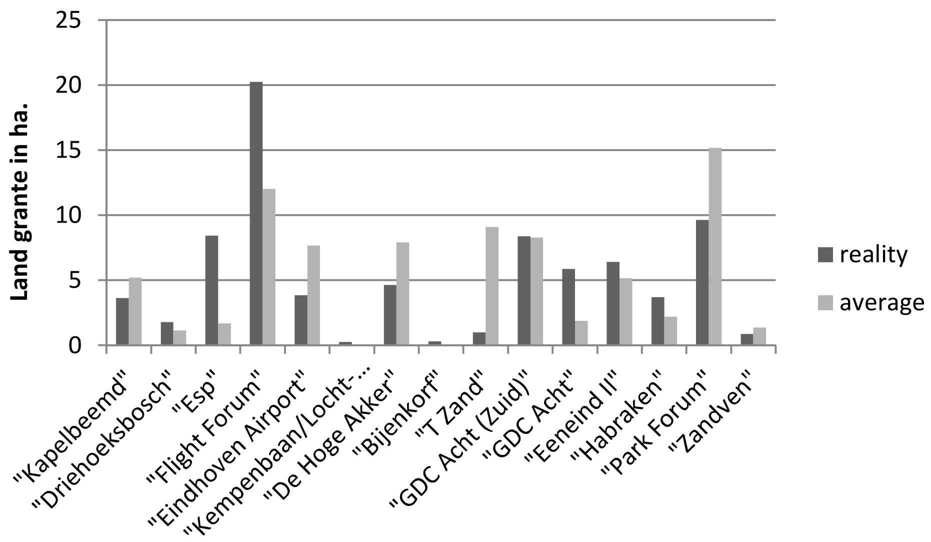

Figure 6.9: Location choice between 2004 - 2013 realised and modelled

6.4.3 Vacancy

Lastly the model is validated with the vacancy development in reality (see 'Appendix 29'). The model does not store vacancy in between years but gives the end result. Therefore only the end results can be compared. A vacancy of 4,9 percent is artificially created at the beginning of the model. The end, the results should be 8,9 percent vacancy. The model realised a 7,5 percent as a mean with a standard deviation of 1,7 resulting in an 65% reliability area between 5,8 and 9,2 percent. The boxplot of the result is shown in Figure 6.10.

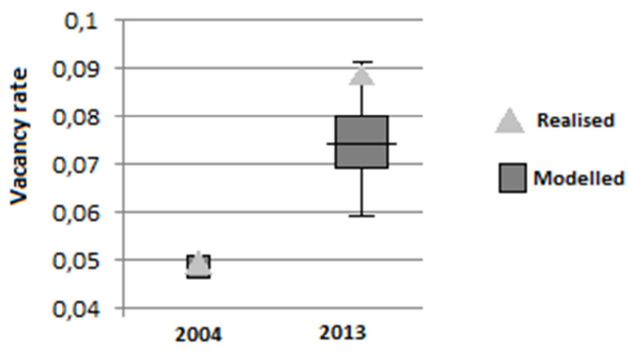

Figure 6.10: Vacancy modelled versus realised

Now that the results of the replication of 2004 to 2013 are analysed, the boundaries and limitations of the model are identified. It runs more linear as the reality and the vacancy undershoots the realisation by a little. The location model performs better with the incorporation of the financial factors and has a hit rate of 60%, which is higher as the initial Bayesian Classifier Network. And it can be concluded that the high municipal expectations, can actually be explained with the model. The widely spread standard deviation triggers them to want to have sufficient supply even for a best case scenario.

6.5 Results

Now that the model is validated the predictions of the future can be made and these runs can be analysed and processed. This will identify the influences of supply and attempt to find an approach to creating a sustainable policy towards business purposed land. Future runs are not based on certain growth ratios as the previous runs, therefore it is stated again that these are a simulation of the future based on predictions. Though alteration of the input is enables the user to create countless scenarios, it is chosen to demonstrate the applicability and the relevance of the model, in the form of several scenarios. These scenarios are a result of the discussions with policy makers and based on general conceptions to see if the desired result can be created.

The first scenario will be a status quo scenario representing the current affairs. These results will be used to compare the results of other scenarios as a point of reference. The second scenario is based upon the general believe, among municipal councils: 'Lowering the prices will improve the selling rate and benefit our employment'. The third scenario will test the competition between municipalities and will elude what happens if only one municipality lowers their land prices. This will explore the concept of competition as Krabben & Buitelaar (2011) described. The fourth scenario will remove the plans to introduce future terrains, which would be the rational and most likely decision of municipalities if the current supply could fulfil all demand. The fifth scenario select a select few good terrain of substantial size and focuses on the grants of only these terrains, reflecting the provincial view on the solution of this problem. A sixth and last scenario will test if the individual reform of a terrain could decrease the vacancy rate. Based upon these scenarios the influence of policy will be quantified.

6.5.1 Status Quo

Maintaining the status quo is characteristic for conservative politics and in this scenario the model continues under the current affairs. As a result it can be seen that a total demand for business land will grow with 64 ha. But this demand will not all be gobbled by land grants. The amount of land granted in this scenario is 56 ha. As vacancy will still increases to about 9,9 percent, some of the growth will be absorbed by investments in companies' premises. Resulting in a growth of 9,1 ha. of additional vacancy. Two conclusions can be drawn from this; for each hectare granted 0,16 hectare becomes vacant and 15 percent of the growth can be absorbed by the current accommodations.

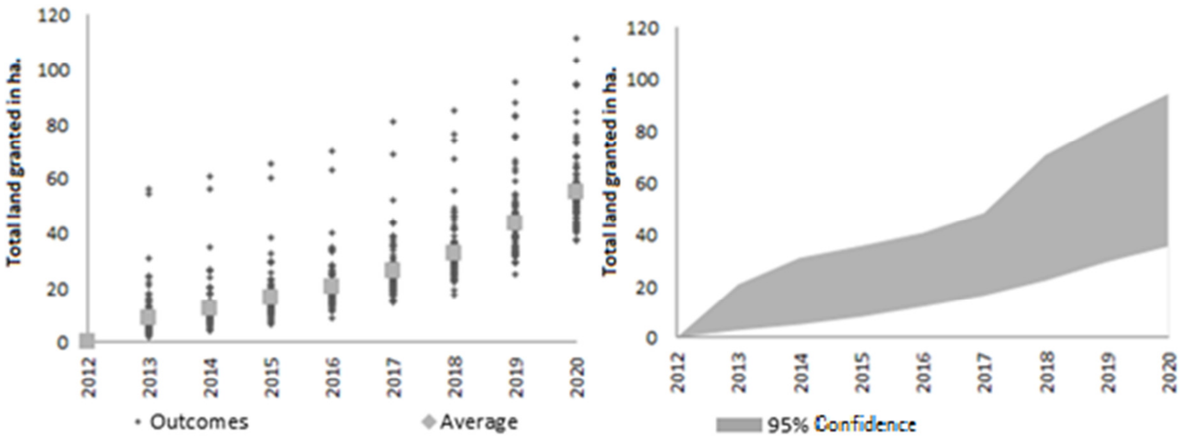

Figure 6.11: Results of the run status quo land grant outcomes & confidence boundaries

The vacancy can be explored in more detail with the vacancy map in Figure 6.12. Some very dark terrains signify a high vacancy rate. These dark terrains are concentrated on the east of

Eindhoven and all have a low score on accessibility. These terrains have a simulated vacancy of around between 20 – 40 percent in 2020. They are mostly located on the on locations far from the highways exits.

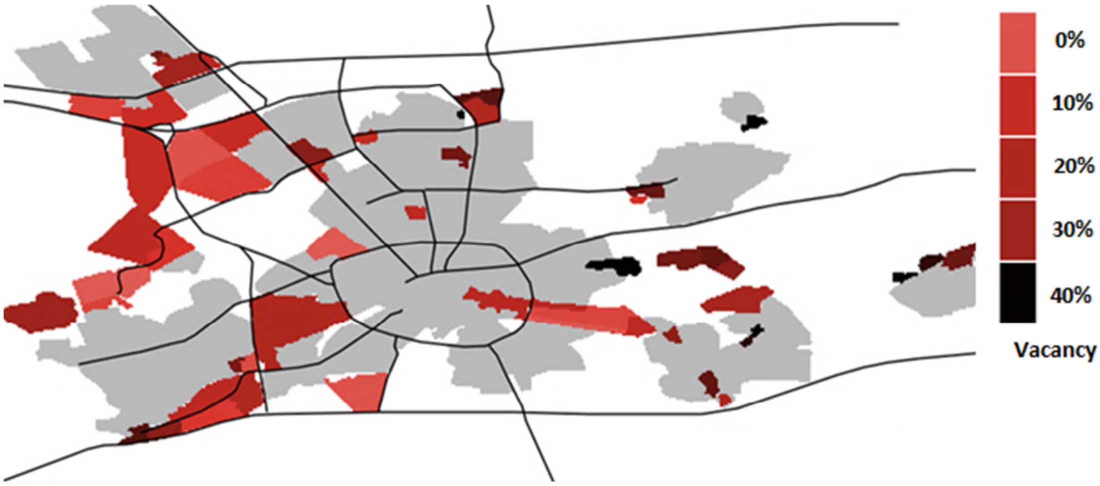

Figure 6.12: The modelled vacancy per terrain

The location choice of the companies is shown in Figure 6.13. The terrains 'Park Forum', 'Habraken' & 'Zandven' are all located on the south west and are similar in charachteristics and score more or less the same. The terrain 'Bea2' is very popular, when introduced to the market. However the characteristics of this terrain are based upon a preliminary land use plan and form an uncertain foundation for this statement. In 'Appendix 30' the relative grants are shown compared tot the supply at hand.

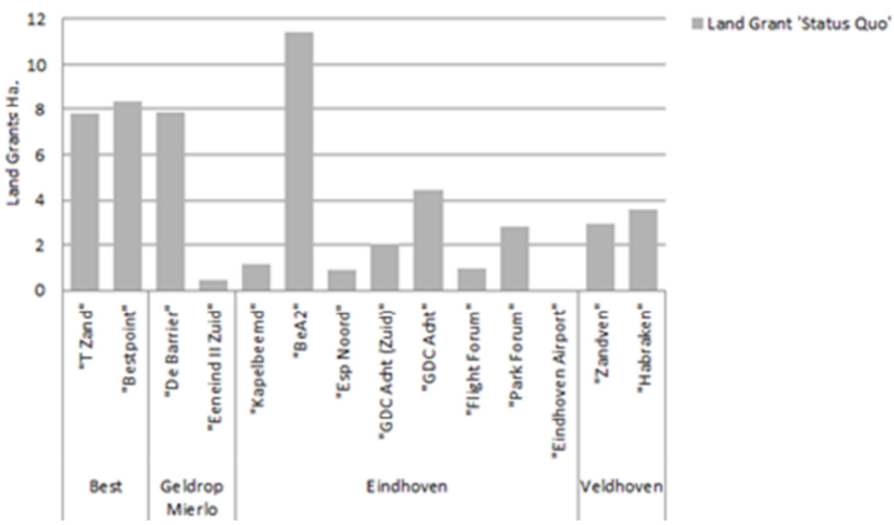

Figure 6.13: Location choice in the status quo scenario, land granted per terrain

Now it is possible to compare the reference scenarios to other scenarios and the relations between land use, finances and policy can be explored.

6.5.2 Land Price Discount

In this scenario the land prices have been dropped to boost the land grant rates. Land prices have dropped €50. The average dropped from 145€/m² to 95€/m². The result of this is a slight surge in grants giving a 4 ha. boost in total, spread over eight years. The results of the grants can be seen in Figure 6.14. Surprisingly the vacancy (10 ha.) did not rise as much and is almost similar to the status quo scenario (9 ha.). It can be concluded that the each acre granted by price drops leads to an 0,25 ha. vacancy. But most interesting is that this shows that the price elasticity of the land price is very low.

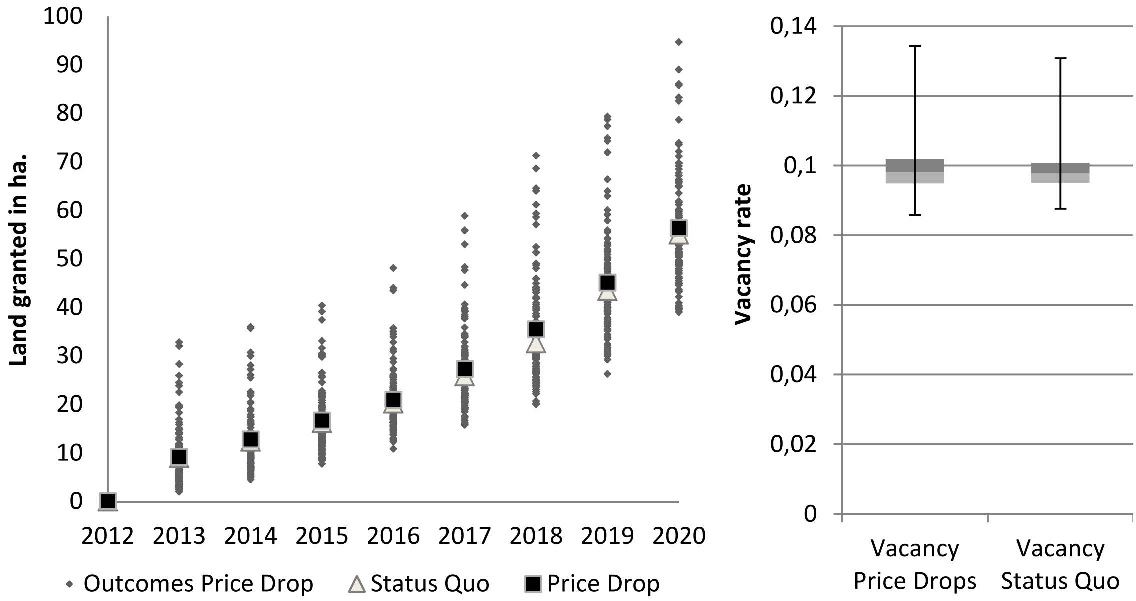

Figure 6.14: Comparison of the land grants (in ha.) and the vacancy rate; price drops versus status quo

6.5.3 Competition among Neighbours

In this scenario the municipality of Eindhoven drops the price of 'Park Forum' from 155€ to 105€. This is far below the neighbouring terrains of the municipality of Veldhoven; 'Habraken' (165€) and 'Zandven' (152€). The results are shown in Figure 6.15. As can be seen 'Park Forum' fares somewhat better as in the status quo scenario, however the land increase is not coming from 'Habraken' or 'Zandven', but rather from somewhere else in Eindhoven. Park forum wins 1 ha. which is mostly originating from 'GDC Acht' and 'Kapelbeemd'. This concludes firstly that the model is capable of showing complex feedback loops. But more importantly it is imperative that before trying to compete with neighbours, it should be carefully analysed what the full extent is of the competing influences.

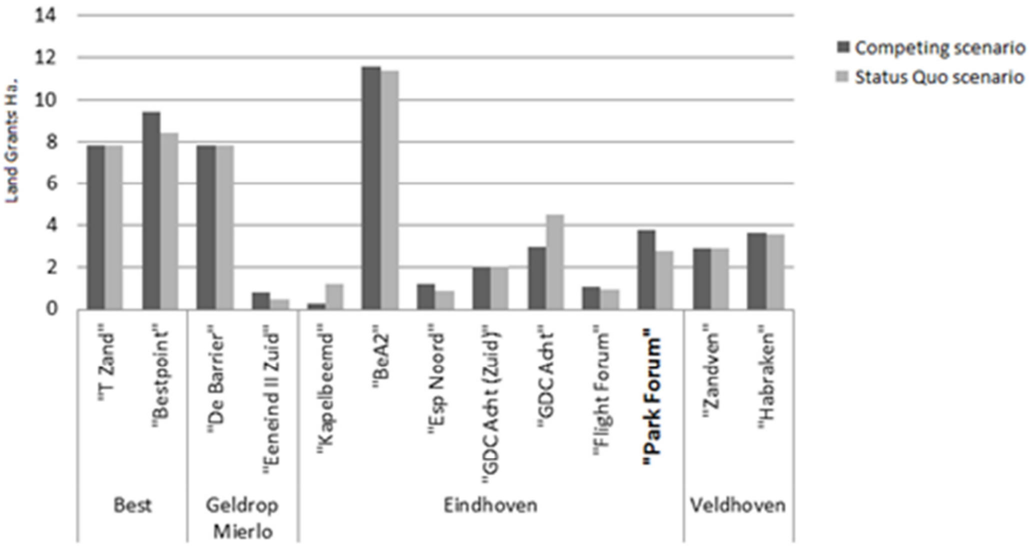

Figure 6.15: Comparison of the location choices (in ha.); competing versus status quo

6.5.4 Exclusion 'Soft Plans'

In this scenario the 'soft plans' (pipeline plans/ LNID) of the municipality for the terrains 'BeA2' and 'Esp Noord' will not be executed in the future. The model will not allow granting for these terrains even when in planning they should have been allowed. The result is that the granting rate and the vacancy stay exactly the same, however the location choice changes. The terrain 'Park Forum' replaces the lion's share of the grants previously absorbed by these two future terrains. (see Figure 6.16). It can be concluded that the realisation of the soft plans will be successful, however it will decrease the success of the other terrains with equal force and the net result will be more terrains with a lower occupancy.

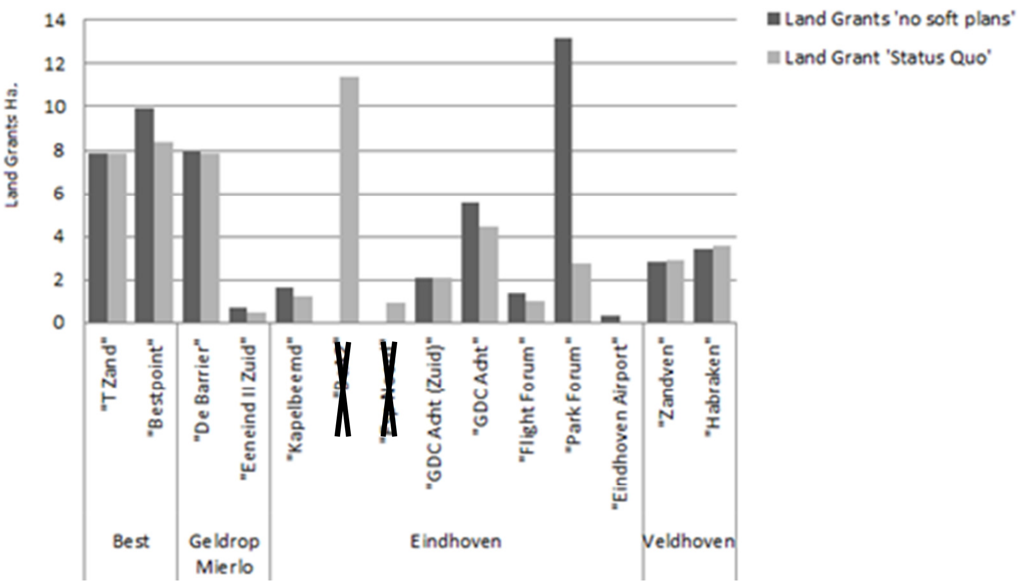

Figure 6.16: Comparison of the location choices (in ha.); exclusion of soft plans versus status quo

6.5.5 Restricted Land Grants

With the restricted grants policy, the model allows for granting on only 3 terrains, which have proven successful in the status quo scenario. The less successful terrains are put on hold and no land is grated form them. The terrains chosen for this scenario are (1) 'GDC Acht' (2) 'GCD Acht-Zuid' and (3) 'Park Forum'. As a result the grants drop drastically and so does the vacancy. The grants cumulate to 35 ha., a decrease of 22 ha. from the status quo scenario. Vacancy drops to 8,2 percent instead of rising to 9,9 percent. It can be concluded that the restriction of terrains, to a larger extent, will decrease the granting rate and the vacancy. For each hectare grated less by this policy 0,7 hectare of vacancy is solved. This could be viewed as sustainably the best solution but the forced compaction and re-use could have a negative impact on the employment conditions or employment itself trough a decrease in attractiveness of the region.

