Agglomeration effects on Dutch industrial sites

To what extent does proximity to economic centres explain variation in the intensity of space use on industrial estates across Dutch municipalities?

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Abstract

This thesis analyses whether proximity to economic centres explains differences in land-use intensity on industrial estates across Dutch municipalities. Using municipal-level data on industrial estates and accessibility, the results show that proximity plays only a limited role. Instead, variation is mainly related to regional structure, average estate size, and local employment dynamics.

Preface

This Master thesis has been written in order to investigate whether industrial sites show signs of increased spatial efficiency when they are located near economic centres such as the Randstad area. A large dataset has been built in order to perform spatial analyses and to be able to answer the posed research question. During this (sometimes quite difficult) year I have received excellent guidance from dr. Eric Koomen. From providing datasets and thinking along in the process of writing and narrowing down my research, his help has been highly appreciated. Additionally, I want to thank mister Koomen (and mister Vincent van den Berg) for their high levels of understanding during this rocky year.

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1. Introduction

During recent decades land use in the Netherlands has changed significantly, with urbanization being a key term. Research has indicated that within a time period of 18 years (2000-2018), urban land use types have increased with roughly 15% (Koomen & Claassens, 2022). A lot of these impervious areas have been built on former agricultural grounds or natural areas, meaning a loss of (semi-)natural areas. Looking at Europe, the Netherlands even have the highest rate of urban land use relative to its size (Koomen & Claassens, 2022). This process is not limited to the Netherlands; it can be observed throughout Europe (Kuemmerle et al., 2016) . Since the start of this century, Europe has seen an increase of more than a million hectares in urban land use types. These changes are putting increasing pressure on (sometimes fragile) natural systems, causing land degradation and harm to biodiversity (Bajocco et al., 2012). In order to counter this process, the European Union has come up with the 'no net land take by 2050' initiative. This initiative has to ensure the decrease of natural land use types in favour of new urban areas comes to a hold (PBL, 2019).

Industrial estates make up an important part of these urban land use types. They play an essential part in providing employment and many types of technological developments for example. Additionally, they are areas with high economic output. Combining these factors indicates why almost every municipality would want their own business estates (Louw et al., 2012). These industrial areas are able to attract new businesses and potential employees to settle in the respective area, making a municipality more attractive to potential new residents. The graph below (*fig. 1.1*) showcases the steady growth of industrial estates in the Netherlands since the 1990's (Koomen & Claassens, 2022).

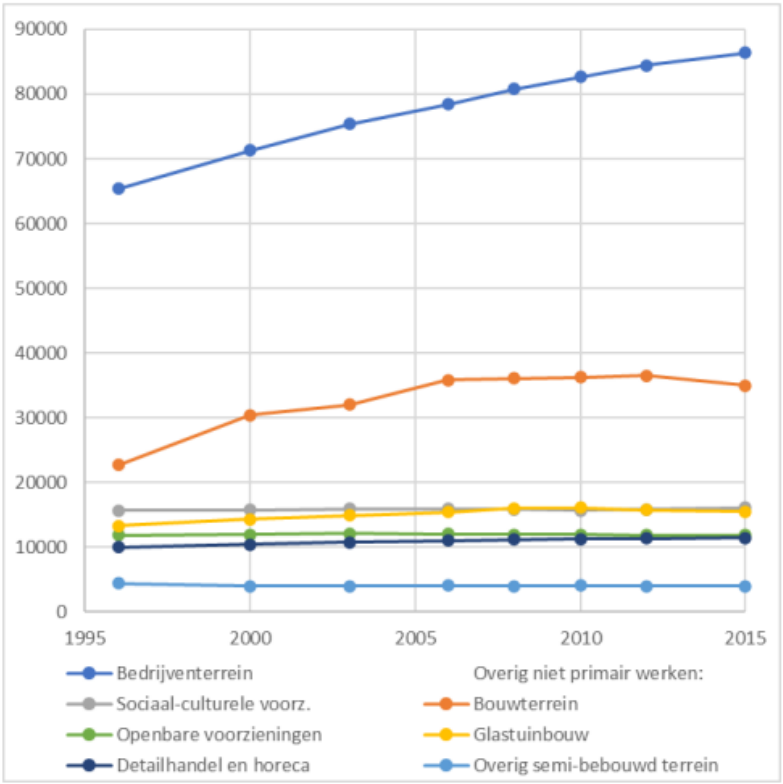

Figure 1.1 The growth of total urban land use surface in the Netherlands in hectares, dark blue line depicts industrial estates (Koomen & Claassens, 2022).

