Abstract
In the Dutch industrial land market, a municipality is the land use policy maker and also acts as an active stakeholder in the land development process. Therefore, acquiring a land, changing the land use plan, and further grant it for profits is a common development path for a municipality. Until recently, this particular development process has been very lucrative, and resulted in oversupply of the serviced industrial land that is ready for real estate development. In order to avoid long-term negative effects of new land use policies, this paper suggests an agent based model that estimates future demand for various industrial sectors and matches it with current supply. The demand model consists of two parts: a) a specific industry sector growth model represented by demand for space and b) a location choice model, that estimates a companies’ preferences for a specific location with Bayesian classifier network. Further, this agent based model simulates companies’ decisions either to relocate, or to expand the existing location, or neither. Such decisions are also supported by financial feasibility data. Data used for demand model to estimate a general growth is local employment data, and for demand regarding a specific location is collected by GIS out of the national IBIS and LISA databases. To indicate the applicability of the developed approach, a case study was conducted for the urban area of Eindhoven in the province of Noord Brabant in the Netherlands.

Keywords: industrial land market, land use policy, sustainable transformation, agent based model

1. Introduction
In the Netherlands the municipalities are experiencing turbulent times. Municipalities are coping with an increasing amount of responsibility, marginal increases in council resources and severe losses on land speculation (Allers, 2010; Ten Have et al., 2013). The Dutch industrial land market uses a model in which the municipalities may act as a land use policy maker, but also act as active stakeholders in the land development as well, granting land for profits. As a result Dutch municipalities have acquired, over the last decade, an abundance of land destined for business. Based on optimistic prognoses and conceit, municipalities believed until beyond 2004 that they had a shortage of industrial land in supply for business purposes (Olden, 2010). However this hypothesis was never tested accurately and the demand never truly developed as anticipated. The industrial land that was expected to be sold by now is lying vacant. Interest on the costs of acquiring and preparing the land are pressing on the municipal budgets. Consequently municipalities have started to depreciate the land value of these assets in an attempt to sell, and take the loss in value. In the beginning of 2014, these losses have allegedly risen to between 4 and 6 billion euros for all types of land (Ten Have et al., 2013). Next to the losses a large inter-municipal competition for attracting new, but mostly relocating, firms has arisen. A heedless attempt to increase selling demand could lead to vacancy in the current stock, negligent use of space and high interest expenses for municipalities (Oort et al., 2007).

To give municipalities and regional governance insight into the consequences of the land policy in reaction to this mismatch in supply and demand, a model is created to quantify the complex relations and
feedback loops in this market. It is highly important to examine the effects of land policy deployment on the total business property stock, to prevent excessive vacancy in the current stock, or unnecessary losses on depreciation.

Previous research has explored the possibilities of identifying demand for land development in city expansion (Suryani et al., 2010; Sánchez et al., 2007; He et al., 2006). Halleux et al., (2012) takes this a step further and places this expansion in the context urban sprawl and vacancy. In the Netherlands the demand for industrial land has been explored before, on provincial scale, with governmental estimation tools, to give an indication of selling rate of the supply and or implement price corrections (Traa and Knoben, 2008; Weterings and Knoben, 2008; Beckers et al., 2012; Ploegmakers and Vor, 2013). This would be suitable in any other competitive market, but the land market has some imperfections that differentiate it from the other markets. According to Adams et al. (2001) the land development market is heterogeneous instead of homogenous, because the location and allocation of land make it not interchangeable. They also point out that land is traded infrequently and high transaction cost form an entrance barrier which reduces liquidity and thus makes difficult to determine accurate prices. The unique location of land, the choice between relocation and development combined with high governmental involvement and public funds differ from other markets. Kocabas and Dragericevic (2009) state that, by integrating urban policy, population growth dynamics, and land-use change prediction will become more accurate. An agent based model integrated with a Bayesian network can be used as a complementary decision support tool to guide policy makers, urban planners, and urban developers (Kocabas and Dragericevic, 2009). Agent-based modelling is particularly well suited to study bottom up microeconomic to macroeconomic systems (Batty, 2009). Agent based models can capture dynamic feedback among land use patterns, spatial location and land use composition (Parker and Meretsky, 2004). The suggested model can show policy makers the consequences of refraining from expansion plans and what the effects are on vacancy by tempering or encouraging sale rates.

2. Agent based model (ABM) as an industrial land use policy tool

In essence, the proposed model matches the existing supply with predicted demand. This model can be implemented as a policy tool to understand the causes and consequences of land use changes.