6.5.6 Changes in land-use-restrictions

This scenario changes some aspects of one of the terrains with high vacancy rates to see if improving the situation here would be able to reverse the process. The model calculates the success of this intervention to check if there is any change in the vacancy. For this scenario the terrain 'Herzenbroeken' is improved. The terrain is suffering from high vacancy rates in the status quo scenario. Firstly the accessibility was improved. This simulates the policy of the municipality to implement the east-side highway. Secondly the public space was upgrade and the business park was upgraded to a high-end use park. Thirdly park management is introduced. The result was a run with indeed a slightly deceased vacancy rate compared to the status quo scenario, but the vacancy still rose from 8,9 to the averages shown the boxplot in Figure 6.17. It can be concluded that the changes in land use restrictions reduced the increase in vacancy. Nonetheless the terrain is still degrading rapidly; this can be assigned to the fact that there are factors which can, realistically, not be changed e.g. the current composition of the terrain. Secondly this could be caused by the competition from other terrains, which offer more possibilities and better clustering. These degrading terrains own a set of characteristics unfavourable in many conditions, which will need more attention to prevent degradation.

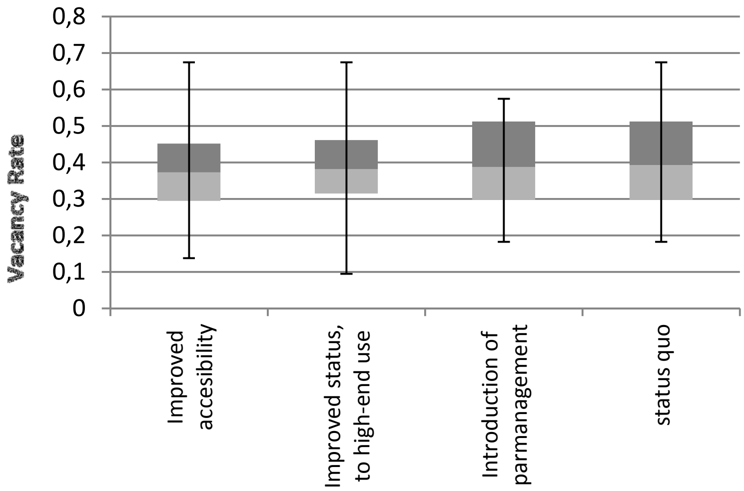

Figure 6.17: Comparison of the vacancy rates; changes in land-use restrictions versus status quo

7 Conclusions & Further Research

The problem, an oversupply of land purposed for business activities, as can now be concluded, is not caused by one actor. It has evolved due to a mix of policy, optimism, structure and the unique composition of the land market. The two hat dilemma puts the responsibilities of the municipality in a split because of a faulty system. The cause lays mainly in the prevailing policy; allowing competition, loose regulations and the ability to profit from city expansion has proven to be too much for municipalities, especially for those who lack the capacity; financially or in man power.

It has become apparent that the problem is multifaceted and the solution is not as simple as just recalculating the amount of hectares needed. Land is not an interchangeable bulk product and policy can backfire in the form of vacancy. The goal of the research, the development of a decision support tool, was realised through an agent based model. The strength of this model lies in the incorporation of feedback loops, the location and allocation of land and the current stock. This allows policy makers to see the consequences of certain business-land policies in a broad perspective. The estimation methods currently used by governmental bodies can and should be supplemented with the factors which were incorporated in this model; quantifying the supply and demand from a qualitative perspective. This model can be of great value for any municipality with business parks within its borders, firstly because the plans of many local governments, such as lowering the land prices, will backfire on vacancy. Secondly it is useful to monitor redevelopment project for existing terrains. The model is not only of use to municipal planners, but provincial planners could use an up scaled version to monitor policies initiated by municipalities. The results of the model can identify policies that will harm surrounding municipalities, with for example exorbitant prices.

The model is coping with a huge amount of data and therefore is relying on a lot of sources. Using different sources makes the data less reliable. There are more unified data sets available in commercial databanks (e.g. LISA). It is suggested that for further research a unified dataset is used. Also it would be desirable to inventory the vacancy of individual terrains. In that case the model can be supplied with a more accurate set up but also can be validated on this subject, potentially increasing the confidence in the applicability. The reliability model is dependent on the reliability of the input, which in this case are the results of the BLM. The BLM is a powerful tool, even for smaller scales, it is nonetheless again as reliable as the accuracy of the employment predictions. As WLO scenarios, were found to be irrelevant for the scale level using them would subvert the outcomes. New predictions were extrapolated with increased input uncertainty and therefore extra caution is warranted towards interpreting the results. For further research it is proposed incorporate other companies beyond the designated terrains and incorporate the office market to prevent lack off overlap. Though the outcomes of the validation runs resemble the developments that were realised within acceptable boundaries, an increase in scope, a more unified data source, and more detailed data would benefit the model greatly.

The outcomes of the model explore the complex relations in the market for business land. It was found that running a simulation is a tedious process. A full analysis of where to absorb the abundance and where to change the land use plans, would not be possible given the time frame. Therefore the scenarios were constructed to test the applicability of the model, by testing the relevance of policy propositions found during the research. The most opted policy, lowering the price of the land, will serve its primary objective: increasing the sale rate. However this pales in comparison to the side effects. It will increase vacancy, decrease compaction and above all cost the municipalities relatively a lot in the process. If the main motivation for lowering the prices is competition, it should be carefully analysed what the effect is on the own stock, as this policy could easily seize only demand from the discounter itself. The exact same statement can be made for the introduction of future plans; it could drastically decrease the success of the other terrains. The best option seen from a sustainable point of view is to restrict the grants of terrains to an extent in which the vacancy is reduced and compaction is stimulated. This will however results in short term losses through a low grant rate. To further decrease the vacancy the terrains which are hit the hardest must be addressed. The model showed that it is hard to reduce the vacancy rate on some terrains to an acceptable level. This is allocated to an unfortunate combination of uncompromisable characteristics.

This thesis set out to improve the conditions for municipalities in their decision making process. The model supplies municipalities this decision support tool. It is found however that the scale level of local government is not sufficient to comprehend the full consequences of policy. Ultimately for further research it is proposed to upscale the model to a full COROP region. This will reduce the noise created from probabilities and decrease the border limitations to 94 percent closed system. As this is an inter-municipal decision area and the best option, seen from a sustainable point of view, is not the immediate best for an individual municipality; it is proposed that the province takes on a central role. The empowerment of the province in this societal complication shall create the will and capacity to disarm this bubble.

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9 Appendices

1. Appendix: Scope of the problem

The financial situation of Dutch municipalities has worsened significantly because of losses on land developments. Ten Have et al. (2012) researched the state of municipal budgets in relation to land reserves commissioned by the Vereniging Nederlandse Gemeenten (VNG). It was found that municipalities had estimated their profits for 2009 and 2010 to be 500 and 380 million euro respectively, in contrast the results were -414 and -723 million euros. Since then it has been estimated that the municipalities of the Netherlands have an approximate total loss of 3,9 to 4,4 billion euros. As mentioned before, about 15 percent of the municipalities in the Netherlands will come in financial danger due to abundant land supply and an additional eight municipalities are placed under preventive supervision (Vakberaad Gemeentenfinanciën 2012). These losses were caused by the land supply in general, which includes housing, retail and offices next to businesses.

A hint of the excess of business land can be seen in Figure 9.1, in which the actual take-up is compared to the reserves. The reserves are often based on a comparison with the annual grants.

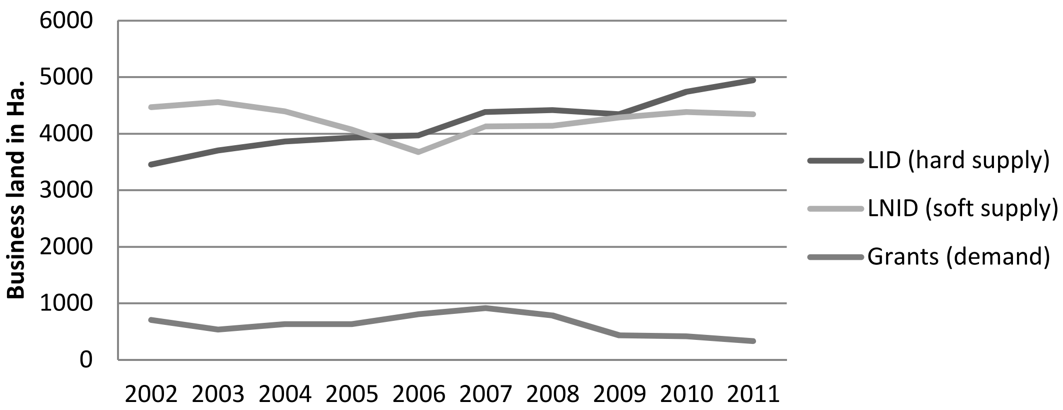


Figure 9.1: State of the business land reserve in the Netherlands (Ministry of Infrastructure and the Environment 2012a)

In the Netherlands all business-locations (including 'harbours' and 'economic zones') cover a total area of 81.748 hectare. Approximately 27.500 hectares of these areas are brownfields; vacant developed business areas (Ministry of Infrastructure and the Environment 2012a; Ministry of Infrastructure and the Environment 2011). This results in 29 percent of partial or complete obsolescence in business locations (6 percent is unknown, 65 percent is current). Despite this, municipalities are still granting new land.

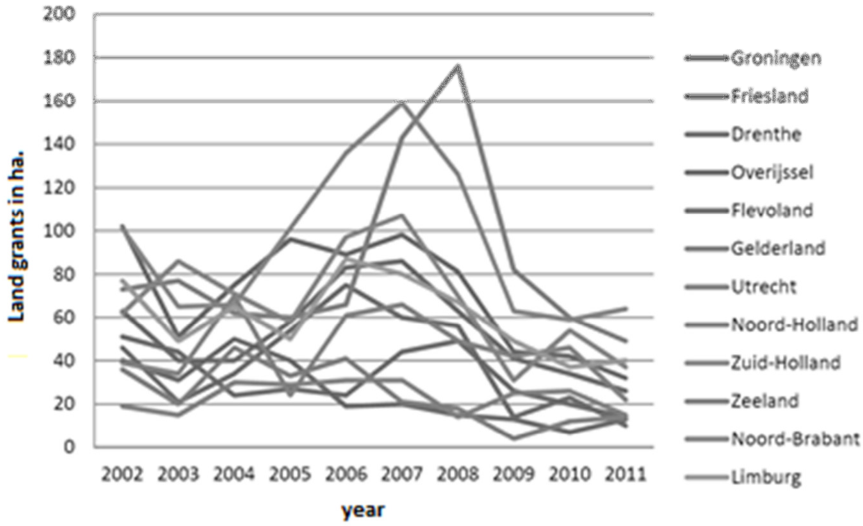


Figure 9.2: Trend in land grants per province since 2002 (Ministry of Infrastructure and the Environment 2012a)

In 2011 the granting contained 623 hectare. Noord-Brabant is the largest supplier of business land (10000 ha.) and its land grants are among the highest of all provinces each year (Figure 9.2). In 2012 Noord-Brabant granted 64 hectare of new working location. However the amount of obsolete working locations is 29,7 percent and 12 percent is unknown. It is safe to say that at least a third of all working locations qualify as obsolete. When looking at the origin of the obsolescence, it can be concluded that 88 percent of these locations are spatially obsolete, which indicates the lay-out of the location, the spatial integration is obsolete, and/or there is a conflict among functions (Ministry of Infrastructure and the Environment 2011). While the municipalities of Noord-Brabant remain to grant land for construction of new business parks, the amount of obsolete working locations is still growing as can be seen in Figure 9.3. Some provinces are battling obsolesce effectively with redevelopment, other provinces are still struggling. Noord-Brabant seems to be among these provinces, though it is close to breaking even in degradation and redevelopment.

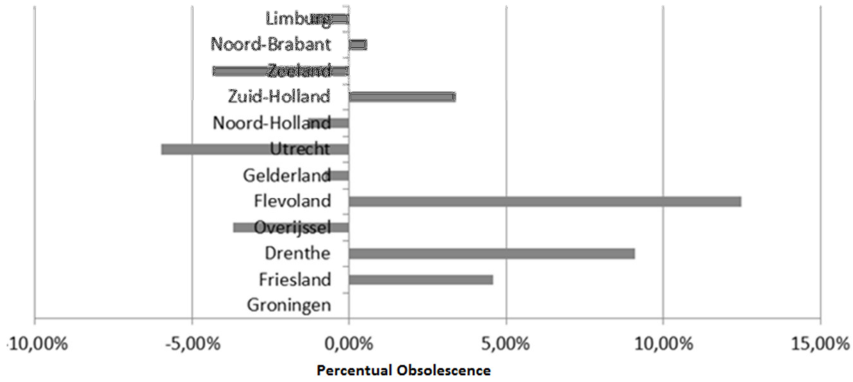


Figure 9.3: Percentage of growth of obsolete working locations per province (Ministry of Infrastructure and the Environment 2012a; Ministry of Infrastructure and the Environment 2011)

Other costs caused by the urban sprawl can be defined as: loss on real estate tax (Dutch: Onroerendezaakbelasting; OZB), loss on redevelopment initiatives and loss on transportation. The 3.505 business locations in the Netherlands contain 270.000 companies, settled in 127.000 buildings, having a cumulative value of 177 billion euros. Currently, 43 billion worth of real estate is vacant on the business locations, nearly 25 percent. This results in a loss of 70 million of OZB income for municipalities each year (Keala Group 2012). However it should be noted that this is not a direct result of the land granting, but an indirect result.

The municipalities of the Netherlands are looking at the difficult task of identifying the scope of their abundance of land. They need to take losses on their prognosed profits on land development and acknowledge the drop in demand could be structural. It must be noted that it is unclear whether the drop in land grants is just part of the recession or the actual trend. Nonetheless in the current market there is an abundance of land destined for business use. Continuing the current policy will enhance the urban sprawl and puts pressure on municipal and other governmental budgets. Secondly, municipalities need to prevent the degradation of the current stock and redevelopment to supply the companies in their demand for suitable business land.

2. Appendix: Spatial Planning and Development in the Netherlands

Land-use planning in the Netherlands is a complex form of spatial planning, because of the high density of the build environment and scarce ground reserves. In the Netherlands, all ground is covered by the land use plans. These form a plan led approach on which the national government and the provinces lay out the global plans and the regional governments implement it in their vision. Compared to other countries, the proportions of the public and private development are well balanced in the Netherlands. Because of complex surrounding and a compact built environment in the process of development, only key stakeholders are involved. Citizen involvement is kept to a minimum to speed up procedures and the approach is mostly a policy orientated, rather than political (Heurkens 2012).

Halleux et al. (2012) created an overview of the three theoretic governance forms of coordinating mechanisms regarding land use. They describe three ideal types of governance; property-rights regime, land-regulation regime and cooperative regime (Figure 9.4).The ideal type of regime, namely property-rights regime, demands that the market is the sole governance structure. The regime works under the private law and price is the coordinating mechanism. The conditions require that suppliers and demanders are perfectly independent. The land-regulation regime is based on the public development regime in which a hierarchical form of governance is ruled by the public authorities. It works under the rules of public law, which define the legally binding devices to which land and property owners must accept limitations of their individual rights. These devices can be translated as: “building regulation, zoning plans or expropriation laws”. Note that price is not a coordinating system, but a price must be paid for the trading of land. The last regime, where land transactions and land-use changes are cooperatively determined, is called the cooperative regime. This regime has parties that are interdependent rather than a perfect hierarchy or are independent and thus need a coordination based on trust and cooperation. This translates in reality to a form of public private partnership (PPP), a regime which operates under private as well as public law.

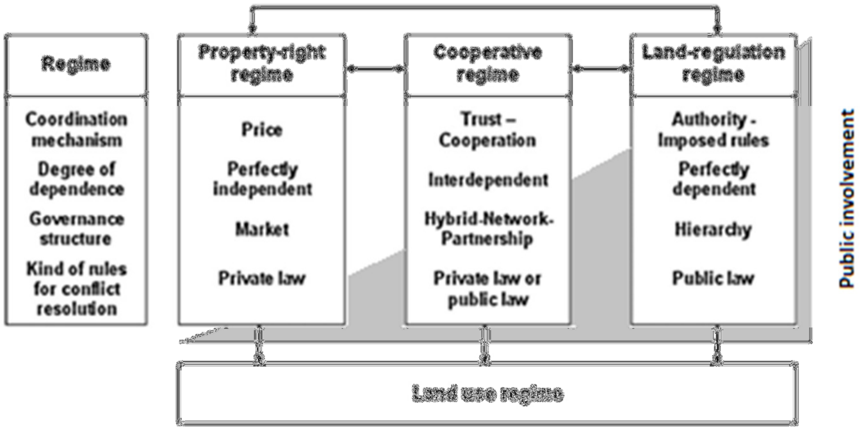


Figure 9.4: The model of the land use regime (Halleux, Marcinczak, and Van der Krabben 2012)

In the Netherlands the business land market is regulated under a land-regulation regime. Authorities impose rules and limitations in the land use plan for the final buyers. For that matter the parties should be perfectly dependent on the government. Municipalities have shown to be dependent on companies for generating employment (Buitelaar et al. 2008). Therefore the two parties are interdependent and in combination with market failures destabilise the 'property-right' and 'land-regulation' regimes. Therefore the Cooperative regime could be a more appropriate approach towards the land use regime. Nonetheless it is necessary to have the government lead the land developments because of the long planning terms. Thus it is wise for the government to investigate the consequences of their restrictions on the dependent companies to optimize the regime.

This research tries to provide municipalities with a tool that will enforce the current land-regulation regime, without ignoring the cooperative regime tendencies. By investigating the general company preferences, it is possible to adjust the land-use plans to fit the companies needs, without compromising the top-down structure.

3. Appendix: Land Development

In the Netherlands, development often takes place in two consecutive but distinct stages: land development and property development (Ploegmakers, Van der Krabben, and Buitelaar 2013). Land development is the first stage of development and consists of the land acquisition, land parcellation and servicing of the land. The division of development into two stages often causes land to be exchanged twice before construction takes place. First, the land's ownership is transferred in the acquisition of the initial owner (supplier) to the land developer (demander). Secondly serviced building plots are sold by the land developers, often to commercial property developers or final users. In the business land market, in the Netherlands, the building plots are usually sold directly to the final user. These firms then subsequently commission the construction of new commercial property. The next section will explain the fundamentals of land development.

Construction land can be acquired in one of two distinct types of land; brownfield and greenfield. Brownfields are abandoned, idled, or under-utilised industrial and commercial facilities (Alker et al. 2000). The redevelopment of these areas has been stipulated as beneficial for the public in the long run (Persky and Wiewel 1996; Hara 2003; Wang et al. 2013; Chrysochoou et al. 2012). Brownfield redevelopment is hampered by an imperfect market, causing several problems (Adams et al. 2001). The problems are encountered in the phase of land development considering brownfields as opposed to greenfields are of a high complexity. The complexity of sustainable urban redevelopment is emphasised by several authors (Adams et al. 2001; McCarthy 2002; Walker, Hipel, and Inohara 2008; Ghaffarzadegan, Lyneis, and Richardson 2010; Chrysochoou et al. 2012). According to Samsura et al. (2010) the complexity is due to four aspects: (1) different groups of actors or stakeholders are involved and they respond to each other's strategies differently and also with different rationalities, (2) The utility functions of stakeholders are usually based on more than one aspect (e.g., financial aspects, spatial quality and the wish for future cooperation), (3) Institutional context and market processes may change the stakeholders' strategies, (4) Interdependency among stakeholders. Stakeholders affect others with each decision made; or are affected by the decisions of other stakeholders.

The term ’brownfield‘ is related to the opposite term, ‘greenfield’. Greenfields, although there is no clear definition in literature, are undeveloped, not extracted and not contaminated parcels of land (Glumac et al. 2012). In short; a greenfield is a piece of undeveloped land in a city or rural area considered for urban development. The process of greenfield land development does often not include complicated ownerships and demolition or clean-up costs. The land is acquired in large pieces of mostly agricultural land. The greenfields are mostly used for agriculture, landscape design or left to evolve naturally. Upon agreement in negotiations with the developers or end buyers, the parcellation and land-use are changed to the desired size and function. This land-use change greatly increases the value of the land and is thereby highly profitable for the land developer. In the Netherlands, the municipality is the land developer the majority of the time (Van der Krabben and Jacobs 2013). These differences between the two types of land cause a disequilibrium in the market. According to Ball et al. (1998) an solution to this disequilibrium can be found. This research will focus on a small part of this imperfect market; the impact of greenfield development on brownfield creation and redevelopment.

In the Netherlands brownfield redevelopment hardly occurs, because of all the related problems. Without external funding brownfield development is mostly not feasible. The benefits are spread over a wide range of parties and are mostly not direct, which prevents these values to be captured by law and thus cannot be redressed.