As stated before, the whole of Europe is dealing with land use changes. These changes cause different types of problems for governments and residents, but spatial factors cause the Netherlands to be an interesting country to analyse. The Netherlands is a very densely populated and built up country which causes a wide variety of conflicts when it comes to land use. With a population which is projected to keep growing in the coming years (CBS, 2024), a lingering nitrogen crisis and the 'no net land take' initiative, it becomes clear that unrestrained growth of industrial areas is not viable. Additionally, once a piece of land has been transformed into an urban land use type, it will likely remain an urban area for a long period of time. This also applies to vacant land, the costs are often too high to achieve conversion to natural land use (Louw et al., 2012 & Chen et al., 2018).
This means that business parks need to use the space that they are given efficiently. Research shows that the average occupancy rate at business parks in the Netherlands is around 0.4 (de Kort & Gradussen, 2023). A low occupancy rate indicates that the space is not being used in an efficient manner, while a high rate shows that the available space is being used very efficiently. In addition, it is known that demand for space in business parks is expected to grow in the coming years, while the vacancy rate is already quite low at 1.8% (Stec Groep, 2023). When you combine this with the shortage of space in the Netherlands, it can be concluded that existing sites will have to use the space that has already been allocated more efficiently to avoid a shortage of space for new companies to settle on industrial sites. Among other things, this is important in order not to hinder economic development.

Dutch municipalities have a very strong position when it comes to the land market and in order to make themselves attractive, they are able to offer pieces of land way below the actual economic value (Segeren et al., 2005 & Koomen & Claassens, 2022). This led to an increased issuance of new business parks by Dutch municipalities which has been studied and, according to several sources, has negative implications for land use intensity (Louw et al., 2012 & Chen et al., 2018). Basic microeconomics imply that in a perfectly competitive market, a piece of land will be rented by an agent who has the largest benefits from paying that rent price. It means that an agent is willing to pay more than another agent who would benefit less from renting that piece of land, which is also known as Alonso's bid rent (Broitman & Koomen, 2020). This theory states that the spatial structure of cities and their hinterlands follows a fixed pattern. The closer to the city centre, the higher the rent and vice versa. This means that companies with a low amount of land needed and a high output settle near the centre, while for example agricultural firms settle more in the hinterland where land is cheaper and available in larger quantities.

Taking this into account, one would expect that from an agglomeration perspective, locations close to major economic centres should experience stronger spatial pressure. In such contexts, firms are expected to economise on land by building more compactly and intensively. If this mechanism holds, municipalities closer to economic cores should systematically exhibit higher levels of industrial land-use intensity. Due to a lack of existing research on this topic, this leads to the following research question:

To what extent does proximity to economic centres explain variation in the intensity of space use on industrial estates across Dutch municipalities?

This research question is addressed through a combination of spatial data analysis and a review of relevant literature on agglomeration and land-use economics. A nationwide dataset of industrial estates was aggregated to the municipal level and enriched with indicators reflecting proximity to economic centres, demographic pressure and spatial structure. Regression analysis

is then used to examine whether municipalities that are more strongly embedded in economic cores systematically exhibit higher levels of space-use intensity on their industrial estates. In doing so, this thesis provides an empirical assessment of whether existing industrial land in the Netherlands is used more intensively where economic pressure is highest, thereby offering insight into the extent to which current spatial patterns reflect an effective match between demand and the physical allocation of space.

2. Data & methodology

The spatial analysis carried out for this research can be divided into two main steps. The first step consists of gathering relevant spatial datasets, processing them, and combining them into one large and accessible database suitable for analysis. The second step involves exporting this database and estimating regression models in STATA in order to answer the research question posed in the first chapter.

The empirical analysis starts from a large dataset provided by IBIS. This file contains all industrial estates in the Netherlands, including their geographic location, total size, issued land, built-up floor area, sectoral composition, and the number of jobs in 2012 and 2023. The data were loaded into a geographical information system (QGIS), which allows spatial operations and the integration of multiple datasets into one large dataset (*fig. 2.1*).

