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The productivity of industrial land in the Netherlands¹

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Abstract

In regional science the interest in spatial distribution of productivity is focussed on labour productivity. In our research we focus on another important production factor that is land. By planning local authorities allocate land to different categories of land use. As part of research on the efficiency of this allocation process in the Netherlands, a method is developed to determine the productivity of industrial land (added value per hectare industrial land).

To calculate this 'spatial productivity', data from the Dutch industrial estates database are used in combination with regional employment and regional output statistics. The paper will explain the method used and show some results. The research outcomes show that there are substantial differences in spatial productivity in the Netherlands. These differences seem to correlate positively with the urban density. On the other hand the share of added value created on industrial estates by region seems to correlate negatively with urban density. Therefore there is some evidence for the hypothesis that industrial land in urbanised regions is used more efficiently than in other areas, indicating that agglomeration effects are observable in spatial productivity.

¹ The research was supported by the Dutch Ministry of Economic Affairs.

1. Introduction

The classical economists included land as a factor of production along with labor and capital, but the contribution of land receives little serious attention today. “Despite its obvious importance, land has almost disappeared from economic analysis” (Hubacek and Vazques 2002). The assumption is that unlike the other factors of production, the total supply of land is relatively fixed and cannot be significantly increased in response to higher demand and prices. Moreover, due to the physical characteristics of land, and the institutional features of the transactions, land markets are less efficient than other markets. One of the institutions of the land market is spatial planning. In many countries spatial planning to some extent determines the supply of land for various land use categories. In countries such as the United Kingdom and the Netherlands the supply of land for industrial development has become a matter of increasing concern to many local authorities (Adams and others 1994; Louw 2000; Adams et al. 1994). They assume that by supplying industrial land, they can improve conditions for economic growth and restructuring. There is however a limited understanding of how the process of land supply and development contribute to meeting the production requirements of industry at the local and regional level. Theoretical and empirical analysis on this subject is very limited (Adams et al. 1994).

The relationship between the supply of industrial land and economic growth is also one of the key issues in discussions about sustainable spatial development. On the one hand economic growth is an almost necessity to implement sustainable development, while on the other hand economic growth almost automatically increases the demand for industrial land². Spatial planners are faced with this dilemma and are ill equipped to deal with this dilemma. It seems an issue for urban and regional economists. However, according to (Evans 2003) there is a huge gap between urban economists and planners. Although, in the 1970s and 1980s urban economists paid substantial interest in the economic effects of land use planning, their research has largely been ignored by land use planners, “... the planning profession [...] appeared to be immunized against the subject...” (p. 525). Evans might be right but, why should he not raise another question: do urban economist answers the questions planners have? We think the answer to this question is no. Why is it that we, planners and regional scientists alike, do not know how productive land is? Is it changing? Are there regional differences? Can we explain differences...? In regional science and urban economics the interest in spatial distribution of productivity is focussed on labour productivity. Spatial differences in average labour productivity are explained by spatial externalities and increasing returns at the firm level combined with non-tradabilities or transport costs. This explanation is better known as agglomeration effects.

Past theoretical and empirical work on agglomeration effects was focused on city and industry size as determinants of productivity and on technological spillover as a source of agglomeration economies. There are hardly any studies that have examined spatial density directly. The study of Ciccone and Hall (1996) is one exception. Using data on gross US state output they found that a doubling of employment density increases average labour productivity by around 6 percent. Also more than half of the variance of output per worker across states can be explained by differences in the density of economic activity. Density affects productivity in several ways (Ciccone and Hall 1996):

- If technologies have constant returns, but transportation of products from one stage to the next involves costs that rise with distance, than the technology of production of all goods

² In the Netherlands the amount of industrial land is growing faster than land for housing.

- within a particular geographical area will have increasing returns. The ratio of output to input will rise with density.
- Externalities associated with physical proximity of production, then density will contribute to production.
 - Higher degree of beneficial specialization in urban areas.

By taking density (output per acre) in account, Ciccone and Hall looked at the influence of the production factor land on the production factor labour. However, they consider all space equivalent. By doing so, it is not possible to tread land as a distinctive factor of production because it is unknown how much land is used by economic activities, apart from other types of land use. In urban areas some economic activities are highly mixed with housing and leisure, while other economic activities (mainly manufacturing, transport and commercial services) are clustered in industrial estates, business parks or Central Business Districts. Space on these estates and districts is therefore not an equivalent to for example space in residential neighbourhoods, where housing of a mixture of various commercial (e.g. shops) and non-commercial services dominate.