4. Appendix: Financial Indicators

Business Branch		Refurbishing costs	Building costs	Firm type	Landvalue in costs*
A	Landbouw en visserij	N/A	N/A	N/A	N/A
B	Voedings- en genotsmiddelenindustrie	914	720	1	130
C	Overige industrie	914	720	1	130
D	Chemische, rubber- en kunststofverw. ind.	914	720	1	130
E	Metalektro-industrie	914	720	1	130
F	Aardolie-industrie	N/A	N/A	N/A	N/A
G	Delfstoffenwinning	N/A	N/A	N/A	N/A
H	Openbare nutsbedrijven	914	720	1	130
I	Bouwnijverheid en –installatiebedrijven	591	860	1	130
J	Verhuur van en handel in onroerend goed	360	960	2	200
K	Handel en reparatiebedrijven	591	860	1	130
L	Transport- en opslagbedrijven	360	720	1	130
M	Communicatiebedrijven	360	960	2	200
N	Bank- en verzekeringswezen	591	960	2	200
O	Uitzendbureaus en huishoudelijke diensten	360	960	2	200
P	Overige tertiaire diensten	360	960	2	200
Q	Gezondheids- en welzijnszorg	914	960	2	200
R	Overheid	360	960	2	200

*difference must be added to the costs

5. Appendix: Probability to Utility Formula

The multinomial logit model calculates the probability of choosing i given choice set A. Netica gives this probability ($P_{i|A}$). The multinomial logit model is described by:

$$P_{i|A} = \frac{expV_i}{\sum_{i\epsilon j} \exp V_j}$$

Now the formula can be rewritten so we isolate the desired variable; the utility for choosing level i (V_i):

$$expV_i = P_{i|A} * \sum_{i\epsilon j} \exp V_j$$

This can be rewritten as:

$$V_i = \ln\left(P_{i|A} * \sum_{i\epsilon j} \exp V_j\right)$$

The sum of the exponents of all utilities of j is constant for all i in this j. Constant C_j:

$$C_j = \sum_{i\epsilon j} \exp V_j$$

If we substitute C_j in the formula we get:

$$V_i = \ln(P_{i|A} * C_j)$$

Now we assume that C_j is proportional to the mutual information, because it represents the reduction in entropy given certain evidence. Constant C_j has exactly the same function; it represent the total entropy reduction given evidence of attribute j:

$$C_j \propto MI = \sum_{a\epsilon A} \sum_{i\epsilon j} P(i,a) \ln\left(\frac{P(i,a)}{P(i)\, P(a)}\right)$$

Because the utilities V_i do not have units and are only proportional to each other, it can be said that:

$$V_i = \ln(P_{i|A} * MI)$$

6. Appendix: SBI Coding and Branch Coding

Sector	Takken	SBI08 codes per tak
Landbouw en visserij	Landbouw en visserij	1 2 3
Industrie	Voedings- en genotsmiddelenindustrie	10 11 12
	Overige industrie	13 14 15 16 17 18 29 30 31 32 33
	Chemische, rubber- en kunststofverw. ind.	20 21 22 23
	Metalektro-industrie	24 25 26 27 28
	Aardolie-industrie	19
	Delfstoffenwinning	6 7 8 9
Energie en water	Nutsbedrijven	35 36 37 38 39
Bouwnijverheid	Bouwnijverheid en -installatiebedrijven	41 42 43
Comerciele diensten	Verhuur van en handel in onroerend goed	68
	Handel en reparatiebedrijven	45 46 47 48 95
	Transport- en opslagbedrijven	49 50 51 52 53
	Communicatiebedrijven	58 59 60 61 62 63
	Bank- en verzekeringswezen	64 65 66
	Uitzendbureaus en huishoudelijke diensten	78
	Overige tertiaire diensten	54 55 56 69 70 71 72 73 74 75 77 79 80 81 82 90 92 96 97
Gezondheid en Welzijnszorg	Gezondheids- en welzijnszorg	86 87 88
Overheid	Overheid	84 85 91 93 94

7. Appendix: SBI Recoding between ’93 AND ‘08

Omschrijving	SBI'08	93 Code
Landbouw, jacht en dienstverlening voor de landbouw en jacht	SBI1	1
Bosbouw, exploitatie van bossen en dienstverlening bosbouw	SBI2	2
Visserij en kweken van vis en schaaldieren	SBI3	5
Winning van delfstoffen (geen olie en gas)	SBI8	14;10
Dienstverlening voor de winning van delfstoffen	SBI9	11
Vervaardiging van voedingsmiddelen	SBI10	15
Vervaardiging van drunken	SBI11	15
Vervaardiging van tabaksproducten	SBI12	16
Vervaardiging van textile	SBI13	17
Vervaardiging van kleding	SBI14	18
Vervaardiging van leer, lederwaren en schoenen	SBI15	19
Primaire houtbewerking en vervaardiging van artik. van hout	SBI16	20
Vervaardiging van papier, karton en papier- en kartonwaren	SBI17	21
Drukkerijen, reproductie van opgenomen media	SBI18	22
Vervaardiging van chemische producten	SBI20	24
Vervaardiging van farmaceutische grondstoffen en producten	SBI21	24
Vervaardiging van producten van rubber en kunststof	SBI22	25
Vervaardiging van overige niet-metaalhoudende minerale prod.	SBI23	26
Vervaardiging van metalen in primaire vorm	SBI24	27
Vervaardiging van prod. van metaal (geen machines en app.)	SBI25	28
Vervaardiging van computers, elektronische en optische mach.	SBI26	32;33
Vervaardiging van elektrische apparatuur	SBI27	31;29
Vervaardiging van overige machines en apparaten	SBI28	29;30
Vervaardiging van auto's, aanhangwagens en opleggers	SBI29	34
Vervaardiging van overige transportmiddelen	SBI30	35
Vervaardiging van meubels	SBI31	36
Vervaardiging van overige goederen	SBI32	36
Reparatie en installatie van machines en apparaten	SBI33	29;31
Productie, distributie, handel in elektriciteit, aardgas	SBI35	40
Winning en distributie van water	SBI36	41
Afvalwaterinzameling en –behandeling	SBI37	90
Afvalinzameling en -behandeling; voorbereiding tot recycling	SBI38	90;37;38
Sanering en overig afvalbeheer	SBI39	90
Algemene burgerlijke en utiliteitsbouw, projectontwikkeling	SBI41	70;45
Grond-, water- en wegenbouw (geen grondverzet)	SBI42	45
Gespecialiseerde werkzaamheden in de bouw	SBI43	45
Handel in en reparatie van auto’s, motorfietsen, aanhangers	SBI45	50
Groothandel en handelsbemiddeling (niet in auto's e.d.)	SBI46	51
Detailhandel (niet in auto's e.d.)	SBI47	52
Vervoer over land	SBI49	60
Vervoer over water	SBI50	61
Luchtvaart	SBI51	62
Opslag en dienstverlening voor vervoer	SBI52	63
Post en koeriers	SBI53	64
Logiesverstrekking	SBI55	55
Eet- en drinkgelegenheden	SBI56	55
Uitgeverijen	SBI58	22
Productie en distributie van films en televisieprogramma´s	SBI59	92
Verzorgen en uitzenden van radio- en televisieprogramma's	SBI60	92
Telecommunicatie	SBI61	64
Dienstverl. activiteiten op het gebied van informatietechn.	SBI62	72
Dienstverlenende activiteiten op het gebied van informatie	SBI63	74;92

Financiële instellingen (geen verzekeringen , pensioenfonds)	SBI64	65
Verzekeringen en pensioenfondsen (geen verplichte soc. verz)	SBI65	66
Overige financiële dienstverlening	SBI66	67
Verhuur van en handel in onroerend goed	SBI68	70
Rechtskundige dienstverlening, accountancy, belastingadvies	SBI69	74
Holdings (geen financiële), interne concerndiensten	SBI70	74
Architecten, ingenieurs en technisch ontwerp en advies	SBI71	74
Speur- en ontwikkelingswerk	SBI72	73
Reclame en marktonderzoek	SBI73	74
Industrieel ontwerp en vormgeving, fotografie, vertaling	SBI74	74
Veterinaire dienstverlening	SBI75	85
Verhuur en lease van auto's, consumentenartikelen, machines	SBI77	71
Arbeidsbemiddeling, uitzendbureaus en personeelsbeheer	SBI78	74
Reisbemiddeling, reisorganisatie, toeristische informative	SBI79	63
Beveiliging en opsporing	SBI80	63
Facility management, reiniging en landschapsverzorging	SBI81	63;94
Overige zakelijke dienstverlening	SBI82	63
Openbaar bestuur, overheidsdiensten, sociale verzekeringen	SBI84	75
Onderwijs	SBI85	80;85
Gezondheidszorg	SBI86	85
Verpleging, verzorging en begeleiding met overnachting	SBI87	85
Maatschappelijke dienstverlening zonder overnachting	SBI88	85
Kunst	SBI90	92
Culturele uitleencentra, archieven, musea, dierentuinen	SBI91	92
Loterijen en kansspelen	SBI92	92
Sport en recreatie	SBI93	92
Levensbeschouwelijke en politieke organisaties	SBI94	91
Reparatie van computers en consumentenartikelen	SBI95	32;52
Wellness en overige dienstverlening; uitvaartbranche	SBI96	93
Huishoudens als werkgever van huishoudelijk personeel	SBI97	95

Source: CBS

8. Appendix: Predicted growth per WLO scenario

Branch code (see Appendix 6)	RC mutation 2001-2020	RC mutation 2021-2040	SE mutation 2001-2020	SE mutation 2021-2040	TM mutation 2001-2020	TM mutation 2021-2040	GE mutation 2001-2020	GE mutation 2021-2040
A	-2,90%	-2,10%	-2,90%	-2,10%	-2,50%	-2,30%	-2,40%	-1,90%
B	-1,50%	-1,70%	-0,70%	-0,90%	-0,20%	-0,80%	0,30%	0,80%
C	-0,90%	-1,80%	-0,50%	-1,30%	0,10%	-1,40%	-0,80%	-2,10%
D	-1,30%	-1,90%	-0,80%	-1,90%	-0,80%	-2,20%	-1,00%	-2,10%
E	-2,30%	-1,80%	-2,00%	-2,40%	-1,80%	-2,40%	-2,30%	-2,50%
F	-0,50%	-1,50%	-0,30%	-2,40%	1,50%	0,00%	1,20%	0,50%
G	-5,30%	-3,60%	-5,70%	-2,70%	-5,40%	-3,20%	-5,80%	-3,00%
H	0,10%	-0,40%	0,30%	0,20%	0,40%	-0,20%	0,90%	0,80%
I	-1,40%	-2,50%	0,00%	-0,80%	-0,30%	-0,60%	1,20%	0,50%
J	-0,50%	-1,10%	0,90%	-0,30%	0,50%	-0,50%	1,40%	0,80%
K	-0,10%	-0,60%	0,10%	0,30%	1,00%	-0,10%	1,00%	0,30%
L	0,10%	-0,90%	0,30%	-0,40%	0,60%	-1,10%	1,10%	0,80%
M	0,40%	0,40%	0,30%	0,70%	0,20%	0,70%	1,30%	2,00%
N	-0,20%	-0,50%	0,60%	-0,20%	0,50%	-0,40%	1,20%	-0,20%
O	-0,20%	-0,70%	-0,10%	-0,30%	0,00%	-0,50%	0,50%	-0,30%
P	-0,10%	-0,90%	0,30%	-0,20%	0,40%	-0,70%	1,20%	-0,70%
Q	0,70%	0,50%	1,50%	1,20%	1,50%	1,20%	1,90%	1,70%
R	0,60%	-0,20%	0,70%	0,20%	0,00%	-0,40%	0,10%	0,00%
Totaal	**-0,30%**	**-0,70%**	**0,20%**	**-0,10%**	**0,30%**	**-0,30%**	**0,70%**	**0,20%**

Note that the WLO scenario mutation have been tested and dismissed because of large discrepancies with the local development of Eindhoven (GA).

9. Appendix: Estimation Methods

Demographic Methods

The simplest of these methods is the 'population method'. It estimates the spatial demand (SD) needed by multiplying the used space area per 1000 inhabitants (TQ) with population prognoses ($P_{p,t}$).

$$SD_t = TQ * (1 + P_{p,t}) \qquad \textbf{(A)}$$

The 'fervour method' is a more refined variation of this method; it does not consider the entire population, but uses working population prognoses ($P_{wp,t}$). Mostly this method is refined with a correction factor because not all growth in employment will be absorbed by industrial areas.

$$SD_t = TQ * P_{wp,t} \qquad \textbf{(B)}$$

This correction is also used in the 'demographic method' but it uses a correction for historic deviation. These methods are very crude and have large deviations with reality.

Economic Methods

The 'mixed method' an economically orientated method is combined with a demographic like approach; it defines an employment factor (α) by correcting population prognoses and the working population prognoses. The corrected employment growth is then multiplied with a terrain quotient to estimate the needed space. These terrain quotients TQ_{bb} are based upon large datasets and extract the amount of square meters that are used by employees per business-branch.

$$SD_t = TQ_{bb} * P_{wp,t} * \alpha P_{p,t} \qquad \textbf{(C)}$$

The 'industrial method' is almost exactly the same but only considers the working population prognoses.

$$SD_t = TQ_{bb} * P_{wp,t} \qquad \textbf{(D)}$$

The ‘economic method’ is based on nationwide employment prognoses, multiplied with local terrain quotients $TQ_{(bb,rr)}$. The ‘confrontation method’ is similar to the economic method but only considers the deviations in employment and unemployment $(1 + \Delta P_{wp,t})$.
Lastly there is the ‘granting / industrial method’. It strongly resembles the industrial method but considers historical land grant in the process.

$$SD_t = \Delta SD_{t-1} * \left(TQ_{bb} * \left(1 + P_{wp,t}\right)\right) \qquad \textbf{(E)}$$

All of these methods have some interesting characteristics and are therefore analysed and combined into the BLM (Bedrijfslocaite Monitor) method, designed by the PBL (Planbureau voor de Leefomgeving).

Meso/Micro-economic Methods

These methods shine light on some new perspectives on the estimation methods. The ‘granting method’ is the overall simplest method. It reviews the historical land grants and then applies a rule of thumb to that, resulting in the amount $(2 < F < 5)$ needed in reserve. It is similar to the previously discussed rule of thumb.

$$SD_t = SD_{t-1} + (\Delta SD_{t-1} * F) \qquad \textbf{(F)}$$

It is often used by municipalities because of its simplicity or, which is more alarming, to raise professionally calculated amounts (Knoben & Traa, 2008). This is actually unwise for long term planning and can only be used in short term planning. Planning based upon previous years as if the future will resemble those years is brusque. Patterns in our society are much more complicated than projecting the past few years onto the future. Only in the boom of the business cycle it is possible to look at economic developments like a pattern, however in all other quarters of the business cycle, one has to accept that the system is much more complicated. Continuing to look at the future this way will result in a classical pig cycle, characterised by overshoots and collapses. It is crude and will not be able to cope with business cycle waves.

Then there is the ‘company consultation method’; this method does not concern any demographic factor or terrain quotient. The method bases its prognoses on interviews and surveys with entrepreneurs. It is an intensive method and is only used on a low scale level. Extraordinary is that this is the only bottom up method with a high locational quality. However it lacks the ability to look out of its small scale borders because of its intensity and therefore misses out on large scale trends.

The ‘demographic company simulations method’ is a theoretic method which would combine small scale company consultation on a nationwide level. This would lead to extremely accurate estimations. Nevertheless it is never applied on a nationwide scale because of the labour intensity. Secondly, it would neglect international trends and would need a correctional factor for this. Lastly, it would not be able to look far ahead since it would only look as faras entrepreneurs would, which is often not sufficient for the land market.

Not using the terrain quotient but something similar is the ‘building stock method’. It is not based on the amount of people per square meter, but the value of the building per square meter. It uses changes in production volume multiplied with this value per square meter to predict the need for industrial land. However this method is very sensitive for different branches and there is not enough information about the stock value in the Netherlands. Also will this value quotient not be constant and is in need of a correctional factor over time. This method is not differentiating between locations so it is useful for function mixing as well.

The physical method is similar to the terrain quotient methods, though it does not consider employment in its estimates. It is a method designed for large scale physical production mostly found in harbours. The volume quotient (VQ) is often calculated in tons/m² and is then multiplied with estimated production and transportation volume (V). Unfortunately the growth of production volume is hard to estimate and lacks theoretical support.

$$SD_t = VQ * (\mathrm{V} + \Delta V_{t-1}) \qquad \textbf{(G)}$$

Lastly there is the timeline analysis,it uses historical grants of industrial land, which is then combined with data of economic developments to extrapolate relations between several variables. Then estimations are made for future developments of the economic variables. With these estimations it is possible to calculate medium term predictions for the land granting. It is able to check policies for effectiveness within a short period of time and it is able to identify conjuncture deviations. Knoben & Traa are very enthusiast about this method and plan to use it to combine it with the BLM that Arts, Ebregt & Stoffers developed.

10. Appendix: BLM Formulas

The demand for business locations is calculated for a specific branch (bb), region (rr) location type (ll) and year (t). The BLM has 6 sectors with 18 business branches and 40 regions (COROP). Formula H is used to calculate the spatial demand:

$$SD_{(rr,bb,ll,t)} = EG_{(rr,bb,t)} * LVQN_{(rr,bb,ll,t)} * TQ_{(rr,bb,ll,t)} \quad \textbf{(H)}$$

$SD_{(rr,bb,ll,t)}$ = **Spatial demand** per region, branch and location type in a year

$EG_{(rr,bb,t)}$ = **Employment** per region and branch in a year

$LVQN_{(rr,bb,ll,t)}$ = **Location type preference** per region, branch and location type in a year

$TQ_{(rr,bb,ll,t)}$ = **Terrain quotient** per region, branch and location type in a year

Because the terrain quotient is the most deviant factor in the equation, it is multiplied by a calibration factor to resemble a more realistic figure. This is done by formula I:

$$TYQN_{(rr,bb,ll)} = TQQN_{(rr,bb,ll)} * YKQN_{(rr,bb,ll)} \quad \textbf{(I)}$$

$TYQN_{(rr,bb,ll)}$ = **Calibrated terrain quotient** for a region, branch and location type

$TQQN_{(rr,bb,ll)}$ = **Uncalibrated terrain quotient** for a region, branch and location type

$YKQN_{(rr,bb,ll)}$ = **Calibration quotient** for a region, branch and location type

In which $YKQN_{(rr,bb,ll)}$ is calculated in formula J:

$$SD\ ibis_{(rr,ll,tm)} = YKQN_{(rr,bb,ll)} * \sum_{bb} SD_{(rr,bb,ll,2001)} \quad \textbf{(J)}$$

$SD\ ibis_{(rr,ll,tm)}$ = the **actual spatial demand** on location type ll proven in the year tm

$\sum_{bb} SD_{(rr,bb,ll,2001)}$= the sum of the modelled results for the same year

The modification of the terrain quotient does not stop there. With formula K the terrain quotient is adapted for the nationwide redistribution of businesses:

$$TQQPMZ_{(rr,bb,BT,t)} = \frac{1}{6} * APQPNL_{MS}(t) \qquad \textbf{(K)}$$

$TQQPMZ_{(rr,bb,BT,t)}$ = the annual **change in terrain quotient** for a branch on business parks in the region of Noord-Brabant in year (t)

$APQPNL_{MS}(t)$ = annual **change in productivity** of the sector in the Netherlands

Traa & Declerck also spotted a trend in the location preference and composed formula L based on their regression values:

$$LVQD_{(rr,bb,t)} = max\{0.0, \alpha_{(sec)} * \left[\gamma_{(sec)}\text{-}LVQN_{(rr,bb,t\text{-}1)}\right] + \beta_{(sec)} * \frac{AUOP_{(rr,bb,TO,t)}}{100}\} \qquad \textbf{(L)}$$

In which:

$LVQD_{(rr,bb,t)}$ = the **yearly variance** in locational preference for a branch, region

$\max\{a, b\}$ = **the maximum** of the two arguments, preventing a negative number

$\alpha_{(sec)}$ = **parameter** of the branch regressed from the data

$\gamma_{(sec)}$ = **parameter** of the branch regressed from the data

$\beta_{(sec)}$ = **parameter** of the branch regressed from the data

$LVQN_{(rr,bb,t\text{-}1)}$ = the **locational preference** of last year for the same branch and region

$AUOP_{(rr,bb,TO,t)}$ = the annual **employment growth** of the branch on all locations in that year