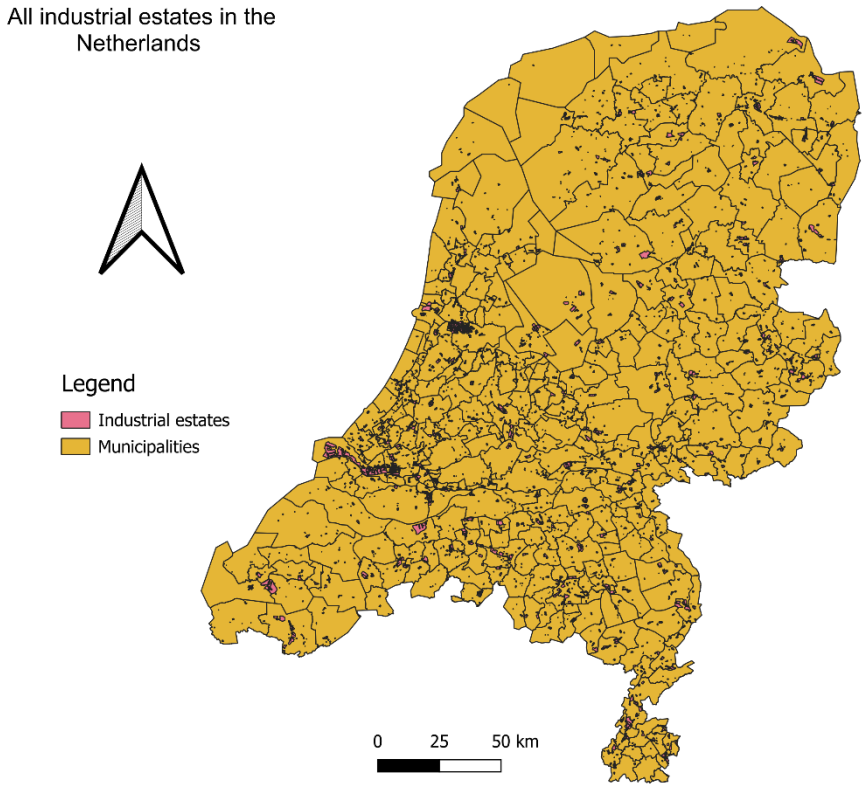

Figure 2.1 All the industrial sites within the Netherlands with black lines indicating municipal boundaries.

In order to carry out the analysis at a municipal level, all industrial estates were spatially linked to the municipal boundaries of the Netherlands. These boundaries can also be seen in the figure above. This aggregation level was chosen, because municipalities play a central role in spatial planning and land supply on business parks in the Dutch context (Segeren et al., 2005 & Koomen & Claassens, 2022). They are the main actors in issuing land, setting development conditions, and competing for firms. This makes aggregating on a municipal level the best approach, since this is the institutional scale at which relevant decisions are made. When aggregating the data, weighted averages were applied so that larger industrial estates have a stronger influence than smaller ones. This prevents small sites from dominating municipal outcomes and ensures that the resulting indicators reflect the spatial reality of industrial land use within each municipality.

The central variable in this research is the intensity of space use on industrial estates. This variable directly reflects how efficiently scarce industrial land is used in practice. Rather than measuring prices or productivity, it captures the physical outcome of spatial and economic pressure: how much built floor area is realised on a given amount of industrial land (Yan et al., 2020).

Within the IBIS dataset, both the total issued land and the total built-up floor area are available. These two variables are used to calculate a coverage ratio for each industrial estate, defined as the total built floor area divided by the issued industrial land. A low ratio implies low spatial efficiency, while higher values indicate more intensive use of space. Values above one are possible, reflecting multi-storey buildings where total floor area exceeds the land surface. This measure therefore captures not only whether land is occupied, but also how intensively it is developed.

The estate-level ratios are aggregated to the municipal level using weighted means, with the size of each estate as weight. The resulting municipal indicator represents the average intensity of space use on industrial estates within a municipality in 2023. The analysis therefore focuses on a cross-section of municipalities and does not model change over time.