In this paper we will deal with land as a separate factor of production, by introducing a method to calculate the productivity of land that is used exclusively for economic activities. By doing so we only look at the quantity of land that is in use by economic activities and not at different qualities of land (soil, distance/location), as was done by classical economists for agricultural land. We define land productivity as the output (added value) per unit of land and will use Dutch data. In contrast to the classical economists we do not take agriculture land into account, but only analyse industrial land.

The aim of the research was to investigate ways to measure the productivity of industrial land. The emphasis was on the design of the method and the practicability of the data. Therefore the focus of the paper is the method and the results, and less on the analysis of these results. The paper is structured as follows. In the following section we will describe the data and the method. It will be shown that the method is simple, but that the limited availability of spatial data and the quality of some data are important and may have significant effects on the results. In the third section we will show some results. One of the main results is that there are substantial differences in the productivity of industrial land. These regional differences in land productivity are higher than regional differences labour productivity. In the fourth section we make a first attempt to explain these differences. In the final section we draw some conclusions about our method, the results and the way these may be used in spatial planning and regional science.

2. Method to calculate the productivity of land

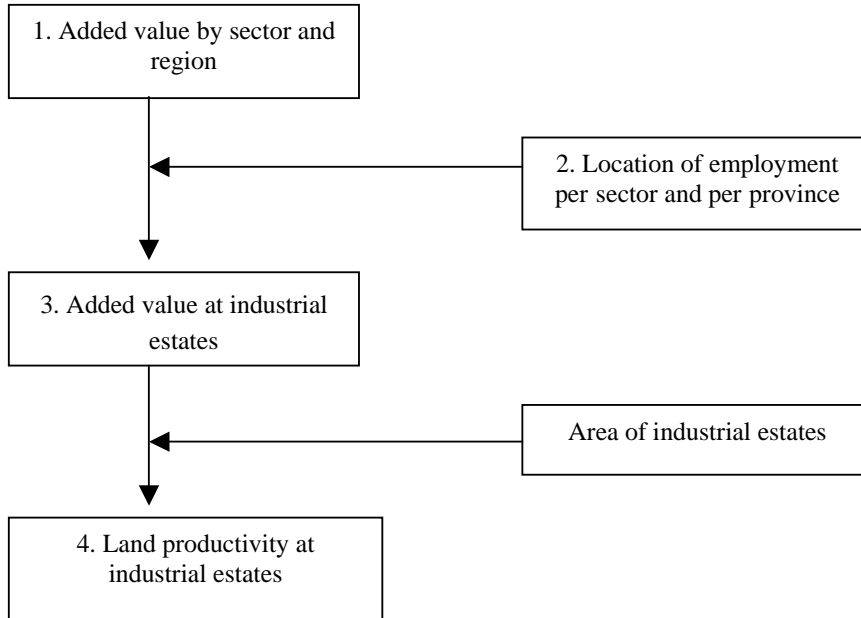
The productivity of land is defined as the monetary added value per unit of industrial land (usually one hectare). Industrial land is defined as land that is exclusively used by economic activities. To calculate the productivity of industrial land the added value created by companies and organisations located on this type of land has to be separated from added value created at other locations. In this paper this is done by using the proportion of employment on industrial land.

Summarizing, the four main steps of our method to calculate land productivity are (see figure 1):

1. Determination of added value per region and per sector;
2. Determination the location of the employment;

3. Allocating added value per sector and region to industrial estates;
4. Determination of land productivity at industrial estates.

Figure 1 Four steps to calculate land productivity



The added value in a certain sector is allocated to the industrial estates in a certain region (AVI_{prs}) as:

$$AVI_{prs} = E_{ps} * AV_{prs} \quad (1)$$

and to other locations (AVO_{prs}) as:

$$AVO_{prs} = (1 - E_{ps}) * AV_{prs} \quad (2)$$

This implies using labour productivity expressed by monetary added value per job to determine the added value on industrial estates. Next, the added value on industrial estates in a certain region (AVI_{pr}) is determined as:

$$AVI_{pr} = \sum_{s=1}^S AVI_{prs} \quad (3)$$

and the added value on other locations (AVO_{pr}) as:

$$AVO_{pr} = \sum_{s=1}^S AVO_{prs} \quad (4)$$

Land productivity in a certain region (LP_{pr}) is then calculated by dividing the added value on industrial land in that region by the surface of industrial estates in that region:

$$LP_{pr} = \frac{AVI_{pr}}{S_{pr}} \quad (5)$$

Finally, land productivity in a certain province (LP_p) is calculated as:

$$LP_p = \frac{\sum_{r=1}^{R_p} AVI_{pr}}{\sum_{r=1}^{R_p} S_{pr}} \quad (6)$$

For formulas (1)- (6) applies $r \in R_p$, $p \in P$.

The explanation of variables is as follows:

AV_{prs} is defined as the total added value of a certain sector in a certain region.

E_{ps} is defined as the proportion of employment in a certain sector located at industrial estates in a certain province.

S_{pr} is defined as the surface of industrial land in a certain region.

Indices are explained as follows:

r is index for region, $r = 1$ to R_p , the total number of regions in a province.

s is index for economic sector, $s = 1$ to S , the total number of economic sectors.

p is index for province, $p = 1$ to P , the total number of provinces.

The data on industrial land came from the Dutch Integral Industrial Estates Information System (IBIS). IBIS represents by far the most accurate and comprehensive source of information on industrial estates in The Netherlands. IBIS yearly registers for each of the 3500 industrial estates, among other things, its size, type³, area in use, disposal of serviced land, location, etc.. In IBIS not every plot of industrial land is listed. Small plots and sites used by only one company are excluded. Therefore, fragmented industrial land within residential areas or Central Business Districts are not included in IBIS. In IBIS also office parks are registered, but they are not measured in land area but in office floor space. Consequently, the land productivity for these office sites cannot be calculated.

Employment data (including the self-employed) came from the LISA-database. This database contains employment data for 24 economic sectors by 6-digit postal code area⁴. This low level geographical aggregation makes these data well suited for a GIS-analysis with the spatial data of IBIS⁵, to determine the volume and composition of the employment on industrial estates. The output of the GIS-analysis was the proportion of the employment located at industrial estates in 24 economic sectors for each of the 12 provinces in the Netherlands.

The added value is defined as the monetary value of the output minus the value of intermediate inputs. Data on the added value are from the CBS Statistics Netherlands. Regional data on the added value (gross regional product: GRP) are available for the 12 provinces, 40 Corop-regions⁶

³ There are five types of industrial estates; seaports, estates for heavy industries, mixed estates, business parks and logistics parks. Distinction between these types of industrial estates is very arbitrary and often differs between provinces. Also, there are only a limited number of business parks and logistics parks. Therefore it was decided only to calculate the land productivity for all estates together and separately for seaports because they are clearly defined. In addition, seaports are known for their extensive use of land, which makes it intriguing to calculate their land productivity.

⁴ Plant level employment data aggregated to 6-digit postal code area.

⁵ The GIS-analysis was not performed by ourselves, but by the Netherlands Ministry of Spatial Planning, Housing and the Environment on behalf of the Netherlands Bureau for Economic Policy Analysis.

⁶ Corop-regions are a subdivision of provinces.

and 24 economic sectors. The self-employed are included in the GRP. These regional data and the 24 sectors mean that we take industrial and geographical differences in labour productivity into account.

Calculations were made at lowest level of aggregation possible. Data on the dispersion of employment and added value are available at the level of 24 economic sectors. However, the classification of sectors slightly differs between the LISA and CBS-data. As a consequence some sectors had to be taken together, implying summing up employment, added value or both. Data on added values is available at Corop-level and data on the location of employment at province level. As a consequence, the location of the employment at province level has been applied to allocate the added values to industrial estates at Corop-level. Area data are available for each single industrial estate and includes areas for infrastructure and amenities such as small parks⁷.

The added values of the sectors Agriculture and Mineral Extraction have been excluded from the calculations. In Dutch research into regional differences in labour productivity, the sector Mineral Extraction is often excluded because it is very dominant in a few regions with natural gas resources (see also (Broersma and Dijk 2003)). The extreme characteristics of the sector, low number of employees and high added value, have a large impact in the labour productivity in these regions. Including this sector in the calculations will increase the land productivity in some regions significantly (for example in the province of Groningen by 46%). For some regions the added value by Mineral Extraction is concentrated in a few companies and in such a case these data are not available. For these reasons the sector Mineral Extraction has been excluded in the calculation of land productivity.