11. Appendix: Frequency Table Business Dataset

Terrain\Branch	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Tot.
Akkereind Zuid	0	0	0	1	1	0	0	0	0	0	3	0	3	0	0	4	1	0	**13**
T Broek	0	2	9	3	14	0	0	0	10	3	43	7	8	2	0	20	2	5	**128**
Bleek	0	3	5	2	13	0	0	0	18	1	55	3	8	3	1	27	12	7	**158**
De Run 6000	0	1	1	0	3	0	0	0	0	1	9	0	2	0	0	8	0	0	**25**
Kempenbaan/Locht-	0	0	2	1	4	0	0	0	15	0	14	1	4	1	0	22	1	3	**68**
De Kade	0	4	13	0	5	0	0	2	6	2	70	5	7	2	1	42	15	5	**179**
Rapenland	0	0	2	0	0	0	0	0	7	3	16	4	4	1	0	20	6	8	**71**
Driehoeksbosch	0	0	3	0	1	0	0	0	4	1	5	0	2	2	3	19	0	3	**43**
De Tempel	0	1	3	1	2	0	0	1	4	3	35	1	5	1	2	18	8	4	**89**
Kapelbeemd	0	1	9	6	13	0	0	1	19	0	58	9	7	2	0	39	2	6	**172**
Achtste Barrier	0	1	3	4	7	0	0	0	24	3	66	5	9	3	4	43	4	11	**187**
Woenselse Heide	0	0	0	0	0	0	0	0	0	0	28	1	4	4	0	13	0	0	**50**
Blixembosch	0	0	3	0	1	0	0	0	0	0	1	0	1	2	0	13	1	5	**27**
Esp	0	0	10	1	6	0	0	0	8	1	43	0	10	4	1	32	1	3	**120**
Herzenbroeken	0	0	2	0	2	0	0	0	2	0	16	1	1	0	1	17	0	0	**42**
GDC Acht (Zuid)	0	0	2	1	1	0	0	0	1	0	23	28	4	1	4	20	0	0	**85**
De Hurk/Croy	0	4	34	9	39	0	0	2	50	8	173	6	31	7	11	132	16	5	**527**
Flight Forum	0	0	1	0	3	0	0	0	2	0	13	7	8	2	8	17	5	1	**67**
Eindhoven Airport	0	2	8	0	12	0	0	2	6	2	67	18	26	8	10	98	4	7	**270**
Bleekvelden	0	0	2	0	1	0	0	0	2	0	6	0	2	1	1	7	4	2	**28**
Berkenbosch -	0	1	5	2	1	0	0	0	6	1	45	1	7	3	2	33	5	2	**114**
Uitbr. Berkenbosch	0	0	4	3	1	0	0	1	5	0	13	0	3	1	0	18	0	1	**50**
Eeneind II	0	4	10	7	12	0	0	1	15	0	62	6	4	0	1	32	0	1	**155**
Eeneind I	0	1	6	1	10	0	0	0	1	0	22	1	2	0	1	16	0	2	**63**
T Zand	0	0	14	6	11	0	0	0	18	1	69	4	8	1	2	25	2	7	**168**
Breeven	0	0	6	6	19	0	0	1	13	2	62	3	13	4	2	59	2	8	**200**
Oudven	0	1	5	0	5	0	0	0	8	0	15	1	3	1	1	9	1	1	**51**
De Smaale	0	1	4	0	5	0	0	0	5	0	16	2	1	0	0	11	1	2	**48**
De Ronde	0	0	2	0	0	0	0	0	5	0	6	0	1	1	3	11	0	3	**32**
Spaarpot	0	0	10	4	15	0	0	2	12	1	29	6	1	0	0	18	0	1	**99**
Twekaterrein	0	0	1	0	1	0	0	0	0	0	5	0	3	0	0	3	0	1	**14**
De Run 7000	0	0	5	0	0	0	0	0	6	0	7	0	0	0	0	7	0	3	**28**
Zandven	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**2**
De Hoge Akker	0	0	2	1	2	0	0	0	6	0	7	3	0	0	0	8	0	0	**29**
Vlier-Hulst	0	0	1	0	2	0	0	0	6	0	5	2	0	0	0	4	1	0	**21**
Emopad	0	1	6	0	6	0	0	0	7	0	19	2	2	0	0	13	5	1	**62**
De Barrier	0	0	1	0	1	0	0	0	1	0	4	0	0	0	0	1	0	0	**8**
Health Tech. Prk.	0	0	2	0	1	0	0	0	0	0	2	0	0	0	1	4	37	0	**47**
Heide	0	0	1	0	0	0	0	0	0	0	4	1	0	0	2	5	2	1	**16**
Habraken	0	1	3	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	**6**
High Tech Campus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	**3**
BeA2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	**3**
Kerkakkers	0	0	0	0	1	0	0	0	2	0	2	0	0	0	0	2	0	0	**7**
Bestpoint	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	2	0	0	**8**
Bijenkorf	0	0	0	0	0	0	0	0	0	0	3	1	1	0	0	1	0	0	**6**
Geldropseweg	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	**3**
GDC Acht	0	0	1	0	0	0	0	0	0	0	2	2	0	0	0	1	0	0	**6**
DAF Zuid	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Total	**0**	**29**	**204**	**59**	**221**	**0**	**0**	**13**	**297**	**33**	**1149**	**132**	**195**	**57**	**63**	**900**	**138**	**109**	**3599**

Branch codes 0 = A; 1=B; 2=C; … etc

12. Appendix: Frequency Table Attributes

Discrete variables		Description	Frequency
Branch	A	Agriculture and Fisheries	0
Discrete	B	Food and beverage industry	29
	C	Remaining Industry	204
	D	Chemical, Rubber- en Synthethics Industry.	59
	E	Metalektro-industry	221
	F	Oil and Refineries	0
	G	Mining and Quarrying	0
	H	Public Utilities	13
	I	Construction and Installation Companies	297
	J	Rental and Real Estate	33
	K	Trade and Repair Companies	1149
	L	Transport- and Storage Companies	132
	M	Communication Companies	195
	N	Bank- en Insurance Companies	57
	O	Employment Agencies and Facility Management	63
	P	Other Tertiary Services	900
	Q	Healthcare	138
	R	Government	109
Size	A	Class 1 - 0 employees	0
Discrete	B	Class 2 - 1 employees	1073
	C	Class 3 - 4 employees	1047
	D	Class 4 - 9 employees	504
	E	Class 5 - 15 employees	384
	F	Class 6 - 35 employees	356
	G	Class 7 - 75 employees	142
	H	Class 8 - 125 employees	56
	I	Class 9 - 300 employees	27
	J	Class 10 - 600 employees	2
	K	Class 11 - 875 employees	0
	L	Class 12 - 1000 employees	8
Minimally built percentage	A	< 50 %	212
Continuous	B	50 - 65 %	3187
	C	> 65 %	200
Maximally built percentage	A	< 80 %	1209
Continuous	B	80 -90 %	1196
	C	> 90 %	1194
Max environmental category	A	≤ 3	1514
Continuous	B	≥ 4	2085
Representation	A	Mixed-use terrain	3064
Discrete	B	High-end-use terrain	535
View location	A	Yes	294
Discrete	B	No	3305
Park management	A	Yes	1590
Discrete	B	No	2009
Parking possibilities	A	Sufficient	2163
Discrete	B	Insufficient	1436
Distance to Highway Entrance/Exit	A	0 - 500 m	732
Continuous	B	500m - 1km	1008
	C	1km - 2,5km	958
	D	> 2,5km	901

Distance to airport Continuous	A	< 2km	339
	B	> 2km	3260
Accessibility Public transport Continuous	A	Sufficient	2133
	B	Insufficient	1466
Distance to city centre Continuous	A	< 2 km	121
	B	2 - 5 km	190
	C	> 5 km	3288
Distance to living area Continuous	A	< 200 m	1970
	B	> 200 m	1629
Clustering Discrete	A	Above Average	2582
	B	Below Average	1017
Landprice Continuous	A	< 140 €	653
	B	140€ - 169€	430
	C	≥ 170 €	70

13. Appendix: Frequency Table Attributes

Discrete variables\	Branch	B	C	D	E	H	I	J	K	L	M	N	O	P	Q	R
Size	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	1	43	11	41	1	91	18	323	28	66	15	12	322	58	43
	C	9	66	18	44	1	59	11	398	24	57	24	24	253	28	31
	D	3	32	10	35	0	44	2	171	15	26	5	12	118	20	11
	E	3	24	7	38	1	39	1	128	15	20	6	5	78	10	9
	F	5	27	8	31	5	41	0	83	23	18	5	8	79	13	10
	G	6	6	1	22	2	20	0	30	14	4	1	2	27	2	5
	H	1	3	4	6	2	2	1	11	7	3	1	0	12	3	0
	I	1	2	0	3	1	1	0	5	6	1	0	0	5	2	0
	J	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
	K	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	L	0	1	0	1	0	0	0	0	0	0	0	0	4	2	0
Minimally built percentage	A	0	7	6	19	1	15	2	68	3	13	4	3	61	2	8
	B	29	181	47	191	12	259	30	1006	125	173	51	55	803	134	91
	C	0	16	6	11	0	23	1	75	4	9	2	5	36	2	10
Maximally built percentage	A	11	67	15	71	7	83	12	388	40	72	19	25	336	39	24
	B	11	77	22	92	2	139	10	377	38	55	12	10	236	71	44
	C	7	60	22	58	4	75	11	384	54	68	26	28	328	28	41
Environmental category	A	14	78	25	81	3	144	15	485	35	75	26	22	366	83	62
	B	15	126	34	140	10	153	18	664	97	120	31	41	534	55	47
Representation	A	26	181	58	196	11	281	29	1015	107	149	43	43	736	91	98
	B	3	23	1	25	2	16	4	134	25	46	14	20	164	47	11
View location	A	1	6	2	7	2	11	2	76	10	33	9	9	112	6	8
	B	28	198	57	214	11	286	31	1073	122	162	48	54	788	132	101
Park management	A	17	96	24	109	5	140	16	507	44	89	23	23	367	93	37
	B	12	108	35	112	8	157	17	642	88	106	34	40	533	45	72
Parking possibilities	A	19	121	34	129	7	168	23	667	63	129	36	46	577	90	54
	B	10	83	25	92	6	129	10	482	69	66	21	17	323	48	55
Distance to Highway Entrance/Exit	A	4	50	16	52	2	69	9	253	11	42	8	15	167	21	13
	B	9	47	11	71	3	69	9	286	40	69	22	24	277	31	40
	C	8	48	20	43	3	66	8	329	45	45	13	17	234	55	24
	D	8	59	12	55	5	93	7	281	36	39	14	7	222	31	32
Distance to airport	A	1	10	0	15	2	8	2	80	25	34	10	18	117	9	8
	B	28	194	59	206	11	289	31	1069	107	161	47	45	783	129	101
Accessibility Public transport	A	23	118	27	130	8	176	21	690	99	114	33	31	533	62	68
	B	6	86	32	91	5	121	12	459	33	81	24	32	367	76	41
Distance to city centre	A	2	6	0	0	2	3	2	47	3	5	2	1	31	14	3
	B	2	15	3	4	1	14	5	58	5	7	2	2	49	13	10
	C	25	183	56	217	10	280	26	1044	124	183	53	60	820	111	96
Distance to living area	A	15	109	29	94	6	186	16	663	44	105	27	30	485	85	76
	B	14	95	30	127	7	111	17	486	88	90	30	33	415	53	33
Clustering	A	19	155	42	165	8	194	20	905	97	142	36	43	584	94	78
	B	10	49	17	56	5	103	13	244	35	53	21	20	316	44	31
Land price	A	25	141	48	166	9	230	27	886	93	137	40	39	664	121	83
	B	4	61	11	52	4	65	6	250	32	50	15	16	217	12	25
	C	0	2	0	3	0	2	0	13	7	8	2	8	19	5	1

14. Appendix: Agent-based Modelling

Agent-based Modelling and Simulation (ABMS) is a modelling technique for complex systems composed of interacting, autonomous decision makers. The decision makers are called 'agents'. An agent is programmed in the model to behave in a certain way. With this behaviour the agent interacts and influences other agents. Agents can be programmed to learn and adapt their behaviour. An agent-based model consists of three fundamental elements:

- Agents
- Relationships & Interactions
- Environment

Agents act based upon the rules of interaction and relationships with their environment and/or other agents. ABMS allows the crossing of the macro and micro levels. In these simulations an understanding can be formed of the influence of high-level structures on low-level agent interactions and vice versa. This method is ultimately well fitted for the bridge between macro-economic developments, as employment growth, and micro economic decision making, like the relocation of a company.

For programming the model NetLogo is used. NetLogo is a multi-agent programmable modelling environment. It is used by thousands of researchers worldwide. It was first created in 1999 by Uri Wilensky at the Center for Connected Learning and Computer-Based Modelling. NetLogo is particularly well suited for modelling complex systems developing over time. Modellers can give instructions to hundreds or thousands of 'agents', all operating independently. This makes it possible to explore the connection between the micro-level behaviour of individuals and the macro-level patterns that emerge from their interaction (Wilensky 1999).

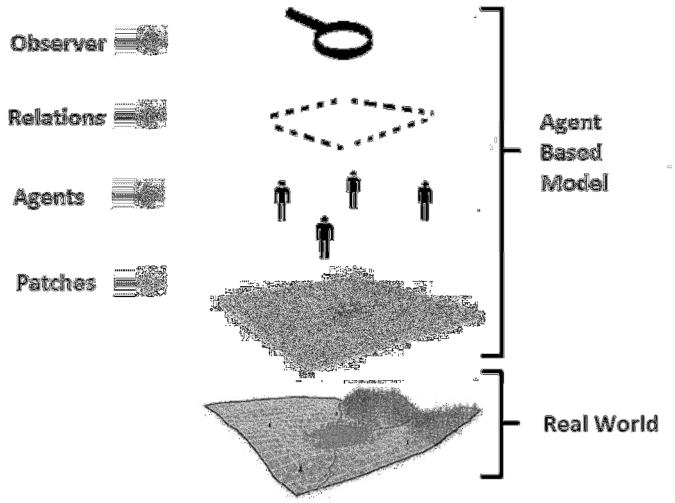


Figure 9.5: The Components of an Agent Based Model

There are four types of agents in NetLogo: turtles, patches, links and the observer. Turtles are the most flexible form of agents and are able to move around and can be categorised into breeds. The environment consists of a grid of patches which can either be formed as a cylinder, a ball or a flat map. Links are connections formed between agents, which can serve as a form of memory. The observer is the observing entity. Patches and turtles are not able to oversee the entire model and can therefore refer to the observer for information. The user of the model is also able to use the observing entity to capture data.

15. Appendix: Model Setup Elaboration

In the setup phase the ‘world’ is created. The world is the simulated area, with the included characteristics. These are loaded from a prepared GIS-shapefile. This file contains the geographical shapes of the terrains and their characteristics. The setup will apply the values of these terrains to a raster grid, which will simulate the spatiality of the considerations of the agents. A second GIS-shapefile overlaps the last one and informs patches if they are a view location or not.

In the second step of the setup, the model will address a last GIS-shapefile. This file contains the companies with their branch, location and size. The model will create a company and a premise for each of these companies. Next it creates some more premises to meet the vacancy rate on each terrain. All unknown averages, as company clustering, can now be update and the setup can be concluded.

In this step there are some uncertainties which deal with a normal distribution. The first is the unknown of current spatial demand. Companies do not have to fit their current location perfectly at the start of the model, therefore there is a deviation from their current premise. This will ensure that the model will have dissatisfied companies from the start of the model and will not be idle the first few years of the simulation because companies will grow more and more dissatisfied. It is impossible to subtract this current dissatisfaction with space from any data and is therefore randomly generated.

Vacancy is not provided with the LISA dataset and has to be assumed. Empty premises are generated with a size and in quantity, according to data provide by the municipalities. The data supplied is unfortunately not on the same level of detail as the LISA database and vacancy is therefore distributed evenly over all terrains.

16. Appendix: Data preparation

The required data is not found purely in the prepared form as described above and must be prepared through a series of preparations. The incipient models, the BLM and the Bayesian Network will combine rough data and extract the data needed for the ABM. In Figure 9.6 the flowchart of the data preparation is given and the processes are described below.

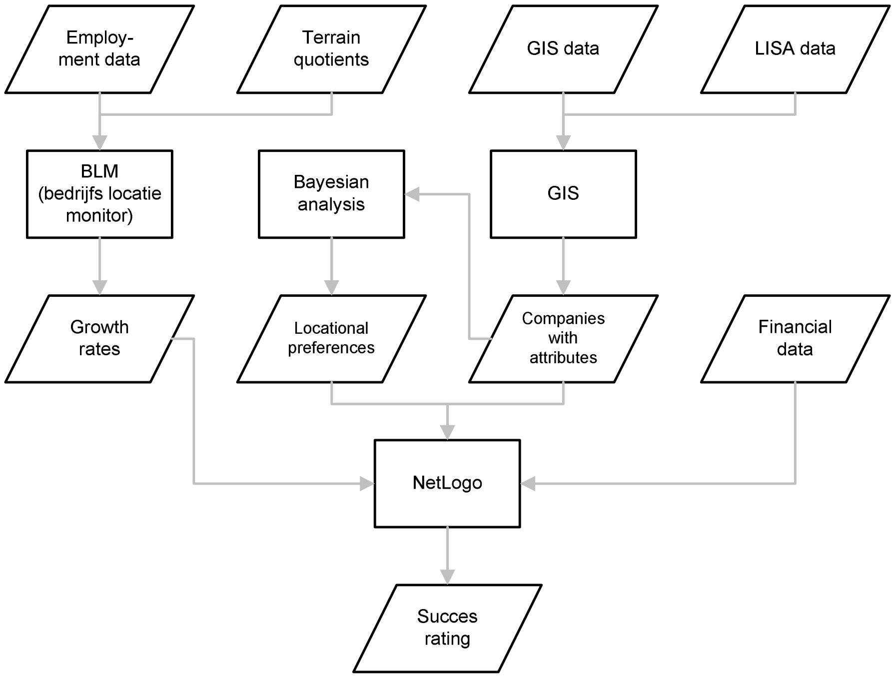


Figure 9.6: Flow chart of the data flows

For the input in of the BLM model the terrain quotients are combined with employment data supplied by the municipality of Eindhoven. In an excel sheet, which contains past employment developments and employment prognoses, the growth rates are produced. The BLM uses the terrain quotients which were derived from a national database for the BLM by the PBL. These sheets result in the spatial growth of each business branch in percentages. These percentages form the input of the ABM.

For the terrain data a ‘shapefile’ is created. This file type is a GIS file which is readable for an agent base model. The shapefile contains all the terrain characteristics: the quantity aspects retrieved from the IBIS database and the quality aspects described in Table 4.4, retrieved from municipal archives and land-use plans. A second, third and fourth shape-file are created to geographically locate view locations, living areas and roads respectively.

The LISA foundation maintains a database which contains the addresses and SBI-codes of over a million companies in the Netherlands. By applying a GIS analysis to this dataset the companies can be placed onto their original location in a GIS file. With this file a fifth shapefile is created with the companies. Each company is represented by a feature in this file, which contains the location size and branch of the company. The data for this research was provided by the province of Noord-Brabant and contains the size, location and business branch of 29.161 companies in the case study area. This dataset can now be combined with the other shapefile-layers to extract the company characteristics. Through a GIS intersect procedure all of these features (representing a company) obtain the values described in Table 4.4 and can now be analysed with a Bayesian network.

With all data obtained with the GIS analysis it is possible to categorise all the attributes to their respective levels. The levels of the attributes are defined with Orme (2002), ranges are defined so that the mean cuts them into equal parts so deviations from normal will be noticed. Now the data must be exported to Netica in a case-file. Netica is a powerful, easy-to-use complete program for working with Bayesian networks and influence diagrams by the Norsys software corporation. From the 'case file' Netica learns the network's nodes, cases and probabilities. These probabilities are then exported into an excel file for use in the NetLogo model.

It was also found that the data from all resources was not all consistent and a lot of corrections had to be made. The IBIS data from the Ministry of Infrastructure and the Environment was the most inconsistent. It was far into the research, that these inconsistencies were discovered. For example attribute levels of train accessibility were incorrectly assigned e.g. railway connections to locations which had no railways in its proximity. If the data was naively incorrect or a merely a mistake cannot be said.