The prosed agent based model (ABM) is based on two models that estimate future demand: a) a general demand model for a specific industry sector; b) a location choice model based on the companies’ preferences (Fig. 1). On the other hand, the supply can be mapped according to these definitions. New developments are an option for relocation however a used building can be an option as well. Therefore the existing industry park stock should be presented next to the developing business stock representing the full supply of business land.

![Agent based model procedure](image)

Figure 1: Agent based model procedure
The input data for the industry growth model is provided by local governmental bodies which monitors the employment for each industry sector. Combined with national parcel data which defines the area per sector per employee, the model calculates the sector specific area demand.

The location choice model depends on a set of national and private databases. Data, retrieved from the Dutch Ministry of Infrastructure and the Environment, that keeps a close watch on the industry locations, provides characteristics for the industrial terrains. Through the ‘IBIS’ registration system all industrial locations, including planned future locations are mapped. With a geographic information system (GIS) analysis the corresponding values can be appointed to the supply. To make the data company-specific we need to add another dataset of the central government; the ‘LISA’ dataset. This dataset contains all registered companies with the respective branch, size and location. Coupled with the IBIS and GIS data a complete picture of the supply is formed.

2.1. General demand model
To gain an understanding of the total market, these aspects of supply and demand must be defined. Over time several models have been developed to estimate future demand (Bastia e Silva et al., 2014). Knoben and Traa (2008) reviewed a large section of the methods applicable to the Dutch governmental data sets. Out of these methods, the method ‘bedrijfslocatie monitor’ (BLM), developed by Arts et al. (2005) has been elected as the most advanced and effective method (Knoben & Traa, 2008). The BLM has been appointed as formal estimation method by the Planbureau for the Environment (Dutch: Planbureau voor de leefomgeving). Nonetheless, Ploegmakers et al. (2013) demonstrate with a series of interviews that in reality this method or any other formal methods are not even used by most municipalities and identify this as a probable cause for the oversupply.

The BLM method quantifies the spatial demand for industrial land \((SD)\) by correlating the employment developments to industrial land in use. The model distinguishes between different business branches because the employment growth is different for each of these branches and branches have different efficiency rates. It defines the total demand (current stock included) in square meters per branch derived from regional or local employment estimations. The model multiplies the employment indicators \((E)\) with two dynamic factors; the terrain quotient \((TQ)\) and the location type preference \((LTP)\). The terrain quotient represents the service area needed per employee, derived from a national database. It is subject to change because the efficiency of surface use changes over time. The location type preference is the share of employees which are accommodated on a specific type of land \((l)\). For this model the share for the industrial locations are used and are adjusted over time to follow spotted trends in location type preference.

The formula for sector \(s\) of this model is shown in equation 1.

\[
SD_{s,t} = E_{s,t} \times TQ_{s,l,t} \times LTP_{s,l,t}
\]  

In this model the variables, \(E_{s,t}, TQ_{s,l,t}, \) and \(LTP_{s,l,t}\), are extrapolations of Dutch historical data. The result is a set of dynamic growth parameters, of which the product forms the total demand for industrial land for a specific branch at a given point in time \((t)\). The sectors and their respective cumulative spatial demand, in \(m^2\) industrial land, are represented in table 1.

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</thead>
<tbody>
<tr>
<td>Food and beverage industry</td>
<td>186</td>
<td>185</td>
<td>183</td>
<td>182</td>
<td>180</td>
<td>178</td>
<td>177</td>
<td>175</td>
</tr>
<tr>
<td>Remaining Industry</td>
<td>1485</td>
<td>1478</td>
<td>1472</td>
<td>1465</td>
<td>1458</td>
<td>1452</td>
<td>1445</td>
<td>1438</td>
</tr>
<tr>
<td>Chemical, Rubber- en Synthetics Industry</td>
<td>261</td>
<td>256</td>
<td>252</td>
<td>248</td>
<td>243</td>
<td>239</td>
<td>235</td>
<td>231</td>
</tr>
<tr>
<td>Metalektro-industry</td>
<td>660</td>
<td>647</td>
<td>635</td>
<td>622</td>
<td>610</td>
<td>598</td>
<td>587</td>
<td>575</td>
</tr>
<tr>
<td>Public Utilities</td>
<td>158</td>
<td>159</td>
<td>159</td>
<td>160</td>
<td>161</td>
<td>161</td>
<td>162</td>
<td>163</td>
</tr>
<tr>
<td>Construction and Installation Companies</td>
<td>406</td>
<td>421</td>
<td>425</td>
<td>430</td>
<td>439</td>
<td>383</td>
<td>386</td>
<td>384</td>
</tr>
</tbody>
</table>
Not all data needed for the micro economic decision model is accurately at hand and some distributed variables must be incorporated. Three distributions were identified for the input, the first being the individual firm growth, compared to the trend. This was found by a regression analysis on growth and conjuncture. The current space available in contrast to space optimally desired is not available; therefore this is distributed according to the ratios found by Oort (2007). Also the introduction of new firms to the model is an uncertain factor and is based on the research on this by van Oort (2007). These distributions give the differentiation to the outcomes and call for a Monte Carlo approach to the simulation. A list of the distributions is given in table 2 from which the model repeatedly samples random.