For two reasons the Agriculture sector was excluded. First, the borders of the 6 digit postal code areas in LISA do not exactly match the borders of the industrial estates in IBIS. Therefore, it is likely that some agriculture employment near an industrial estate have been wrongly allocated to that industrial estate. Second, for purpose of external validation the results had to be compared with a source in which all added value of the agricultural sector is allocated outside the built environment.

Three important remarks concerning the interpretation of the results have to be made:

1. The location of the employment at province level has been applied to allocate the added values to industrial estates at Corop-level. The calculated productivity of land is a result of the location of employment, regional differences in labour productivity and regional sector composition. At the Corop-level within the same province the distribution of the employment is the same, which means that differences in land productivity between the Corop-regions in the same province cannot be explained by the distribution of the employment.
2. Labour productivity is not measured in output by working year, but by average output by job. This has the advantage that the self-employed (of which there are no data on there time of working) are included in the calculations.
3. In our calculations we assume that the labour productivity at industrial estates is the same as in other areas. We are not aware of research that shows otherwise, nor do we have reason to believe so.

⁷ Not yet released plots are excluded in the surface data.

Figure 2 Map of the Netherlands with 12 provinces and build-up area.

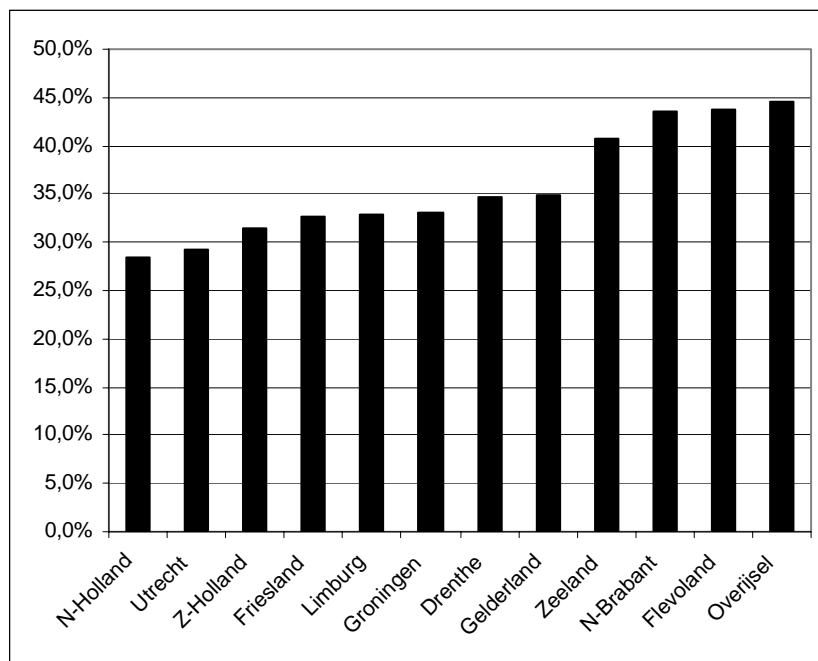


3. Land productivity in the Netherlands

According to IBIS in 2000 there were 3489 industrial estates with a total surface of 71,760 hectare. This is 1,7% of the total surface of the Netherlands. According to the GIS-analysis 34,4% of the Dutch employment was situated there. Industrial estates are particular important settling locations for manufacturing. For some manufacturing sectors up to 80% of the total employment is on industrial estates, while in service sectors such as professional services and bank and insurance this is 31% and 12% respectively.

On the industrial estates 34.2% of the output of the Dutch economy is produced. This is almost the same as the percentage employment on industrial estates. This means that less than 2% of the Dutch territory is responsible for more than one-third of the output. This clearly indicates that not all space is equivalent and some land is used more productive than other land. In figure 3 the share of output on industrial estates for each of the 12 Dutch provinces is shown. This percentage shows great regional differences. Notable is that the three most urbanised provinces (Noord-Holland, Utrecht en Zuid-Holland) have the lowest share of output produced on industrial estates. These three provinces are also the economic heartland of the Dutch economy in which 51.2% of the output of the Dutch economy is produced.

Figure 3 Percentage of output realised on industrial estates per province in the Netherlands in 2000.