17. Appendix: Data Overview

Data	Conditions	Source(s)
Terrain data	Shapefile of all terrains, prepared with GIS to contain the following variables: *Terrain name, surface area, surface area used, Minimally built percentage, Maximally built percentage, Lot size, Environmental category, Branch exclusion, Surface of view location (Dutch: zichtlocatie), Terrain stamp (High-end- or Mixed-use), Park management, Parking possibilities, Accessibility by car, Distance to city centre, Distance to bus stop, Distance to airport, Distance to living area, Clustering of companies, Land price.*	IBIS, Land-use plans.
Exogenous terrain data	Shapefile of roads and living areas.	Land-use plans.
Economic developments	Excel file with terrain demand predictions for the designated branches. To be produced with the BLM.	BLM, CBS, Municipal records
List of costs	An excel file with the following costs for each branch: Average building costs per surface area, Average costs for moving per surface area.	Bouwkosten monitor, Kontek,
Preference weights	The preference weights for the model can either be reused or it can be decided to recalculate them. For recalculation the data needed is a list of companies on business parks in the study area with the following extra data: *SBI-code (branch coding), Postal code (location of the company), Surface area of the company.*	LISA, Municipal records, Provincial records

18. Appendix: WLO Validation

The result of the realisation according to the model against the WLO predictions in the model are displayed in Figure 9.7. Here it can be seen that the parameters are performing poorly on short term predictions. The economy immediately surpasses the highest expectations and then suddenly collapses. These short term miss-matches are also the debate in the report of the Centraal Planbureau and are rejected as business cycle influences. In the long term it can be seen that the developments closely resemble the trend described by the transatlantic market scenario. So the TM scenario of the WLO has proven to be quite accurate on this scale level (conurbation Eindhoven).

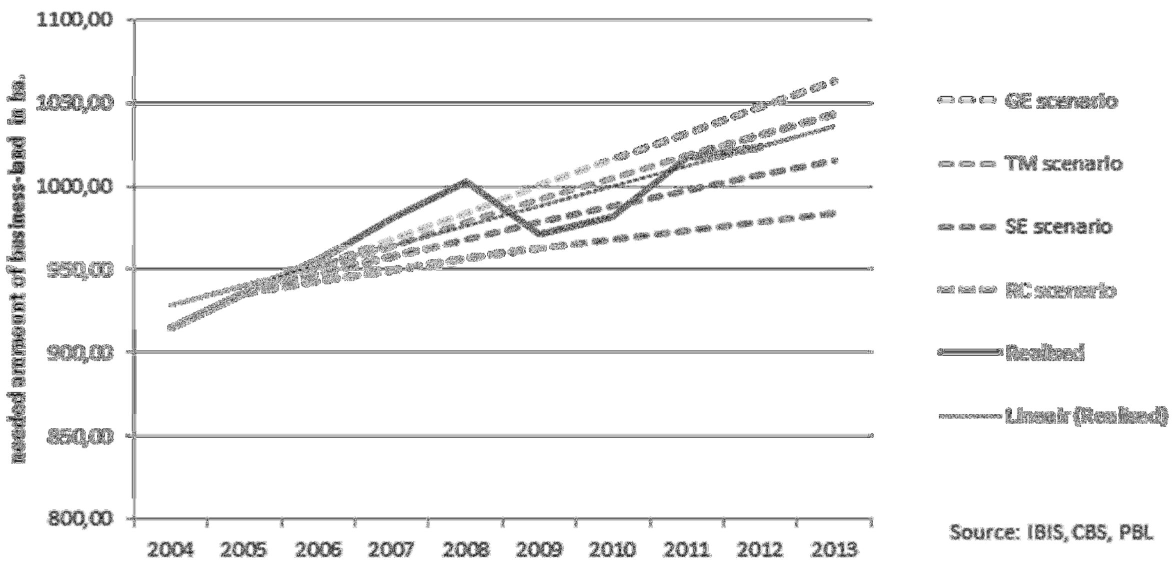


Figure 9.7: Graph of the prediction of Eindhoven (GA)

As accurate as the results look, the developments on a micro level show huge differences per business branch. The developments in Eindhoven deviate heavily from one singular WLO rate and therefore need adjustment. As stated before, the WLO scenarios are parameters in which real policy making will move and will sometimes exceed or undershoot expectations. Also the scale differs greatly; the WLO is made on a national level and these predictions are made on a regional level. Therefore different branches can follow different courses, as the rest of the Netherlands in this region. Some markets are internationalising, while there are sectors where a trend of regionalising can be seen (De Kort 2003). As for the other unknown, some big differences can be seen in privatisation as well. As governmental subsidiaries are privatised, one can see more meddling of the government in other sectors and even de-privatisation can be seen as an upcoming trend. So with no certainty, one of the WLO scenarios can be chosen as the probable one. Only a few branches seem to accurately follow the WLO trends and even fewer branches follow the same line as the Netherlands. The huge discrepancy (see Figure 9.8) of the current trends towards the predicted ones is significant and therefore dismisses the use of WLO scenarios for this scale.

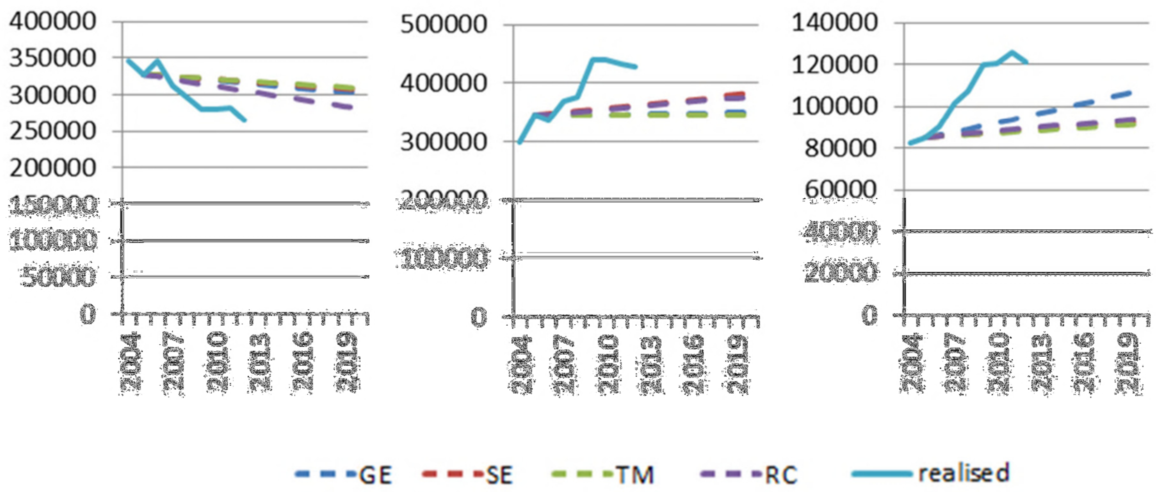


Figure 9.8: WLO predictions against local developments on branch scale; from left to right : (1) Chemical and synthetics processing, (2) Government and (3) Communication companies

This coincides with the criticism of Dinteren et al. (2007) and the results from Beckers, Schuur & Traa (2012), that criticise the BLM for use of national WLO predictions on a smaller scale. These scenarios are just not representative for local focusses, policies and trends.

19. Appendix: Employment Extraction

As an adaptation, new growth predictions are made based upon employment growth data over the last years. Extreme outliers are reassessed and a new coefficient is calculated for them. These will be used for the rest of the research. The results from the employment growth developments can be seen in Table 9.1. The most notable deviation from the predicted ones are the chemical industry, which has shrunk (-2,1 percent a year) significantly faster between 2004 and 2011 than expected . The communication companies' growth overshot the expectations (3 percent a year) between 2004 and 2011. This could be due to the focus of Eindhoven as a technology centre. The unexpected deviation of employment agencies and facility management could be explained due to the outsourcing trend. The deviation in growth in healthcare can be due to the fact that in the region of Eindhoven (GA) there are three major hospitals (Catherina -, Maxima -, St. Anna - hospital) in which the growth is representing the total region. The total dataset used for this is shown in Table 9.2.

Table 9.1: Growth Coefficients

Code	Business-branche	Scenario Resemblance	New growth Coefficient*
1.1 A	Landbouw en visserij	n/a	n/a
2.1 B	Voedings- en genotsmiddelenindustrie0.90	RC	**-1,5%**
2.2 C	Overige industrie	RC	**-0,9%**
2.3 D	Chemische, rubber- en kunststofverw. ind.	None	**-2,1%**
2.4 E	Metalektro-industrie	RC	**-2,3%**
2.5 F	Aardolie-industrie	n/a	n/a
2.6 G	Delfstoffenwinning	n/a	n/a
3.1 H	Openbare nutsbedrijven	TM	**0,4%**
4.1 I	Bouwnijverheid en –installatiebedrijven	RC	**-1,4%**
5.1 J	Verhuur van en handel in onroerend goed	SE	**-0,3%**
5.2 K	Handel en reparatiebedrijven	SE	**0,1%**
5.3 L	Transport- en opslagbedrijven	RC	**0,1%**
5.4 M	Communicatiebedrijven	None	**3,0%**
5.5 N	Bank- en verzekeringswezen	RC	**-0,2%**
5.6 O	Uitzendbureaus en huishoudelijke diensten	None	**2,7%**
5.7 P	Overige tertiaire diensten	GE	**1,2%**
6.1 Q	Gezondheids- en welzijnszorg	None	**2,8%**
7.1 R	Overheid	RC	**0,6%**

Sources: Municipality of Eindhoven, CPB, CBS

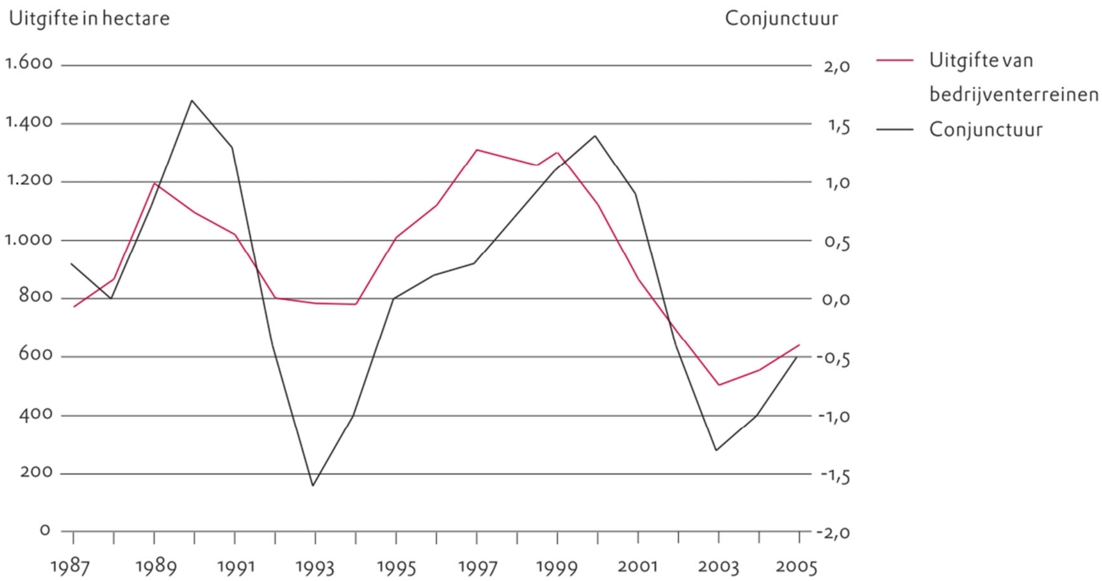
* = Because of low resemblance to one single scenario the new coefficients are recalibrated for the region Eindhoven with an exponential tangent with Eindhoven's supplied data .

Table 9.2: Employment Developments in Eindhoven (GA) per Branch

Bedrijfstak	2004	2005	2006	2007	2008	2009	2010	2011	2012
Landbouw en visserij	100	100	500	500	500	500	500	400	400
Voedings- en genotsmiddelenindustrie	1700	1600	1500	1500	1500	1400	1400	1400	1400
Overige industrie	6200	6200	6000	6200	6300	5500	5500	5500	5700
Chemische, rubber- en kunststofverw. ind.	2000	1900	2000	1800	1700	1600	1600	1600	1500
Metalektro-industrie	11500	11200	10700	10400	10000	9100	9100	9300	9200
Aardolie-industrie	0	0	0	0	0	0	0	0	0
Delfstoffenwinning	0	0	0	0	0	0	0	0	0
Nutsbedrijven	1100	900	800	800	800	900	900	1000	1000
Bouwnijverheid en -installatiebedrijven	7800	8000	8000	8000	8100	7000	7000	6900	6700
Verhuur van en handel in onroerend goed	1600	1900	1800	1900	1900	1800	1800	1800	1700
Handel en reparatiebedrijven	28200	28300	29500	30000	30500	28100	28100	28500	28600
Transport- en opslagbedrijven	7600	7700	7700	7400	7500	7200	7200	7700	7500
Communicatiebedrijven	6700	6900	7300	8200	8600	9600	9600	10000	9600
Bank- en verzekeringswezen	8400	8300	7800	7400	7400	7100	7100	7100	6400
Uitzendbureaus en huishoudelijke diensten	1800	1900	2100	2300	2300	2400	2400	2400	2500
Overige tertiaire diensten	37700	39700	42000	44700	46100	46700	46700	48000	47800
Gezondheids- en welzijnszorg	24900	25400	27400	28800	28700	31900	31900	33200	35000
Overheid	17900	20600	20100	22100	22500	26200	26200	25800	25500
Totaal	165200	170600	175200	182000	184400	187000	187000	190600	190500

Sources: CBS, Gemeente Eindhoven

20. Appendix: Business cycle (conjunctuur) versus land grants (uitgifte)



Source: (Knoben & Traa, 2008)

21. Appendix: Regression values for timeline analysis

Year	Land granted	National employment	National employment -1	Business cycle indicator - 2
$x + 1988$	y	β_3	β_4	β_6
1989	26,60	3,49	2,94	-0,47
1990	23,10	2,12	3,49	-0,10
1991	18,59	1,28	2,12	0,74
1992	7,85	0,07	1,28	1,16
1993	12,20	0,36	0,07	0,96
1994	14,65	2,30	0,36	-0,42
1995	17,61	2,26	2,30	-1,47
1996	35,08	3,32	2,26	-0,53
1997	26,79	3,32	3,32	0,38
1998	23,29	3,73	3,32	-0,09
1999	30,22	2,61	3,73	-0,27
2000	13,54	2,35	2,61	-0,02
2001	18,60	0,66	2,35	0,28
2002	8,35	-0,44	0,66	1,24
2003	11,64	-1,17	-0,44	1,15
2004	4,77	-0,08	-1,17	-0,67
2005	8,49	1,58	-0,08	-1,29
2006	12,66	2,53	1,58	-0,81
2007	15,68	2,93	2,53	-0,91
2008	10,20	0,08	2,93	0,47
2009	4,79	-0,93	0,08	2,36
2010	5,01	0,01	-0,93	0,62
2011	6,73	1,36	0,01	-1,85
2012	6,65	-0,75	1,36	-0,51
2013		-0,15	-0,75	1,18
2014		0,30	-0,15	0,16

22. Appendix: Regression results time line analysis

Gegevens voor de regressive	
Meervoudige correlatiecoëfficiënt R	0,85372406
R-kwadraat	0,72884477
Aangepaste kleinste kwadraat	0,688171486
Standaardfout	4,814937809
Waarnemingen	24

Variantie-analyse	Vrijheidsgraden	Kwadratensom	Gemiddelde kwadraten	F	Significantie F
Regressie	3	1246,316705	415,4389016	17,9195	6,9E-06
Storing	20	463,672522	23,1836261		
Totaal	23	1709,989227			

	Coëfficiënten	Standaardfout	T- statistische gegevens	P-waarde
Snijpunt	6,996584714	1,503740689	4,652786724	0,000153
natemploy	3,605828645	1,092597625	3,300234745	0,003574
natemploylag1	2,07936079	0,949000477	2,191106158	0,040455
conjunctuur2lag	1,862906967	1,295581657	1,437892361	0,165928

Year	*Realised*	*Timeline Analysis*
1989	26,60	24,81
1990	23,10	21,72
1991	18,59	17,40
1992	7,85	12,08
1993	12,20	10,23
1994	14,65	15,26
1995	17,61	17,18
1996	35,08	22,68
1997	26,79	26,59
1998	23,29	27,18
1999	30,22	23,66
2000	13,54	20,86
2001	18,60	14,78
2002	8,35	9,10
2003	11,64	4,00
2004	4,77	3,03
2005	8,49	10,13
2006	12,66	17,90
2007	15,68	21,13
2008	10,20	14,26
2009	4,79	8,21
2010	5,01	6,25
2011	6,73	8,48
2012	6,65	6,17
2013		7,09*
2014		8,07**
2015		7,52 **

* Source CBS ** Source CBS, PBL

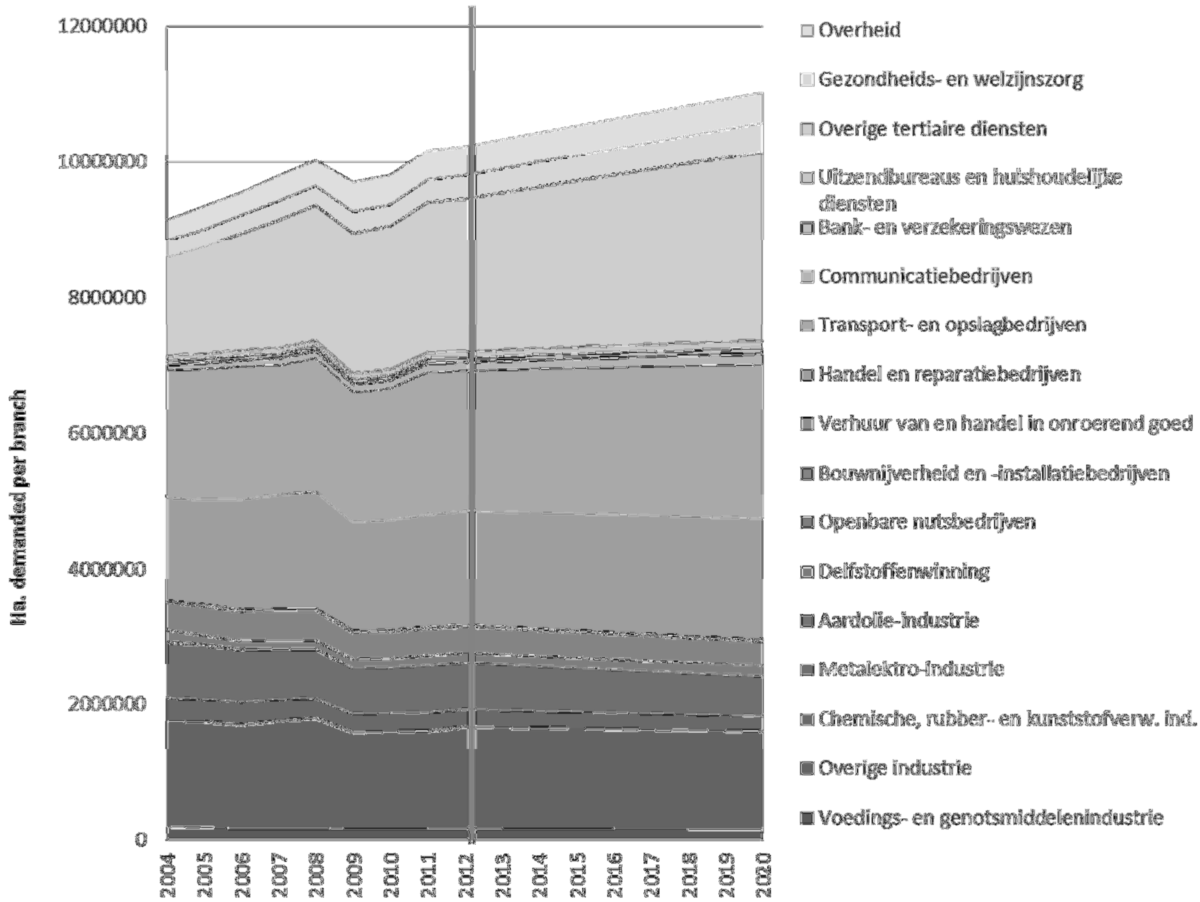
23. Appendix: Entropy reduction

Kolom1	Landbouv	Voedings	Overige i	Chemisch	Metalekt	Delfstoff	Aardolie	Openbare	Bouwnijv	Verhuur v	Handel e	Transport	Communi	Bank- en	Uitzendb	Overige t	Gezondh	Overheid
Clustering	0	0,015	0,067	0,03	0,07	0	0	0,009	0,082	0,018	0,15	0,049	0,064	0,027	0,031	0,141	0,053	0,043
Land price	0	0,011	0,047	0,021	0,049	0	0	0,006	0,058	0,013	0,106	0,034	0,045	0,019	0,022	0,1	0,037	0,03
Maximum	0	0,008	0,034	0,015	0,035	0	0	0,005	0,041	0,009	0,076	0,024	0,032	0,014	0,016	0,071	0,027	0,022
Terrain ty	0	0,007	0,032	0,014	0,033	0	0	0,004	0,039	0,008	0,072	0,023	0,031	0,013	0,015	0,067	0,025	0,02
Distance t	0	0,006	0,026	0,012	0,027	0	0	0,004	0,032	0,007	0,058	0,019	0,025	0,011	0,012	0,055	0,021	0,017
Distance t	0	0,005	0,022	0,01	0,023	0	0	0,003	0,027	0,006	0,05	0,016	0,021	0,009	0,01	0,047	0,018	0,014
View loca	0	0,004	0,018	0,008	0,019	0	0	0,002	0,022	0,005	0,04	0,013	0,017	0,007	0,008	0,038	0,014	0,012
Maximum	0	0,004	0,018	0,008	0,019	0	0	0,002	0,022	0,005	0,04	0,013	0,017	0,007	0,008	0,037	0,014	0,011
Distance t	0	0,004	0,017	0,008	0,018	0	0	0,002	0,021	0,005	0,039	0,012	0,016	0,007	0,008	0,036	0,014	0,011
Park man	0	0,004	0,016	0,007	0,016	0	0	0,002	0,019	0,004	0,035	0,011	0,015	0,006	0,007	0,033	0,012	0,01
Distance t	0	0,004	0,015	0,007	0,016	0	0	0,002	0,019	0,004	0,034	0,011	0,015	0,006	0,007	0,032	0,012	0,01
Accessibi	0	0,003	0,014	0,006	0,014	0	0	0,002	0,017	0,004	0,031	0,01	0,013	0,006	0,006	0,029	0,011	0,009
Minimally	0	0,003	0,014	0,006	0,014	0	0	0,002	0,017	0,004	0,031	0,01	0,013	0,006	0,006	0,029	0,011	0,009
Parking p	0	0,002	0,009	0,004	0,01	0	0	0,001	0,011	0,002	0,021	0,007	0,009	0,004	0,004	0,019	0,007	0,006