Table 2: Input uncertainties in the model and their parameters

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth per individual company</td>
<td>Extrapolation</td>
<td>8,9%</td>
<td>Regression analysis</td>
</tr>
<tr>
<td>Fitting of the current accommodation</td>
<td>0%</td>
<td>18 - 22%</td>
<td>(Oort et al. 2007)</td>
</tr>
<tr>
<td>Newcomers</td>
<td>3%</td>
<td>1%</td>
<td>(Oort et al. 2007)</td>
</tr>
</tbody>
</table>

2.2. Location specific demand model

Location theory addresses questions of what economic activities are located where and why. In the considerations concerning the location or relocation of a company, one group of factors is generally standing out as the most important; the location factors. Many researches reviewed the locational preferences for firm relocation (Krabbenn and Buitelaar, 2011; Dinteren et al., 2007; Oort et al., 2007; Pellenbarg et al., 2002; Dijk and Pellenbarg 2000; Pen 1999; Louw 1996). Oort et al. (2007) concluded that the variables were not changing, but over time their position strengthened or weakened. This implies that the valuation of identified attributes needs to be updated and recalibrated over time. In the analysis of the literature in location theory and interviews with experts the attributes and their respective levels have been defined as shown in table 3.

Table 3: Preference attributes of companies

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimally built percentage</td>
<td>0-50%; 51-65%; 66-100%</td>
</tr>
<tr>
<td>Maximally built percentage</td>
<td>0-80%; 81-90%; 91-100%</td>
</tr>
<tr>
<td>Environmental category</td>
<td>1-3; 4-6</td>
</tr>
<tr>
<td>View location</td>
<td>Yes; No</td>
</tr>
<tr>
<td>Terrain type</td>
<td>Mixed-use; High-end-use</td>
</tr>
<tr>
<td>Park management</td>
<td>Yes; No</td>
</tr>
<tr>
<td>Parking possibilities</td>
<td>Sufficient; Insufficient</td>
</tr>
</tbody>
</table>
Computable microeconomic decisions are often coupled with individual utility maximization (Batty, 2009). To quantify the effects of the attribute on locational preference, 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 for each of the identified aspects in table 1. In equation 1, $U_{in}$ is an unobservable utility that for entity $n$, associates alternative $i$. $V_{in}$ is the explainable utility and $\varepsilon_{in}$ is the unobserved error (Hensher et al., 2005). $V_{in}$ can be composed of multiple ($k$) variables, which all have a different functional form ($f(x)$) and weighting ($\beta$) of these forms. This is mathematically expressed by equation 3:

$$U_{in} = V_{in} + \varepsilon_{in} \quad (2)$$

$$V_i = \beta_{0i} + \beta_{1i}f(x_{1i}) + \beta_{2i}f(x_{2i}) + \ldots + \beta_{ni}f(x_{ni}) \quad (3)$$

To quantify the weightings in these equations ($\beta$) a Bayesian classifier network is used. Bayesian classifier networks (BCN) 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. In BCN’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 $x_1$, $x_2$, ..., $x_n$, the following equation (4) is used:

$$P(A|x_1, x_2, \ldots, x_n) = \frac{\exp(V_i)}{\sum_{j \in A} \exp(V_j)} \quad (4)$$

The preferences are derived from the supply data by analysing the attributes and levels used in a structured network. Three structure forms were tested and the best possible structure for this approach and data set is the Naïve structure. The BCN quantifies the probability of a choice for allocation occurring; which is then translated to a utility by using the choice probability equation (5).

$$P(A| x_1, x_2, \ldots, x_n) = \frac{p(x_1, x_2, \ldots, x_n | A) \cdot P(A)}{\sum_{y_1, y_2, \ldots, y_n} p(y_1, y_2, \ldots, y_n | A) \cdot P(A)} \quad (5)$$