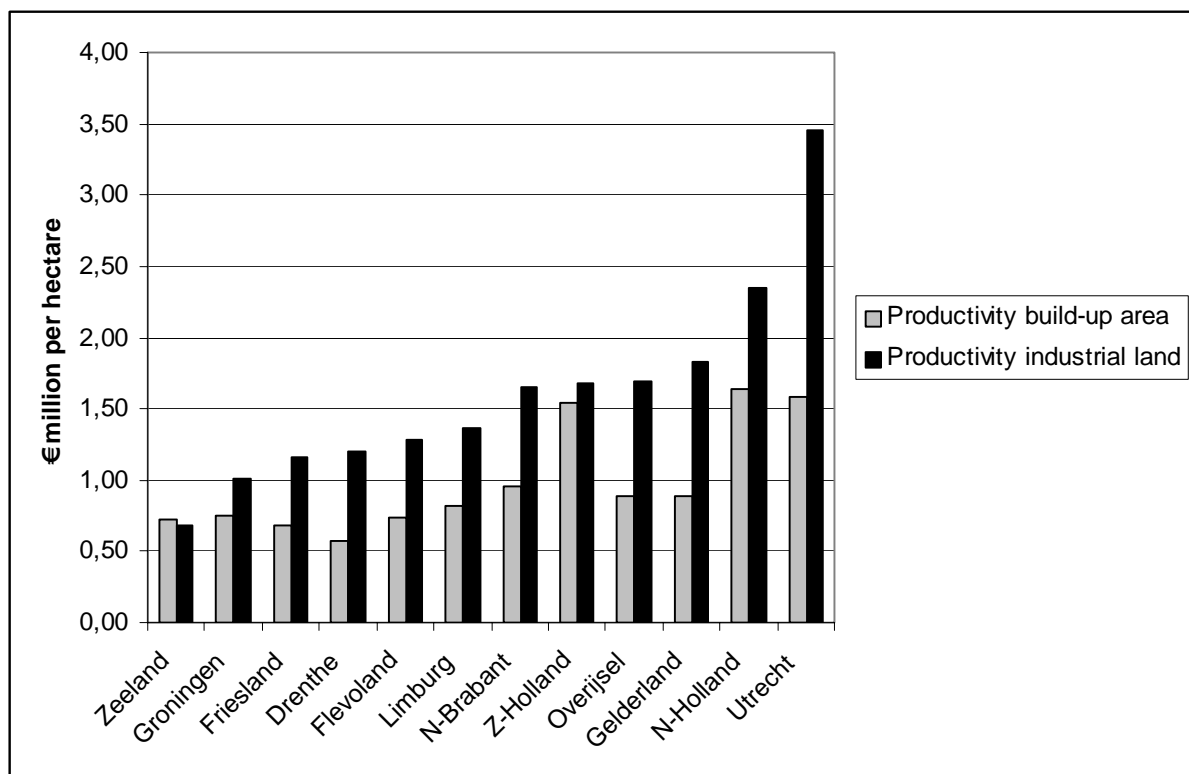


In the provinces Noord-Brabant, Flevoland and Overijssel the share of output realised on industrial estates is well over 40%. These are all provinces with a high growth rate for industrial land use. Flevoland is a particular case because this province totally exists out of land that was reclaimed from the water since 1945 and is planned from scratch according to the spatial

planning principles of functionalism in which the four main land uses of the city (housing, employment, recreation and transport) are clearly separated. This means that more employment is situated on industrial estates and office parks than in all other provinces in which the spatial employment patterns partially dates from the pre-planning times.

When we turn to the productivity of industrial land the regional differences are larger. The average productivity is €1.7 million per hectare, ranging from €0.7 million in Zeeland to €3.4 million in Utrecht (see figure 4). Notable is that the urbanised provinces Utrecht and Noord-Holland have the highest land productivity, while they have lowest share of output produced on industrial estates. In terms of land productivity the other highly urbanised province of Zuid-Holland scores only just above the Dutch average. This is partly caused by the large harbour areas in Rotterdam, which in comparison with other industrial estates have a low employment density (see also figure 5).