24. Appendix: Demand for land on business parks per branch in square meters.

Code/Branch		2004	2012	2020	Growth Ratio 2012-2020	Δ ha. 2012-2020
P	Other tertiary services	1460956	2252391	2780884	0,235	528493
L	Transport- and storage companies	1873411	2062479	2258579	0,095	196100
K	Trade and repair companies	1526584	1683121	1789821	0,063	106700
Q	Healthcare	248954	349935	436448	0,247	86513
M	Communication companies	82145	120994	156342	0,292	35348
O	Employment agency and facility management	64979	90249	111687	0,238	21438
R	Government	299598	426801	447723	0,049	20922
N	Bank- and Insurance companies	65796	72002	86764	0,205	14762
H	Public utility companies	173242	157493	162604	0,032	5111
J	Trade and rent of real estate	21841	27025	28948	0,071	1923
B	Food and beverage industry	210676	187724	175091	-0,067	-12633
I	Construction and installation industry	405568	375435	351937	-0,063	-23498
D	Chemical, rubber- and plastics processing industry	345069	265517	230712	-0,131	-34805
C	Other industries	1554399	1490747	1437964	-0,035	-52783
E	Metal-electro-industry	820113	673116	575390	-0,145	-97726
A	Agriculture and fisheries	n/a	n/a	n/a	n/a	n/a
F	Petroleum industry	n/a	n/a	n/a	n/a	n/a
G	Mining and quarrying	n/a	n/a	n/a	n/a	n/a

25. Appendix: Realised and forecasted demand for Eindhoven (GA)



26. Appendix: BLM Output

With this data the top demand branches and the top growth branches can be identified. In Table 9.3 can be seen that the tertiary sector is the largest consumer of land in business park in the area Eindhoven, followed by the transport branch and trading companies; all tertiary services (J-P) with growth. The last two of the top 5 are industrial consumers (B-G) with a shrinking share in the area of Eindhoven.

Table 9.3: Top demand branches in Eindhoven (GA) in hectares

Top demand branches		2012	2020	'12 - '20 Growth
P	Other tertiary services	225,2	278,1	23,5%
L	Transport- en storage companies	206,2	225,9	9,6%
K	Trading and repair companies	168,3	179,0	6,4%
C	Other industries	149,0	144,0	-3,6%
E	Metal-electro-industries	67,3	57,5	-14,6%

Source: BLM calculation

The top growth sectors show the largest growths that are taking place, these are displayed in Table 9.4. Almost all of these branches are tertiary services (J-P). Most notably is the aggregation of 'other tertiary services' which shows up in both lists and has the highest absolute demand and one of the top growth branches.

Table 9.4: Top growth branches in Eindhoven (GA) in hectares

Top growth branches		2012	2020	'12 - '20 Growth
M	Communication companies	12,1	15,6	29,2%
Q	Healthcare	35,0	43,6	24,7%
O	Employment agencies and facility management	9,0	11,2	23,8%
P	Other tertiary services	225,2	278,1	23,5%
N	Bank and insurance	7,2	8,7	20,5%

Source: BLM calculation

This is confirmed in the ranking of top absolute changes shown in Table 9.5. These are the most substantial changes in the Eindhoven area. The tertiary sector dominates with the highest three, followed by a major shrinking branch in the metal-electro-industries. Last of the top five is Healthcare with a substantial change of 8 hectares.

Table 9.5: op absolute changes in demand

Top demand absolute changes per branche		Change in demand in ha.
P	Other tertiary services	52,8
L	Transport- en storage companies	19,6
K	Trading and repair companies	10,7
E	Metal-electro-industries	-9,8
Q	Healthcare	8,7

Source: BLM calculation

The sum of these projections result in Figure 9.9; where the projected demand is shown with the WLO scenarios as reference. The new projections differ slightly from the projection in Figure 9.7, because all variables that dependent on growth prediction are recalibrated independent from the WLO scenarios. The total projection is now slightly lower.

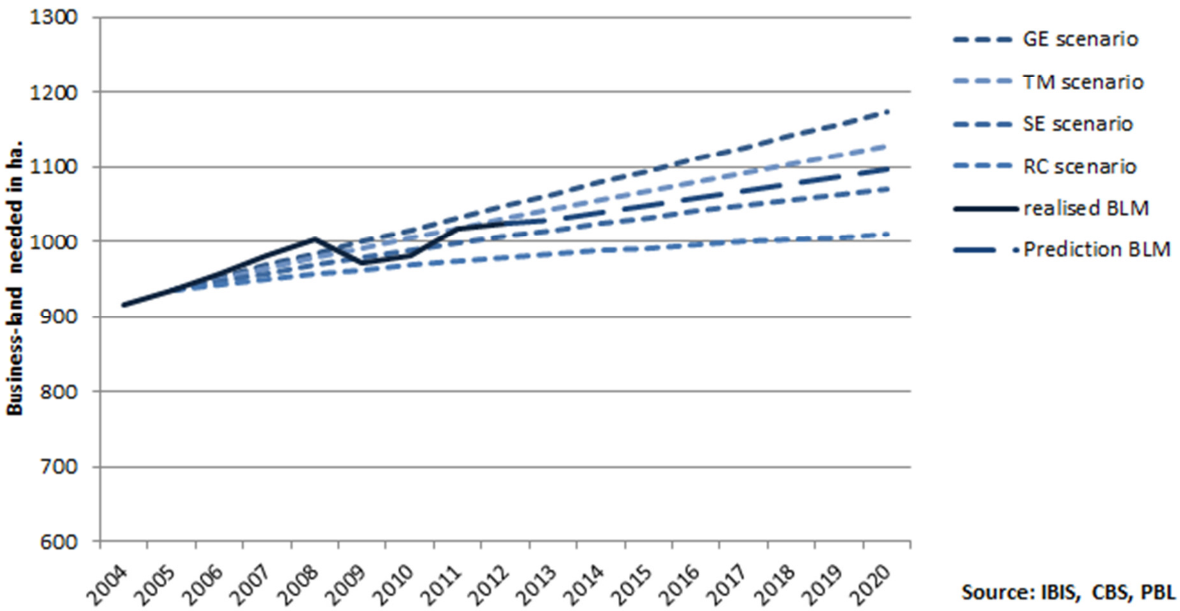


Figure 9.9: BLM prediction for Eindhoven (GA) adjusted for local trends (WLO scenarios shown for reference)

With the BLM, the employment is a good indicator for the expected demand for business land. As it is found in the timeline analysis and in literature (Oort et al. 2007), an increase in jobs or economic activity has a year delay on the land grants. However the drops in employment are almost immediately recognised as a drop in land grants.

As van Dinteren et al. (2007) predicted, the WLO scenarios, created by the CPB, are not applicable on local level. As Knoben (2013) already clarified in an interview, the WLO scenarios are of such a divers origin that they are based on a too broad bandwidth. One should only apply them with great consideration and on the same scale level as they were produced. It can be concluded that the BLM can be a useful tool for smaller scale estimation provided that the WLO scenarios are not used as input for growth. This however implies that all the employment growth dependent variables were all adapted to resemble the newly found growth coefficients.

As a result for the case study Eindhoven the BLM predicts an annual growth in demand of around 10 hectares a year. The timeline analysis method predicts a land grant rate of 7,5 - 8,5 hectares a year till 2015. A crude translation could say there is approximately twenty percent deviation in land grants because of recession and depression. Compared to the suggested 8,9 percent standard deviation, this seems reasonable since the Netherlands are in recession.

27. Appendix: Utilities Input

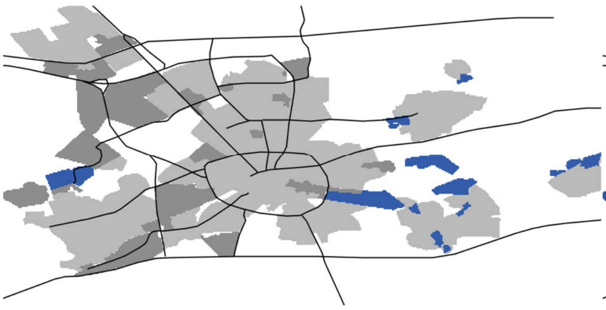
		Branch	"Landbou	"Voeding	"Overige i	"Chemisc	"Metalek	"Aardolie	"Delfstoff	"Openbar	"Bouwnij	"Verhuur
Attribute	Acronym	Description	A	B	C	D	E	F	G	H	I	J
Minimally	A	< 50 %	0	-1	-0,3814	0,83333	0,549896	0	0	0,386749	-0,08951	0,09259
	B	50 - 65 %	0	0,117078	-0,00887	-0,11012	-0,03456	0	0	0,031149	-0,02585	0,015526
	C	> 65 %	0	-1	0,589688	1,061206	0,00884	0	0	-1	0,569616	-0,3858
Maximally	A	< 80 %	0	0,119783	-0,03042	-0,24945	-0,05157	0	0	0,589621	-0,17499	0,073511
	B	80 -90 %	0	0,156786	0,151115	0,137179	0,269561	0	0	-0,53081	0,427304	-0,07585
	C	> 90 %	0	-0,27593	-0,11773	0,118541	-0,21274	0	0	-0,07701	-0,24249	-9,20E-05
Max envir	A	≤ 3	0	0,153148	-0,08669	0,012146	-0,12452	0	0	-0,44877	0,15814	0,085756
	B	≥ 4	0	-0,11028	0,062425	-0,00875	0,089667	0	0	0,323167	-0,11388	-0,06175
Represent	A	Mixed-use terrain	0	0,067654	0,056583	0,170661	0,056134	0	0	0,007638	0,126692	0,0465
	B	High-end-use terrain	0	-0,3545	-0,29649	-0,89424	-0,29413	0	0	-0,04002	-0,66385	-0,24365
Viewlocat	A	Yes	0	-0,5809	-0,64253	-0,588	-0,61503	0	0	0,869851	-0,54985	-0,26339
	B	No	0	0,052079	0,057605	0,052716	0,05514	0	0	-0,07799	0,049296	0,023614
Parkmana	A	Yes	0	0,308818	0,050677	-0,09179	0,10119	0	0	-0,14127	0,052446	0,082516
	B	No	0	-0,25052	-0,04111	0,074461	-0,08209	0	0	0,114606	-0,04255	-0,06694
Parking pc	A	Sufficient	0	0,082437	-0,02005	-0,04792	-0,03563	0	0	-0,11039	-0,06546	0,151492
	B	Insufficient	0	-0,12641	0,030751	0,07348	0,054633	0	0	0,169267	0,100371	-0,2323
Distance t	A	0 - 500 m	0	-0,28724	0,266544	0,401356	0,215882	0	0	-0,205	0,20053	0,409318
	B	500m - 1km	0	0,068593	-0,2067	-0,35804	0,1062	0	0	-0,20541	-0,20005	-0,06093
	C	1km - 2,5km	0	0,041045	-0,11205	0,279251	-0,26573	0	0	-0,12913	-0,16138	-0,08514
	D	> 2,5km	0	0,098731	0,151917	-0,18992	-0,00878	0	0	0,531885	0,247171	-0,15514
Distance t	A	< 2km	0	-0,66756	-0,52742	-1	-0,34566	0	0	0,483181	-0,74032	-0,41572
	B	> 2km	0	0,077258	0,061039	0,115732	0,040003	0	0	-0,05592	0,085678	0,048112
Accesabili	A	Sufficient	0	0,331718	-0,02874	-0,23159	-0,01228	0	0	0,033306	-0,00496	0,068533
	B	Insufficient	0	-0,48845	0,042324	0,341011	0,018083	0	0	-0,04904	0,00731	-0,10091
Distance t	A	< 2 km	0	0,650995	-0,2959	-1	-1	0	0	2,682989	-0,75819	0,450875
	B	2 - 5 km	0	0,126277	0,20081	-0,16961	-0,70442	0	0	0,256232	-0,23019	1,474397
	C	> 5 km	0	-0,03894	7,14E-05	0,058147	0,094656	0	0	-0,14244	0,051022	-0,12165
Distance t	A	< 200 m	0	-0,00426	0,028602	-0,05377	-0,18118	0	0	-0,1115	0,205612	-0,06662
	B	> 200 m	0	0,004609	-0,03092	0,058123	0,195855	0	0	0,120525	-0,22226	0,072018
Clustering	A	Above Average	0	-0,05126	0,100256	0,030836	0,081145	0	0	-0,10887	-0,05412	-0,12238
	B	Below Average	0	0,114396	-0,22375	-0,06882	-0,1811	0	0	0,24298	0,120775	0,273113
Landprice	A	< 140 €	0	0,146581	-0,08071	0,082061	-0,00097	0	0	-0,07921	0,029992	0,088209
	B	140€ - 169€	0	-0,38387	0,335697	-0,16718	0,05104	0	0	0,374437	-0,02239	-0,18783
	C	≥ 170 €	0	-1	-0,59607	-1	-0,44072	0	0	-1	-0,72255	-1

		Branch	"Handel e	"Transpor	"Commun	"Bank- en	"Uitzendb	"Overige t	"Gezondh	"Overheid
Attribute	Acronym	Description	K	L	M	N	O	P	Q	R
Minimally	A	< 50 %	0,066916	-0,59028	0,201849	0,265105	-0,14154	0,22188	-0,73873	0,323137
	B	50 - 65 %	-0,02195	0,057839	-0,00895	-0,00051	-0,02477	-0,00332	0,084699	-0,06739
	C	> 65 %	0,323011	-0,3858	-0,06453	-0,28882	0,608613	-0,18926	-0,70625	0,859497
Maximally	A	< 80 %	-0,0031	-0,10541	0,090026	-0,01595	0,17149	0,102138	-0,1657	-0,34998
	B	80 -90 %	0,000644	-0,12205	-0,13983	-0,35796	-0,51592	-0,2003	0,569052	0,231074
	C	> 90 %	0,002519	0,22716	0,046058	0,368295	0,333211	0,093233	-0,39136	0,128337
Max envir	A	≤ 3	0,00827	-0,36664	-0,08128	0,089566	-0,16586	-0,02861	0,43666	0,358689
	B	≥ 4	-0,00596	0,264025	0,058533	-0,0645	0,119441	0,020603	-0,31445	-0,2583
Represent	A	Mixed-use terrain	0,051965	-0,03469	-0,09007	-0,10164	-0,1872	-0,02615	-0,21473	0,070668
	B	High-end-use terrain	-0,27229	0,18179	0,471965	0,532595	0,980905	0,13704	1,125167	-0,37029
Viewlocat	A	Yes	-0,19608	-0,07924	1,056836	0,919058	0,736291	0,512502	-0,47156	-0,10796
	B	No	0,017579	0,007104	-0,09475	-0,0824	-0,06601	-0,04595	0,042277	0,009679
Parkmana	A	Yes	-0,01482	-0,25577	0,019022	-0,09909	-0,18489	-0,08956	0,504638	-0,24211
	B	No	0,012022	0,20749	-0,01543	0,080386	0,14999	0,072654	-0,40938	0,196412
Parking pc	A	Sufficient	-0,04092	-0,21148	0,092955	0,043457	0,206325	0,059206	0,077483	-0,18151
	B	Insufficient	0,062754	0,324283	-0,14254	-0,06664	-0,31638	-0,09079	-0,11881	0,278327
Distance t	A	0 - 500 m	0,13784	-0,56937	0,113	-0,27474	0,230357	-0,04114	-0,21364	-0,38369
	B	500m - 1km	-0,14294	0,043407	0,218378	0,328971	0,311712	0,059754	-0,22652	0,263575
	C	1km - 2,5km	0,080571	0,286519	-0,12913	-0,13931	0,018324	-0,01881	0,504046	-0,16907
	D	> 2,5km	-0,02594	0,086246	-0,20342	-0,02174	-0,55746	-0,01755	-0,10529	0,169292
Distance t	A	< 2km	-0,32876	0,825886	0,680939	0,691347	1,754479	0,253288	-0,37126	-0,29243
	B	> 2km	0,038048	-0,09558	-0,07881	-0,08001	-0,20305	-0,02931	0,042967	0,033843
Accesabili	A	Sufficient	0,00835	0,259342	-0,01836	-0,02788	-0,17377	-0,00559	-0,24561	0,047526
	B	Insufficient	-0,0123	-0,38188	0,027034	0,041048	0,255867	0,008226	0,36166	-0,06998
Distance t	A	< 2 km	-0,02075	-0,45592	-0,38617	-0,16002	-0,62001	-0,17542	1,428638	-0,34112
	B	2 - 5 km	-0,17563	-0,3814	-0,41376	-0,42698	-0,48155	-0,11087	0,53843	0,498259
	C	> 5 km	0,012956	0,047268	0,046229	0,0366	0,061746	0,015737	-0,10329	-0,01813
Distance t	A	< 200 m	0,110823	-0,3583	0,036587	-0,08811	-0,08329	0,03741	0,185744	0,342265
	B	> 200 m	-0,1198	0,387317	-0,03955	0,09525	0,090035	-0,04044	-0,20078	-0,36998
Clustering	A	Above Average	0,140567	0,064119	0,054499	-0,08542	-0,01163	-0,06036	-0,01363	0,03624
	B	Below Average	-0,31371	-0,1431	-0,12163	0,190644	0,025952	0,134703	0,030412	-0,08088
Landprice	A	< 140 €	0,025596	-0,06293	-0,06557	-0,06664	-0,17665	-0,01873	0,166189	0,012778
	B	140€ - 169€	-0,02809	0,08289	0,145364	0,175506	0,134456	0,077024	-0,61157	0,024523
	C	≥ 170 €	-0,53385	1,184883	0,690283	0,445637	4,231829	-0,13021	0,492777	-0,62201

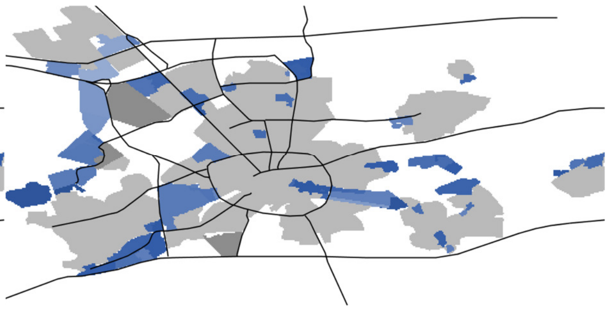
28. Appendix: Terrain scores

The darker the blue the higher the score and the lighter the lower. If a terrain is grey it means the current branch is excluded and has no scoring for this terrain.