Based upon these probabilities learned from the BCN the location choice algorithm is written based upon formula 2 in an agent based model to determine the payoffs of the firm agents for locations based upon their attribute levels. The result from the optimal BCN structure is displayed in figure 2.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway accessibility</td>
<td>0-0.5km; 0.5-1km; 1-2.5km; &gt;2.5km</td>
</tr>
<tr>
<td>Distance to city centre</td>
<td>0-2km; 2-5km; &gt;5km</td>
</tr>
<tr>
<td>Accessibility public transport</td>
<td>0-200m; &gt;200m</td>
</tr>
<tr>
<td>Distance to airport</td>
<td>0-2km; &gt;2km</td>
</tr>
<tr>
<td>Distance to living area</td>
<td>0-200m; &gt;200m</td>
</tr>
<tr>
<td>Clustering of companies</td>
<td>Above 2x average; Below</td>
</tr>
<tr>
<td>Land price</td>
<td>0-140€; 141-170€; &gt;170€</td>
</tr>
</tbody>
</table>

* Supplied by data from IBIS
2.3. Financial feasibility

Louw (1996) states that the second most important decision factor in a relocation process is finance. The financial aspects are highlighted in a publication of van Dijk and 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 and 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. Based on an expert interview and a database for firm relocation, cost averages are calculated for the corresponding firm types to indicate their financial considerations in the decision process. These cost calculations are performed so that they are an indicator for the costs per square meter. These calculations are made for the actions relocating, refurbishing and building a location. These are then coupled to the corresponding firm agent in the ABM.

2.4. Model validation

To ensure reliability of the model a set of validations must be made. The industry sector growth model (BLM) and the location choice model (BCN) must be validated before using their outcomes in the agent based model (ABM). Then the ABM itself must be validated. The process is visualised in figure 3.

![Figure 3: Validation process for BLM, BCN and the ABM](image)

To validate the model a case study is performed on an area in the Netherlands. 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 land 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).

With the addition of historical data of this area, the validation of the models can be performed. The BLM was tested on correlation with historical data. The data used for the BCN was split into a training (75%) and a validation set (25%) and then validated with a hit rate test. In an iterative process the ABM was tested and rewritten to optimally model the developments of the historical timeframe 2004 – 2012. The results of the validations are shown in table 4. The combination of the models also influences their performance and therefore the tests are rerated with outcomes of the ABM. The ABM is validated with a hit rate of 60% which is significantly better as in full entropy.

Table 4: Validation methods and outcomes of the models

<table>
<thead>
<tr>
<th>Model</th>
<th>Validation method</th>
<th>Outcome</th>
<th>Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLM</td>
<td>Correlation</td>
<td>0.87</td>
<td>&gt; 0.80</td>
</tr>
<tr>
<td>BCN</td>
<td>Hit rate test</td>
<td>0.2978</td>
<td>&gt; 0.0678 (entropy)</td>
</tr>
<tr>
<td>ABM</td>
<td>Correlation</td>
<td>0.95</td>
<td>&gt; 0.80</td>
</tr>
<tr>
<td></td>
<td>Hit rate test</td>
<td>0.60</td>
<td>&gt; 0.50</td>
</tr>
</tbody>
</table>

With these reliability figures in mind the predictions of the future can be made and these runs can be analysed and processed. This will identify the influences of policy and attempt to find an approach to creating a sustainable supply policy towards business purposed land.

3. Applying ABM on a case study

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 in development (LID) for sale and 4 more large projects in the pipeline (land not in development, LNID). Land grants in this area have dropped from 35 hectares in 1997 to 6 hectares in 2013.

Future runs are based on extrapolation and manipulation of the data at hand and therefore creates an input uncertainty. However, though alteration of the input enables the user to create countless scenarios, delivering a wide range of applications. To demonstrate the applicability and relevance of the model, several scenarios will be tested. These scenarios are a result of the discussions with land policy makers and based on general conceptions to see if the desired result can be created:

Scenario Status Quo - The first scenario will be a status quo scenario representing the current affairs and exploring the result of maintaining its policy. This scenario will be used as a point of reference to compare the results of other scenarios. In figure 4, the result of the ABM in NetLogo (Wilensky, 1999) is shown with the Status Quo scenario outcomes and dispersion after 1045 runs.
Scenario discount - the second scenario is based upon the general believe, among municipal councils that lowering the prices will improve the selling rate and benefit their employment (Ten Have et al., 2012).

Scenario competition - 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 and Buitelaar (2011) described.

Scenario no introduction of LNID - the fourth scenario will remove all land not in development (LNID) from the future. The policy in this scenario is to refrain from plans to introduce future terrains to the market, which would be a rational and most likely decision of municipalities if the current supply could fulfil all demand (Krabben and Buitelaar, 2011).