Figure 4 Productivity of industrial land and build-up area land per province in 2000

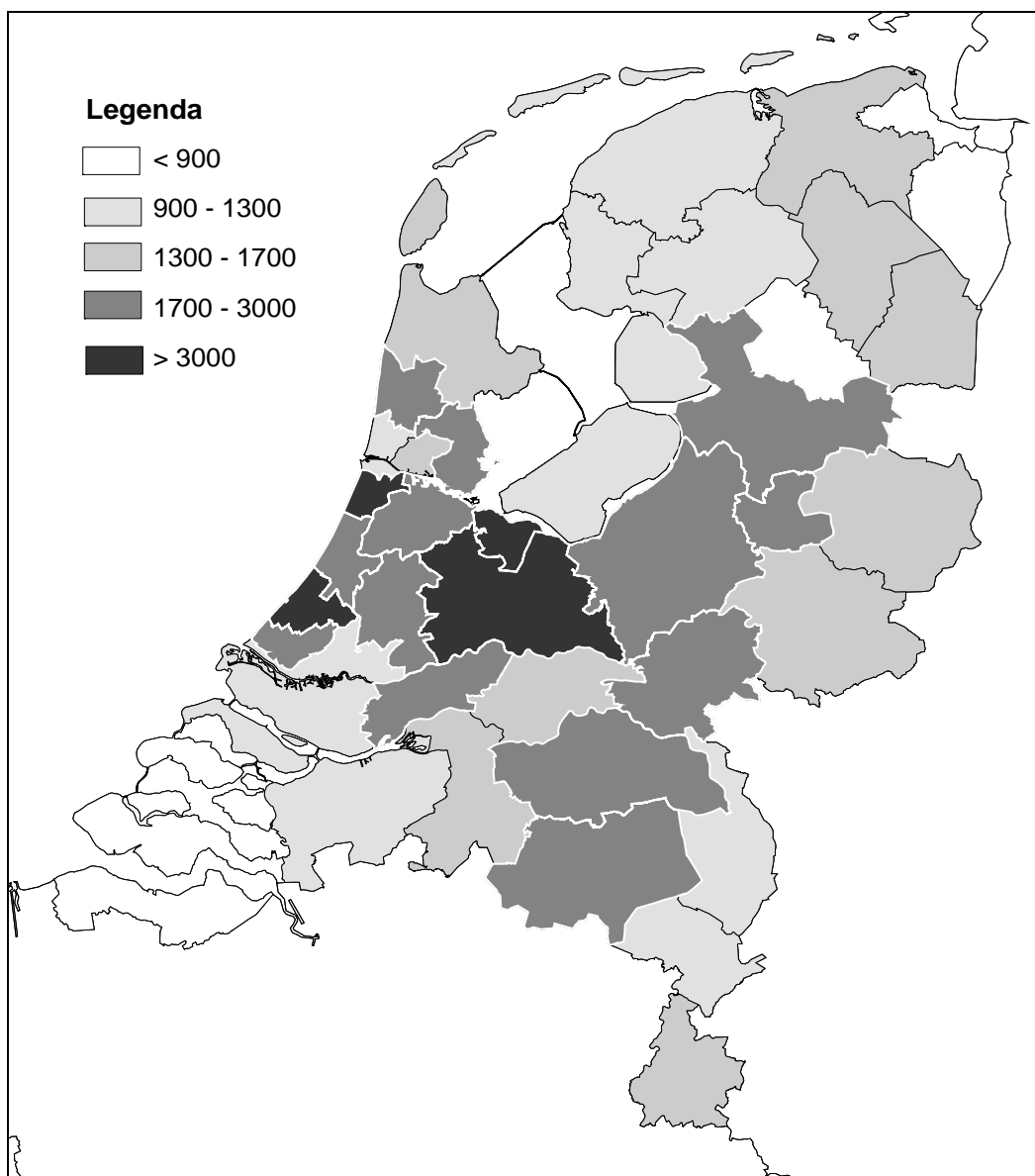


In figure 4 also the land productivity of the build-up area is shown. This type of land productivity is defined as the total output (excluded agriculture) divided by build-up area⁸. Because industrial estates only account of approximately 20% of the build-up area, the productivity of build-up land was expected to be lower than the productivity of industrial land. Figure 4 confirms this. Only in the province of Zeeland the productivity of urban land is just higher than the productivity of

⁸ By using the build-up area we treat all urban land as equal.

industrial land. Probably this is caused by some huge seaport areas with a low level of land productivity in combination with the low level of urbanisation of this province. The land productivity of seaports is low (€0.3 million per hectare). It seems that harbour areas do have a significant influence on the level of productivity of industrial land because all provinces with a high ratio productivity industrial land / productivity build up area have large seaports (in this case the provinces Noord-Holland, Zuid-Holland, Groningen and Zeeland). When de exclude seaports from the calculations than the land productivity rises from €1.7 million per hectare to €2.0 million per hectare.