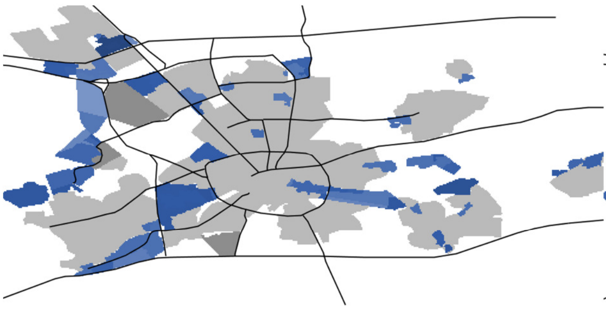
A Agriculture and Fisheries



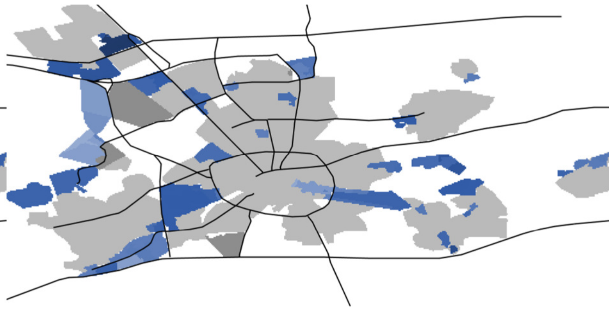
B Food and beverage industry



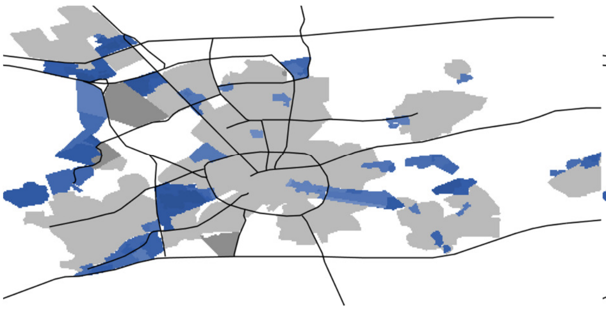
C Remaining Industry



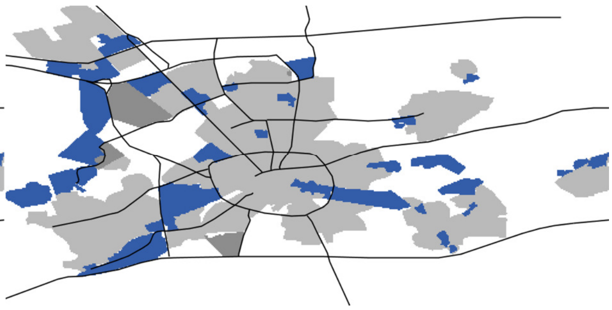
D Chemical, Rubber- en Synthethics Industry.



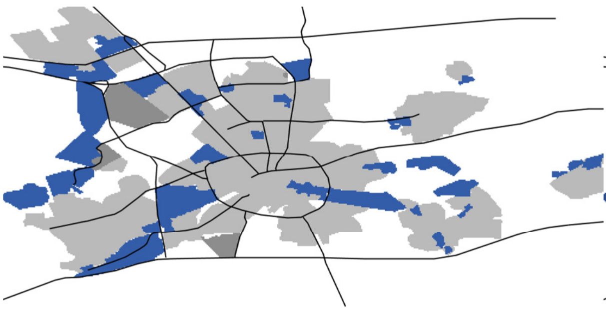
E Metalektro-industry



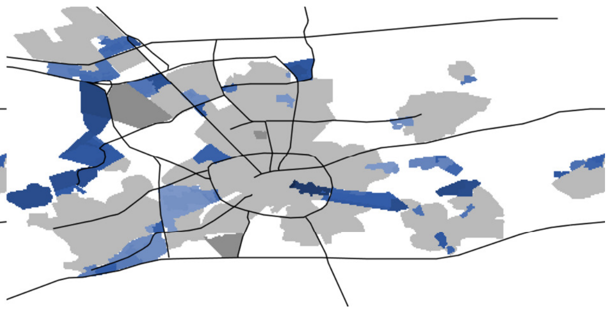
F Oil and Refineries



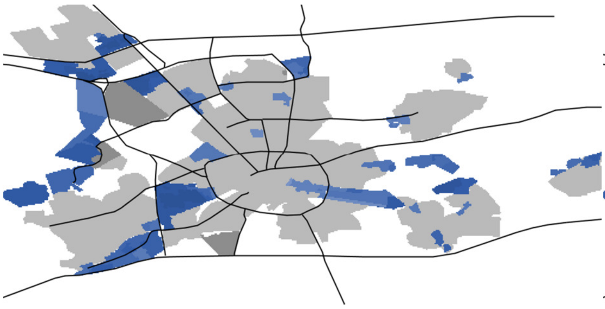
G Mining and Quarrying



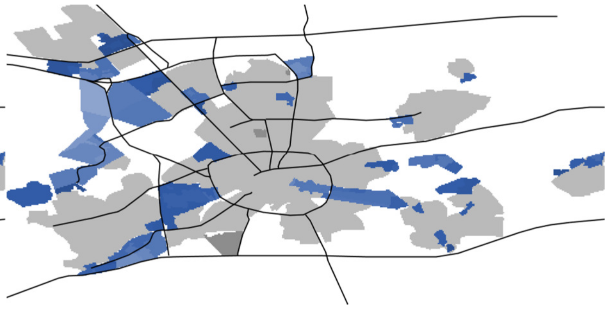
H Public Utilities



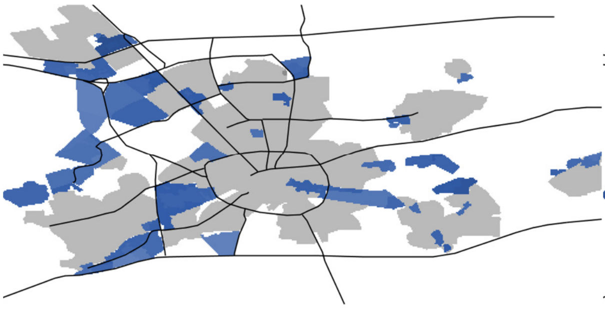
I Construction and Installation Companies



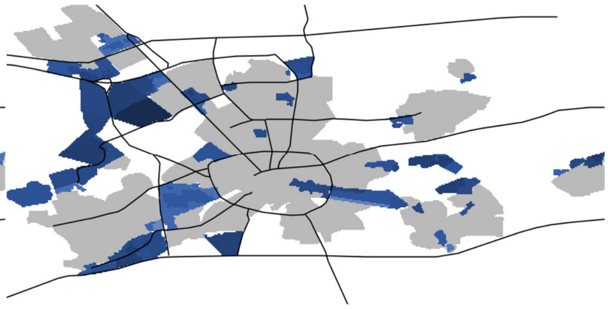
J Rental and Real Estate



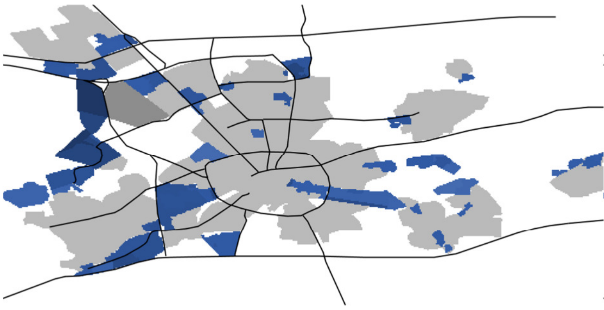
K Trade and Repair Companies



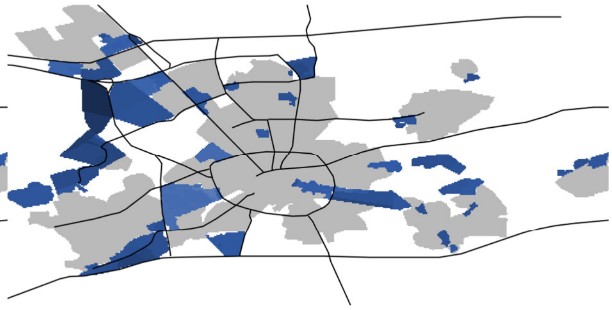
L Transport- and Storage Companies



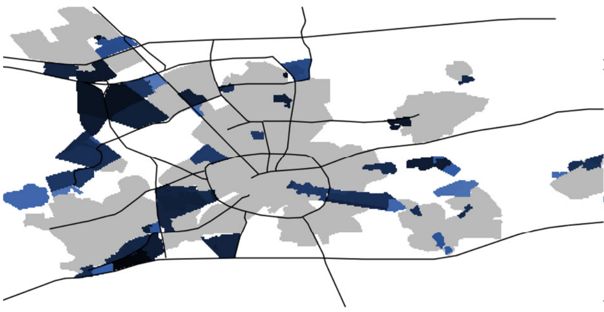
M Communication Companies



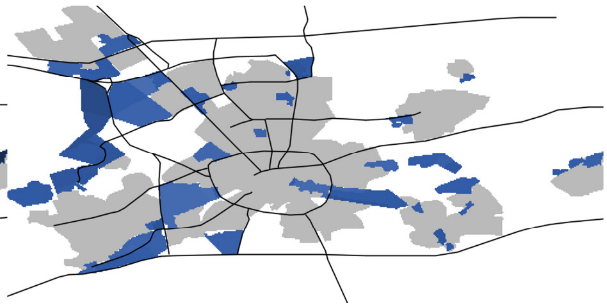
N Bank- en Insurance Companies



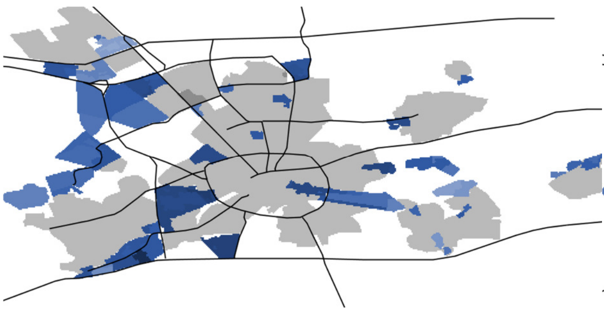
O Employment Agencies and Facility Management



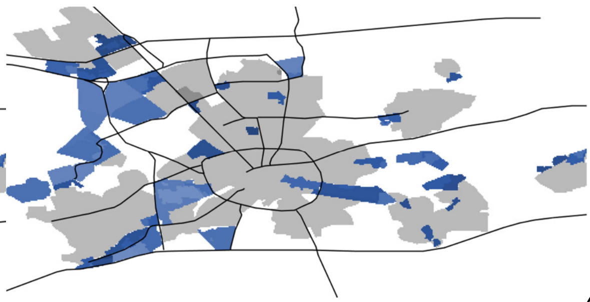
P Other Tertiary Services



Q Healthcare



R Government



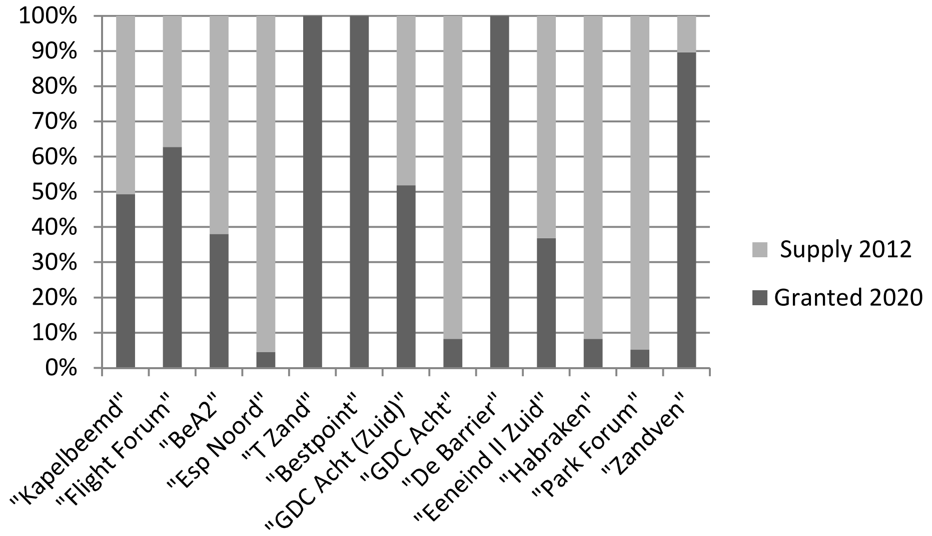
29. Appendix: Vacancy ratios extracted from supply and demand in 1000m² usable floor space

x 1.000 m² v.v.o.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Voorraad	3.100	3.200	3.200	3.200	3.300	3.300	3.400	3.500	3.300	3.200
Aanbod	90	140	157	140	148	102	106	177	186	279
Aanbod-voorraadratio	2,90%	4,50%	4,90%	4,40%	4,50%	3,10%	3,10%	5,10%	5,50%	8,70%

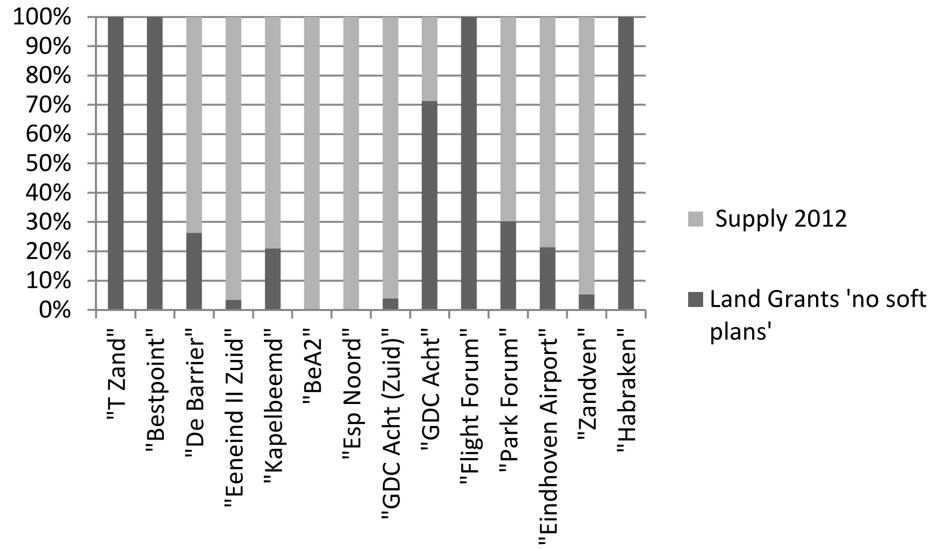
Source: DTZ

30. Appendix: Land granted relative to the supply per terrain

Status Quo



No Soft Plans



English Summary

DEMAND, SUPPLY AND POLICY; A QUANTITATIVE ANALYSIS OF THE BUSINESS- PREMISE AND LAND MARKET

The Creation of a Decision Support Tool

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Date of graduation:

15-01-2014

ABSTRACT

After five years of recession, a lot of initial anticipations and aspirations were negated. Among these, the exploitation plans for the expansion locations of municipalities. The poor housing, retail and office markets are ruining private and public parties, but in the market of business locations, there is only one big loser, the municipality. In this thesis the causes, consequences and opportunities of this social problem are analysed. By identifying and analysing large datasets, the real complexity of the problem is brought to light and an attempt is made to quantify relations it in a model.

Keywords: Supply, Demand, Policy, Bayesian Classifier Network, Agent Based Modelling, Land Use Modelling

INTRODUCTION

Now just before printing this thesis, in 2014 the losses allegedly have risen to between 4,0 and 6,0 billion euros. These figures are in stark contrast to the expected profits of 3,6 billion euros. This results in a total deficit between expected income and expenses of at least 7,6 billion euros; as large as the three quarters of the budget cuts in 2012 of the Dutch government due to the economic crisis (10 billion). Dutch municipalities have acquired, over the last eight years, an abundance of land destined for business. Based on optimistic prognoses and conceit, municipalities believed until around 2007 that they had a shortage of land in supply for business purposes. However the demand for all this ground never truly developed as anticipated. Now all across the Netherlands there are plots of land that have been made ready for construction, may never be used and the plots that are to be sold will leave a vacant building in the region. In 2014 the losses allegedly have risen to between 4,0 and 6,0 billion euros.

The land market is, as the name suggests, a system of supply and demand. The surpluses of acquired land have led to a mismatch between this supply and demand. This would not be a problem in any other market, though the land market has some imperfections, which differentiates it from a standard market. The institutional context for land ownership, exchange and development, combined with high governmental involvement and public funds differs the market as well from a normal market.

Problem definition

There is an oversupply of land purposed for business activities, which instigates vacancy and urban sprawl and strains the budgets of municipalities, which leads to a wide variety of social security problems. Municipal budgets are depending on the profits that are made from city expansion, causing a ‘two hats dilemma’. Municipalities must choose between (1) financial or economic considerations and (2) spatial planning goals. Local governmental responsibilities are limited to their territory and as a result, the relatively high supply creates a competition between municipalities to attract companies.

Research Structure

There have been some crucial exclusions in literature so far. None of the articles consider the current stock in their equation for the amount of land needed. In most papers it is assumed that the land grants will be originating from areas outside the current stock. This is however not the case. Another omission is the incorporation of qualitative aspects in the demand and supply. This research attempts to not only create a model which quantifies the problem for municipalities, but the model will also try to predict the qualitative demands and how to best cope with these. Thus the purpose of the research is: Creating a micro economic model which quantifies the relations of policy on business-land grants on the total supply and demand.

Because the province has to supply municipalities in need with their deficits, it is slowly becoming a problem for them. The province cannot directly dictate the land use plans and the municipalities are allowed to heighten the estimations of the province with their own ambitions. Also the scope of the problem suggests that there is something fundamentally wrong and the problem owner is defined as the province. The aspect of competition between municipalities is also not negligible and calls for a higher level of governance. The province will therefore be seen as the problem owner.

To guide the research in the right direction and test the hypothesis, the following research questions are proposed to help achieve the purpose of the research.

Can demand and supply of business-land be modelled; quantifying policy influence on vacancy and losses?

- *What caused the surpluses of business-land and what are the consequences?*
- *What is the financial structure behind business-land development?*
- *What constitutes supply and demand for business-land and can it be quantified?*
- *Can a decision support tool be created and validated?*
- *What are the influences of supply and can the model help create a sustainable policy towards business purposed land?*

THEORETICAL FRAMEWORK

The business space market can be split into two sections: the business land and the business premise market.

Business-Land Development

Business-land development in the Netherlands is highly focused on new developments. More as other markets in which re-use and redevelopment are more prominent options. Municipalities are responsible for the lion's share of the industrial land development. More than 75 percent of the land predestined for industrial granting is owned by the municipalities (Ministry of Infrastructure and the Environment 2012a). To guarantee continuity municipalities have land reserves. The provinces are mainly aiming at estimation of the demand, the designation of sites and encouraging regional coordination in planning and programming. Most of the tasks and responsibilities are focused on the municipalities, which are responsible for a large part of the planning, programming and the development and distribution. Municipalities mostly base their land reserves on their own calculations, of which only one out of three has been made with the formal code for calculating the land needed on reserve. The demand in practice is predicted by waiting lists and informal discussion. Despite that almost all municipalities claim to monitor the existing stock, only one in four municipalities adjusted their demand by considering the current stock and vacancy rates. Mostly this is because small municipalities do not have the man power to keep an eye on the existing stock and accompany entrepreneurs in their search for a suitable location within the current built environment. Also are they not capable of predicting an accurate demand.

The Business Premise Market

Business premise development is different from business land development is based upon speculations of municipalities instead of private developers. This is reflected in the premise development. As private developers do not take up a large part of business land development, they are not likely to develop business premises. After land is developed by the municipality, it is mostly sold to the end-user instead of a developer. The private end-user will commission a contractor to build his premise for own use. The business premise market consists of specialised and tailored premises. As only 29 percent of business premises have been previously owned, it is possible to conclude that the market is dominated by 71 percent first time use

The relocation of a company has several financial consequences. These can be categorised into building costs, furnishing costs and relocation cost. These fluctuate per branch and the actual relocation costs, they are minimal and the building costs and furnishing costs compose the bulk of the costs. As it comes to costs when developing greenfields, they can be separated into land price and construction costs and fees. Municipalities wrongly assume the land price is the determining factor for location choice. Land price is only a small part of their decision, however it plays a role.