Scenario restricted municipal land grants - the fifth scenario selects few good terrains of substantial size and focuses on the grants of only these terrains, reflecting the provincial view on the solution of this problem. The selected terrains are: ‘GDC Acht’ and ‘Park Forum’, due to their success in the Status Quo scenario and size of LID supply (> 10 ha.).

Based upon these scenarios the influence of land policy will be quantified on land grants, vacancy, compaction and location choice using the agent based model. The land granted is measured by the amount of new land developed by companies in hectares from now until 2020 and is projected against the supply of LID available in that scenario. To determine the vacancy rate, the amount of vacant floor space is measured. The compaction is determined by the increase in demand for land in total and the expected increase based on employment growth. In table 5, the results per scenario can be seen for these three indicators.

Table 5: Mean scenario outcomes based on 500 runs
Scenario | Mean Land Grants 2012-2020 | Mean Vacancy | Mean Compaction |
--- | --- | --- | --- |
Status Quo | 56 ha. out of 237 ha. | 9.9% | 16% |
Discount | 60 ha. out of 237 ha. | 10.0% | 8% |
Competition | 56 ha. out of 237 ha. | 9.9% | 16% |
No introduction of LNID | 56 ha. out of 187 ha. | 9.9% | 16% |
Restricted municipal land grants | 37 ha. out of 97 ha. | 8.2% | 23% |

These means are a summary of the outcomes of the scenarios but the model has a more complex structure and the results are not as monochrome as the table implies. The location choices of the firms are documented and land grants as well as vacancy rates can be specified to individual terrains as shown in figure 5 and 6.

Figure 5: Two scenario comparisons of the land grant rates for individual LID terrains in the model.

Figure 6: Mean vacancy rates for each individual terrain as modelled in the ‘Status Quo’ scenario

From these results can be concluded that land is not an interchangeable bulk product, and estimation methods, which assume so, have become obsolete by the oversupply phenomena. Municipalities no longer dictate the demand. Price, location and allocation have become more and more influential. Under the current policy this will result in a higher vacancy rate. In a scenario of land price discounts, the policy
backfires on vacancy and compaction but increases the demand for business land. Inter-municipal competition in the form of land price discounts will result in a shift of demand. By reducing the future supply with no introduction of LNID, the demand merely shifts to another location choice making current terrains more successful. Only when the supply is drastically reduced to three terrains, the vacancy starts to shrink from the current 8.9% to 8.2%. The vacancy map per individual terrain also points out the weak terrains which will fall into desolation without the necessary precautions. These terrains are often smaller and have a relatively large distance from the highways.

4. Conclusion and Discussion
The Netherlands is coping with a surplus of developed industrial land and the continuation of current policy strain governmental funds. Policy changes are complex and are subject countless variables and actors. To understand how policy changes affect the industrial land market an agent based model is created which incorporates feedback loops and agent interaction. The companies (agents), consider the location and allocation of land and the current stock in a relocation decision. A sector specific growth model adjusts the demand and a location choice model determines, based on location and allocation, where the demand is going to arise. The cumulative actions of the companies are summarised over a large number of runs to represent the impact of allocation and policy. This allows policy makers to see the consequences of certain industrial-land policies in a broad perspective. The outcomes of the model explore the complex relations in the market for industrial land. Understanding these complex relations makes it possible to reconstruct past landscapes, given known historical records, and future landscapes can be envisaged under different scenarios based upon assumptions and policy alternatives.

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, discounting the price of the land, will serve its primary objective: increasing the sales rate. However it will increase vacancy, decrease compaction and costs the municipalities a relatively large sum on the discount. Lowering the prices in competition, could seize most of the 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 existing terrains. The best option to reduce vacancy is to restrict the grants of terrains. Vacancy is reduced and compaction is stimulated. This will however result in short term losses through a low grant rate and the possibility of dissatisfied companies leaving the area. This leads to a sensitive political dilemma weighing employment generation versus urban degradation. To decrease the vacancy and degradation, 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 and relentless competition from other terrains.

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. the full ‘LISA’ database). It is suggested that for further research a unified dataset is used. Also it would be desirable to make an inventory of 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 model supplies municipalities and regional planners with a decision support tool. It is found however that the scale level of local government is not sufficient to comprehend the full consequences of land policy. Ultimately for further research it is proposed to upscale the model to a full COROP region (a Dutch region between municipality and province). This will reduce the noise created from probabilities and decrease the boundary limitations to a 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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