Figure 5 **Productivity of industrial land (x €1,000 per hectare) per Corop-region in 2000**



4 Towards an explanation

The aim of the research was to find a method to calculate the productivity of industrial land. We think we have succeeded in that. However the question remains how to explain the findings. This will be the aim for research that starts later this year. In advance of this we can hypothesize on some explanations. Some of which are of economic nature others more about spatial planning.

Supply and demand of industrial land

It was suggested by (Needham and Louw 2004), that the high level of industrial land supply in the Netherlands, has resulted in low levels of spatial efficiency. In regions with a high demand and low levels of supply one should expect that the price of industrial land are high and in consequence have a high land productivity. However, reliable data on prices of serviced industrial land on industrial estates are not available. The industrial estates database IBIS does contain data on prices but these are the asking prices by the suppliers and are in most cases not the prices companies actually pay for their land⁹. Therefore, a better method to measure the scarcity of land is the supply / demand ratio¹⁰.

Figure 6 shows a scatter plot of land productivity and the demand / supply ratio. This figure gives some evidence for the hypothesis that land productivity and the demand / supply ratio correlate negatively. This is an indication that planning of industrial estates influences the way land is used in terms of the amount of output. Another indicator in this direction is the fact that the spatial differences in labour productivity are very small in comparison to the spatial differences in land productivity¹¹.

Regional differences in sector composition on industrial estates

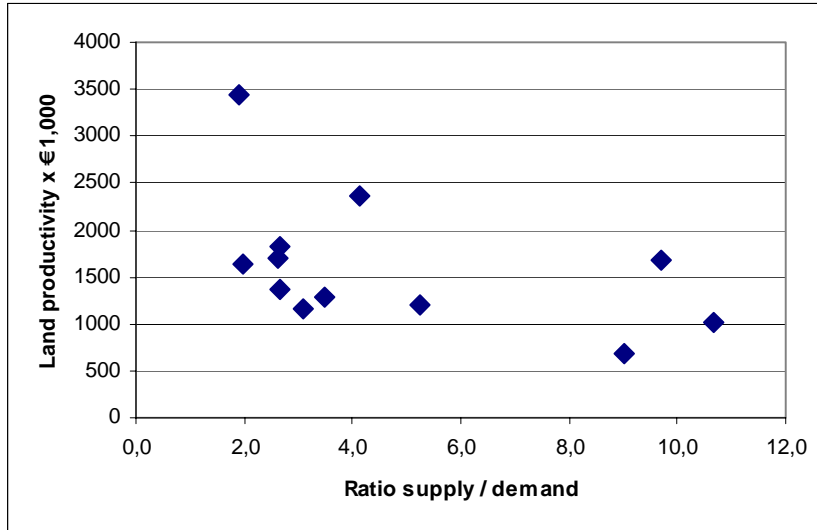
Regions have different economic profiles. In the economic core of the Netherlands (provinces Zuid-Holland, Noord-Holland and Utrecht) there is a service-based economy, while other provinces have (relatively) more manufacturing. These different profiles also are noticeable in the sector composition at industrial estates and affect land productivity in to ways. First, there are regional differences in total labour productivity, but as we have stated above we believe that the influence of these differences is limited. Second, different branches of industry require different amounts of land. The service sector for example only requires a limited amount of space for each job because this sector is accommodated in multi storey office buildings, whereas manufacturing uses single storey buildings. Some types of manufacturing such as refineries, chemical plants and transport sometimes require large amounts of land.

⁹ Dutch local authorities have major role in the supply of industrial land. They make spatial plans and develop serviced industrial land. Municipalities supply currently around 80% of serviced industrial land on industrial estates.

¹⁰ Supply is the amount of serviced land that is available for companies. Demand is the amount of serviced land sold to companies in one year. A demand / supply ratio of 2 means that the amount of serviced land available is sufficient for two years of demand.

¹¹ See paper 'Regional differences in labour productivity in the Netherlands' by Broersma and Van Dijk at the ERSa-conference at Proto.