Methodology

To try to fathom the complex mechanisms involved an Agent Based Model is created. Agent-based Modelling (ABM) is a modelling technique for complex systems composed of interacting, autonomous decision makers. It will combine the macro economic developments and the micro economic decisions made by companies. All the factors will have to be quantified to serve as input for the ABM. To quantify the qualitative aspects of this demand, random utility theory is applied. To quantify the appreciation of the attributes form a static dataset, a Bayesian network analysis is proposed. These quantified preferences are then combined with the increase and decrease in demand and supply and the ABM will model the developments of the business land and property market.

ESTIMATING QUANTITATIVE DEMAND

Supply as well as demand are defined as the amount of land (in hectare) with the function business; named ‘business-land’. The demand is further refined to the amount of business-land needed for the proper functioning of a healthy entrepreneurial environment. The supply is defined as the offered amount of land composed of the ‘iron reserve’, considering LID as well as LNID and the current stock. The demand is dependable on a wide variety of variables, since each entrepreneurial activity demands a different amount of land and has a different efficiency. However the demand of business-land is unmistakeably connected to employment developments and therefore most method use employment as an input for demand estimation. The Spatial Planning Bureau of the Netherlands (Dutch: Ruimtelijke Planbureau) has created a business-housing location monitor (Dutch: Bedrijfslocatiemonitor; BLM) for the Dutch market. The BLM is by far the most sophisticated method for estimating the demand for industrial land due to its incorporation of almost all involved macro-economic trends. It does not pay any attention to meso-economic trends in sectors. By combining the BLM with agent-based modelling it is possible to introduce these business cycle parameters, locational preferences and policy restrictions.

ESTIMATING QUALITATIVE DEMAND

The theories of supply in the land market should take in account the distinctiveness of land as a commodity. Land is unique because of its location and allocation which makes the location theory is an indispensable aspect of the estimation of demand. In the considerations concerning the location or relocation of a company, two of the factors generally stand out as the most important; location factors and financial factors. This concludes in the list of 14 discretized locational attributes used in the Bayesian Classifier Network to find the utilities. These attributes can crudely be categorised in to (1) land use restrictions, (2) representational characteristics, (3) accessibility and the (4) respective location of consumers and clients.

SUPPLY

The supply of business-land in the Netherlands, concerning working locations, is closely monitored by the ‘IBIS Werklocaties’. The existing terrains constitute the first part of the supply the other half of the supply are composed of the land in development and the pipeline supply; land not in development. For this research a case study is done in the area of the conurbation of Eindhoven. The Bayesian Classifier Network analysed 3600 companies in the area to find the utilities for the fourteen attributes. As a result the utilities are known for all 53 terrain in the area for all eighteen branches

THE MODEL

Before the description of the model is given, we first give a set off assumptions on which it is based. The assumptions are: (1) Businesses act only based upon the spatial discrepancy and the best other option. (2) Businesses choose the best option only based upon financial and locational preferences. (3) New companies come in at a constant rate. (4) Vacancy is evenly spread (due to lack of detailed data).

The model is made in NetLogo. An abstract flowchart of the algorithm is given in Figure 1, followed by a short description of the overall workings of the model.

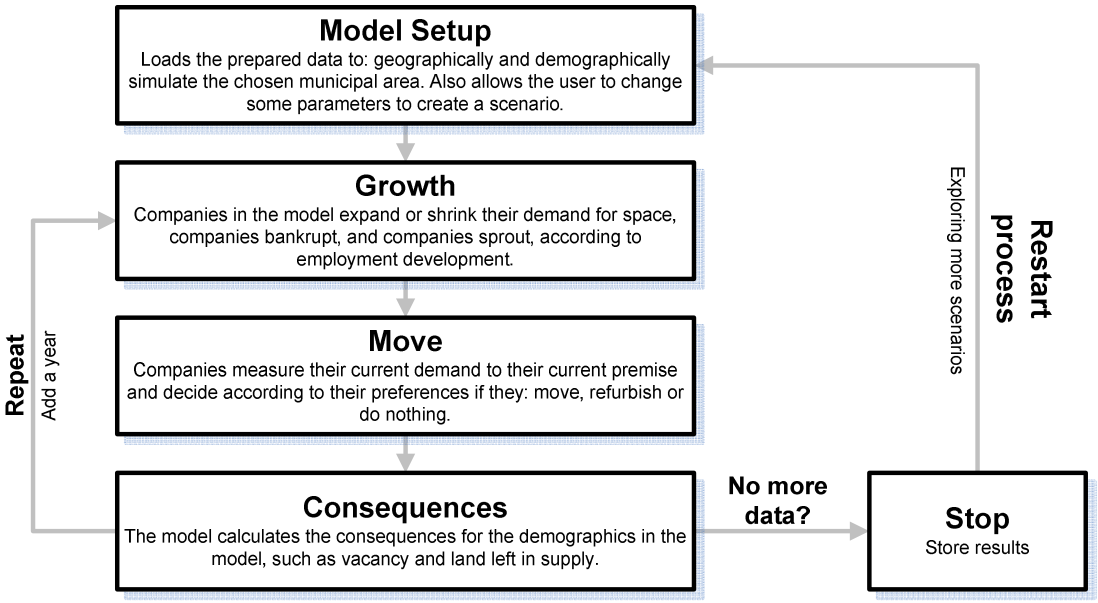

Figure 1: Model structure

In the setup phase the 'world' is created. This world is the simulated area, with the included characteristics. The geographical shapes of the terrains and their characteristics and the companies with their branch, location and size are loaded. As the model is initiated, the simulation will begin each step with a growth command followed with the decision moment of relocation for a company. Each step will be closed by the processing of the consequences and then starts with growth a again. In this growth command the companies add or subtract an amount of demand based upon the findings of the quantitative demand analysis. This growth (or shrinkage) will enhance (or reduce) the discrepancy between the demand for space and the space of the premise for each business. This will lead to some sort of dissatisfaction, which is used as input for the ‘move’ algorithm of the model.

As a result of the growth command, the model has a set of companies which have certain dissatisfaction with the space of their premise and a set of companies with no premise yet. The already settled companies have two causes for their dissatisfaction; their current premise is not spatially satisfying or their current premise is not qualitatively satisfying. Based on these factors combined with financial considerations, the companies will have to decide to take a course of action. The company weighs the costs, spatial discrepancy and the quality to make a decision on their course of action. Therefore four pay-offs have to be generated and are compared. However therefore the quality must be quantified for three locations. These locations are specified in the model as sub-terrains, which are postal code areas (PPC6). The locations are (1) the best available undeveloped patch, (2) the best suited developed patch with a suitable housing location and (3) the rating of the current location.

The payoffs are generated based on satisfaction and are calculated with an algorithm. The company looks up its branch and then searches for the branch’s weighting list. This list is compiled of the weights given to the location attribute levels. Then the company asks all sub-terrains to report their variables and the company multiplies them with their respective weights. This results in a list of scores for all sub-terrains and then the highest one is selected as the best option. To prevent that the best sub-terrain excludes a certain branch, all scores of for these branches are disqualified for this list.

REQUIRED DATA

For the creation, validation and use of the model, a lot of data must be gathered and prepared. This data is available from local governments, such as municipalities and provinces as well as some real estate companies. The required data is not found purely in the prepared form usable for Agent Based Modelling and must be prepared through a series of preparations. The incipient models, the BLM and the Bayesian Network will combine rough data and extract the data needed for the ABM. In Figure 2 the flowchart of the data preparation is given and the processes are described below.

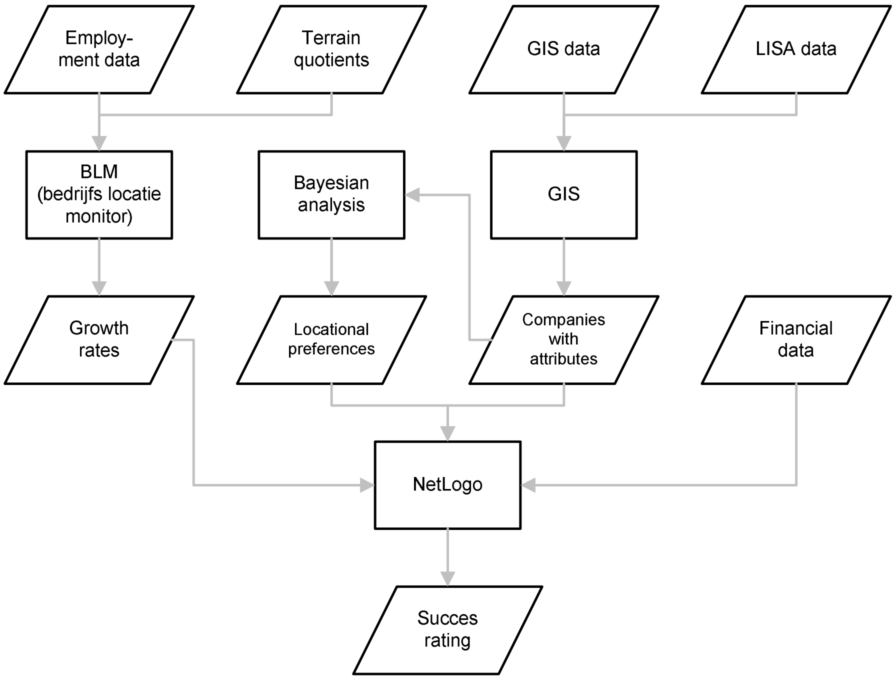

Figure 2: Flow chart of the data flows

RESULTS

Now that the model is validated the predictions of the future can be made and these runs can be analysed and processed. In a scenario under the status quo, it was found that the amount of land granted would be 56 ha. and vacancy will still increases to about 9,9 percent. Some of the growth will be absorbed by investments in companies' premises. But is must be noted that the results are not absolute but are rather distributed as can be seen in Figure 3.

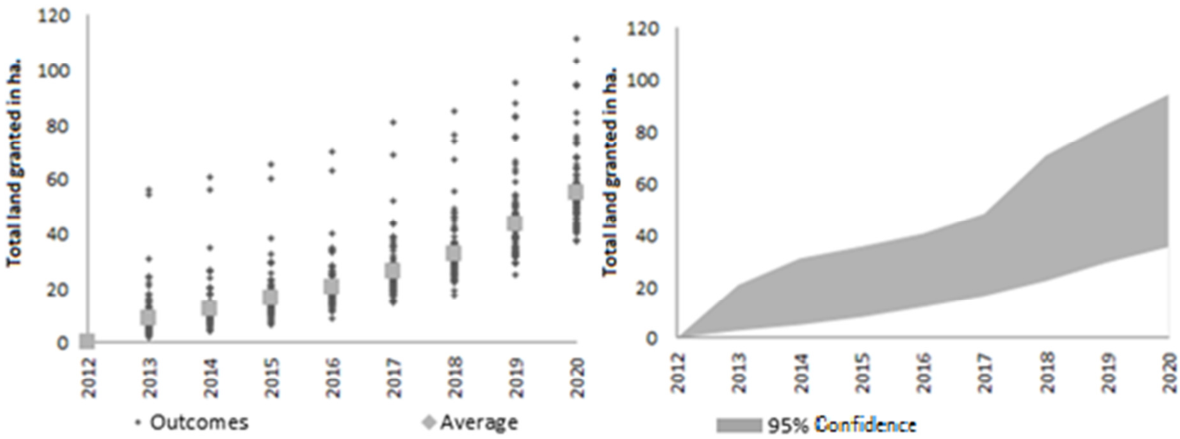

Figure 3: Results of the run status quo land grant outcomes & confidence boundaries

As more scenarios were explored the relations between policy and the market of supply and demand became clearer.

CONCLUSIONS & FURTHER RESEARCH

The problem of an oversupply of land purposed for business activities, has evolved due to a mix of policy, optimism, structure and the unique composition of the land market. It is multifaceted and is not as simple as an recalculation of the amount of hectares needed. Policy can backfire in the form of vacancy. A decision support tool for this complex problem, was realised in the form an agent based model. This model can be of great value for any municipality with business parks within its borders, especially because the plans of many local governments, such as lowering the land prices, will backfire on vacancy. It is suggested that for further research it is proposed to upscale the model to a full COROP region, to use a more unified dataset and to create detailed insight into vacancy.

ir. Bob van Bronkhorst

This thesis is the result of more than a half year of hard work. After a faltered start the Brink Groep joined me in my research and supplying me with the practical point of view. They were a great source of inspiration and pushed me beyond my limits. The topic was complex and versatile but with the help and guidance of my supervisors, family and friends, I was able to finish my it in six months. The final product is more than I hoped for in the beginning.

EDUCATIONAL CURRICULUM VITAE

2001 – 2007 VWO

2007 – 2012 Bachelor Architecture and Building Planning

2011 – 2014 Master Construction Management and Engineering

2013 – 2014 Internship at Brink Management en Advies

Dutch Summary

Vraag, aanbod en beleid; een kwantitatieve analyse van de bedrijfsruimte markt.

Nederland heeft de afgelopen jaren een paradigma verschuiving meegemaakt. Dit heeft de grondbedrijven van de gemeentes hard heeft geraakt. Jaren leek er geen eind te komen aan de wachtlijsten van bedrijven die zich wilde vestigen in op bedrijven terreinen en de kavles van nieuwe terreinen vlogen als warme broodjes over de toonbank. Nu lijkt daar na vele jaren een einde aan te komen. Nu verliezen gemeentes miljarden euro's aan rente op gemaakte kosten en afwaarderingen van geschatte inkomsten. Dit is het gevolg van de structuur die zich bevind achter stadsuitbreidingen. Gemeenten mogen grond opkopen in gebieden aangewezen voor stadsuitbreiding, ook wel uitleglocaties genoemd. Niet alleen mogen zij zelf de planning en bestemmingsplannen beheren maar ook mogen ze deze gebieden zelf bouwrijp maken en verkopen. Dit leidt tot een enorme stijging in de waarde van de grond die gemeente mag afromen, wat op zijn beurt weer leidt tot speculatie maar ook anticipatie. Gemeenten baten bij de inkomsten, grondeigenaren verdienen flink en bedrijven zijn altijd in staat om een passend maatpak te realiseren in dit proces. Echter nu de verkoop uitblijft, raken vooral de gemeenten in de problemen. Als snel duiken gemeenten, naar aanleiding hiervan, op het idee om de kavels goedkoper aan te bieden. Echter laat elke verhuisd bedrijf ook een leeg pand achter, wat bijdraagt aan de degradatie van oude terreinen. Dit onderzoek verdiept zich in het probleem wat is ontstaan door het uitblijven van de vraag en doelt zich op het ontwikkelen kwantificerend model. Hier mee zouden beslissingen omtrent het beleid van uitleglocaties kunnen worden onderzocht en waar nodig ondersteund.

De bedrijfsruimtemarkt is een unieke markt en kan worden opgesplitst in twee takken: de landmarkt en de vastgoedmarkt. De landmarkt onderscheidt zich van winkels en kantoren doordat het bij bedrijven wordt gedomineerd door de gemeente. Gemeentes ontwikkelen het leeuwendeel van bedrijven terreinen zelf en verkopen de kavels zelf. Dit echoot door in de vastgoedmarkt waar het leeuwendeel door de eindgebruiker zelf, van de gemeente wordt gekocht en het vastgoed op maat is ontwikkeld.

De vraag naar ruimte werd voorheen al gemonitord door middel van de Bedrijfslocatiemonitor (BLM). Deze methode raamt de hoeveelheid hectare er de komende jaren bijkomt aan de hand van werkgelegenheidsontwikkelingen en prognoses. Bij deze ramingen wordt onderscheid gemaakt tussen 18 verschillende bedrijfstakken met elke eigen karakteristieken. Het over aanbod wat er op het moment ligt voor bedrijven terreinen levert echter een nieuwe dimensie aan de vraag. Bedrijven staan niet langer in de wacht en kunnen nu kiezen waar ze hun bedrijvigheid gaan uitvoeren. Deze keuze leidt tot een waardering van de locaties. Dit roept om een blik op de voorraad met locatietheorie. Locatietheorie kijkt naar aspecten die bedrijven motiveren te kiezen voor een specifieke locatie. De mogelijkheden van de kavels spelen een centrale rol, maar ook bereikbaarheid, klanten, consumenten, leveranciers en representatie spelen een belangrijke rol. De inventarisatie van deze aspecten levert een set van veertien attributen op die in een Baye's Classificeer Netwerk worden vertaald naar relatieve beloningen voor de geselecteerde bedrijfstakken. Aan de hand van deze beloningen per attribuut, kan voor elk terrein in de voorraad weer een beloning worden bereken met de bijbehorende karakteristieken, die vervolgen vergeleken kunnen worden.

Het resultaat is een voorspelling van de groei of krimp van bedrijven en de waarderingen van locaties. In een agent-gebaseerd model worden deze samen gebracht om de ontwikkelingen van de markt te simuleren. In het model zitten 3600 gesimuleerde bedrijven die ieder jaar groeien afhankelijk van hun bedrijfstak. Als gevolg hier van groeien (of krimpen) zij uit hun huidige accommodatie en beginnen af te wegen of het niet beter is om te gaan verhuizen. De afweging hiervoor word gebaseerd op drie factoren: de financiële consequenties, de kwaliteit van de locaties en de ruimtebehoefte. Deze drie factoren worden gewogen voor vier opties. Het bedrijf kan in het model de abstracte opties kiezen: niets doen, investeren in een uitbouw, verhuizen naar een ander pand en als laatste nieuwbouw plegen. De beste van deze keuzes word uitgevoerd en de resultaten geregistreerd. Omdat het model een paar onzekere parameters bezit, is ervoor gekozen om het proces niet één keer maar vele malen te simuleren. Elke keer wordt de simulatie uitgevoerd met andere startcondities voor de onzekere parameters. Het resultaat van deze verzameling simulaties is reeks uitkomsten die vertaald kunnen worden naar een verdelingsfunctie of een betrouwbaarheidsinterval van de mogelijke uitkomsten.

Het model is gemaakt en toegepast op de grootstedelijk agglomeratie Eindhoven. Door het model het verleden te laten repliceren kan het worden afgesteld en gevalideerd. De mogelijkheden van het gevalideerde model zijn talrijk. Daardoor is er voor gekozen om het model een aantal scenario's te laten uitreken om de toepasbaarheid aan te tonen. Het model laat zien dat onder de status quo de leegstand stijgt tot bijna tien procent. De hoeveelheid uitgegeven terrein is 56 ha.. De terreinen waar de leegstand het meest toeneemt, bevinden zich in het oosten, ver van de snelweg. Hoewel de resultaten absolute getallen zijn, zijn het gemiddelden van normaalverdelingen. De verdeling wordt breder naarmate het model langer loopt, het is immers moeilijker om de verre toekomst te voorspellen. Door meerdere scenario's te onderzoeken werden de invloed van beleid duidelijker.

Uit het onderzoek kunnen de volgende conclusies getrokken worden. Het over aanbod is ontstaan door optimisme, een verkeerde structuur en wensdenken. De uniciteit van land, maakt dat het niet een uitwisselbaar bulkgoed is terwijl ramingen daar wel vanuit gaan. Het model toont aan dat verdere uitbreidingsplannen kansrijk zijn maar allen de huidige terreinen daar zeer zwaar mee belasten. Herstructurering van terrein naast de uitgeefbare concurrentie levert een zeer laag rendement. Het model is gecreëerd en gevalideerd en de toepassingen zijn talrijk. Het is belangrijk instrument voor gemeentes met bedrijventerreinen binnen hun grenzen. Echter blijft er plaats voor verbetering en het model zal er bij baten als het word opgeschaald zodat de waarderingen een stabielere basis hebben en uitschieters gedempt worden. Ook is het belangrijk dat er wordt gekeken naar de leegstand, zowel verborgen leegstand als op een gedetailleerder niveau. Het is een complex probleem wat niet eenduidig is op te lossen en politieke afwegingen moeten gemaakt worden. Daarom is het voorgestel dat de provincie de touwtjes in handen neemt en het probleem tackelt van bovenaf.

List of abbreviations

ABM	Agent based modelling
ABMS	Agent based modelling simulation
BANN	Bayesian augmented naïve network
BCN	Bayesian classifier network
BCNN	Bayes classifier naïve network
BLM	Bedrijfslocatiemonitor
BN	Bayesian network
DAG	Directed acyclic graph
DTZ	(company)
GA	Grootstedelijke agglomeratie
ha.	hectare (10000m^2)
LFA	Lettable floor area
LID	Land in development
LISA	(foundation)
LNID	Land not in development
OZB	Onroerendezaakbelasting
PPP	public private partnership
RUM	Random utility maximisation
TLA	Timeline analysis
WLO	Welvaart en leefomgeving (Welfare and environment)