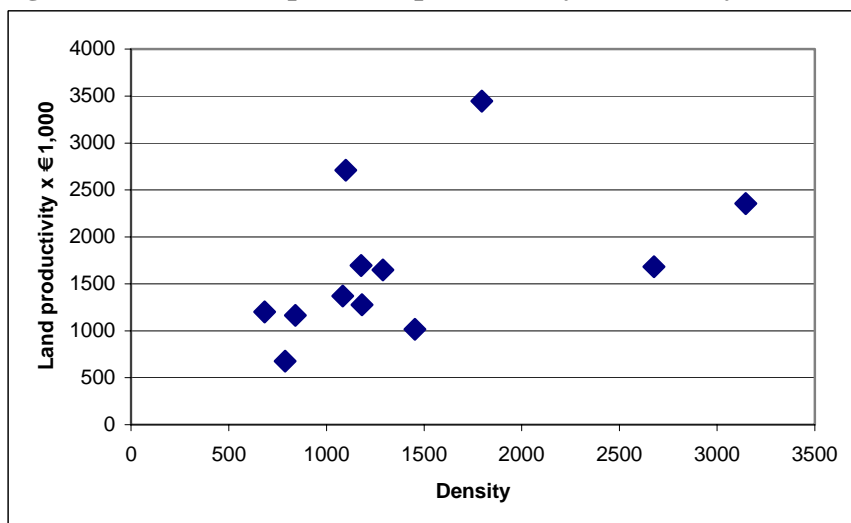
Figure 6 Scatter plot land productivity and ratio demand / supply for industrial land per province in 2000



Density

According to Ciccone and Hall (1996) more than half of the variance of output per worker across the United States can be explained by differences in the density of economic activity. Because in our calculations we use labour productivity to calculate the land productivity it is possible that there is a relation between density and land productivity. We define density as the average number of postal addresses for each square kilometre in a region (so all land is treated as equal). Figure 7 shows a scatter plot of land productivity and density. It seems that there is a weak positive correlation between density and land productivity indicating that agglomeration effects may be observable by measuring productivity of industrial land.

Figure 6 Scatter plot land productivity and density of addresses per province in 2000



5 Conclusion

The aim of the research was to develop a method to measure the productivity of industrial land. By combining several databases we were able to calculate the productivity of industrial land on industrial estates. The method is based on a GIS-analysis of employment on industrial estates, combined with spatial data on added value. We think that our results are reliable for various reasons. First of all the data presented in figure 4. In this figure it is shown that the productivity of urban land in general is lower, than industrial land. This was expected on basis of land use statistics. Second, the spatial differences in land productivity seem to resemble various Dutch research reports on spatial differences in economic activity. However, some details in the method and some data can be improved. For instance it is possible to execute the GIS-analysis on Corop-level. To conduct further analysis this is a necessity.

Our research clearly shows that there are regional differences in the efficiency in which land is used. It seems that in urbanised regions the productivity of industrial land is higher than in less urbanised regions. This seems to confirm the existence of agglomeration economics, but should not be read as there are agglomeration effects on industrial estates because our calculations assume that the in labour productivity on industrial estates is the same as in other areas. Also, there seems to be a relationship between land productivity and land supply.

This information on 'spatial productivity' is highly relevant for spatial planners, because they decide about the allocation of land to economic activities. In the Netherlands, which is densely populated, the supply of industrial land is much debated, because industrial estates are responsible for a substantial part of urban sprawl, while on the other hand the business sector states that a diminishing supply of industrial land will restrict economic growth. Whether this is true is unknown, but our research indicates that additional supply of land in some regions may add more to economic growth than in other regions.

We realize that the research presented in this paper is still in its initial stage and our calculations are explorative. Some adjustments to the calculations are necessary, to make the detailed analyses on the regional differences in land productivity possible. But also we have to explore in theoretical terms what the concept of spatial productivity means. For instance it raises the question whether land is an independent factor of production, or should it be viewed as a form of capital. In this paper we treated land as an independent production factor, but from real estate research we know that land is strongly linked capital. But even, when land is not an independent factor of production, virtually all resource allocation takes place on land (Hubacek and Berg 2002). Therefore, all decisions on resource allocation will influence the way land is used. We think the concept of spatial productivity the way to measure this land use change.

Acknowledgement

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