To analyse potential agglomeration effects, the IBIS data were enriched with additional spatial datasets. The most important explanatory variable is the average travel time from a municipality to areas with at least 100.000 jobs. This raster file measures how long it takes to reach large concentrations of employment and serves as a proxy for proximity to economic centres, in practice capturing distance to the Randstad area and other major urban cores (*fig. 2.2*).

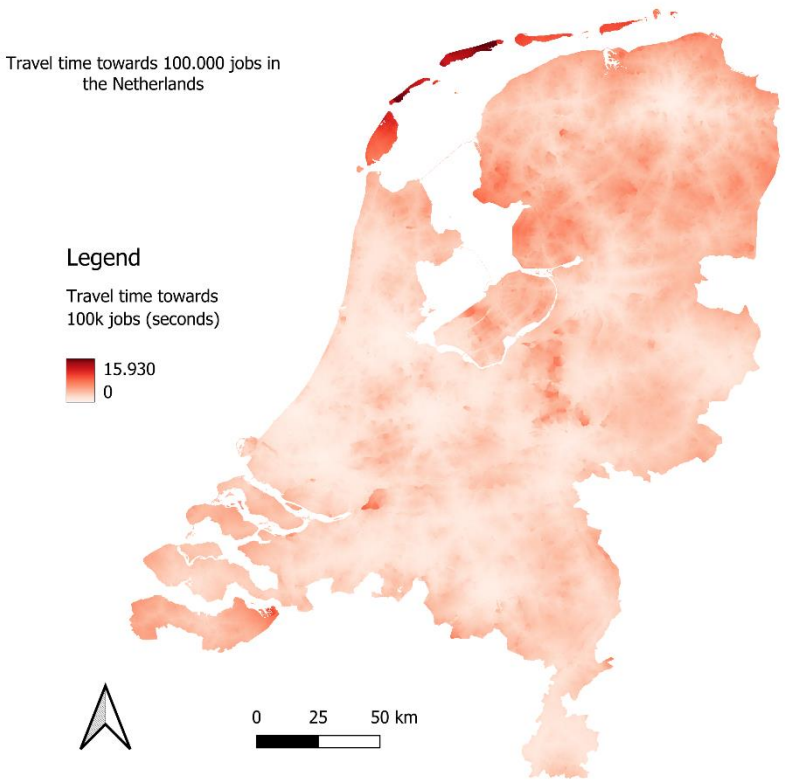

Figure 2.2 Map indicating the time needed to travel from any point in the Netherlands to 100.000 jobs.

In addition, mean population density per municipality is included to capture the degree of urbanisation, and the total number of jobs on industrial estates is used as a measure of local economic scale (Liu et al., 2020). A further variable is constructed that captures the average size of industrial estates within each municipality, based on the issued land area of all estates per municipality. This indicator reflects the typical spatial scale at which industrial land is supplied at a local scale. It allows the analysis to distinguish between municipalities characterised by many small sites and those dominated by large, contiguous business parks (Rotterdam for example). Provincial identifiers were added in order to control for regional differences in planning regimes, economic structure, and historical development patterns, as other research has indicated that this could play an important role (Zhang et al., 2022).

All datasets were merged in QGIS using zonal statistics and spatial joins. The final analysis table contains 349 Dutch municipalities with information on industrial land-use intensity, proximity to economic centres, population density, economic scale, average estate size, and province. This table is exported as a CSV file and imported into STATA for regression analysis.

Dataset	Source
Industrial estates IBIS	IBIS, 2025
Travel time to 100.000 jobs	Koomen, 2018
Administrative boundaries	CBS, 2025
Population density	PDOK, 2026

Table 2.1 Overview of used spatial datasets.

The intensity of space use on industrial estates is the dependent variable in this study because it directly reflects how scarce and valuable industrial land is in practice. Economic theory predicts that land closer to major economic centres commands higher rents (Broitman & Koomen, 2020). Higher rent prices cause the competitive pressure for space to rise and it encourages firms to be effective with the amount of space available, leading to more compact and vertical development (more high-rise buildings as can be seen near city centres). The intensity of space use thus represents the tangible spatial outcome of agglomeration forces (Zhang et al., 2022).

The key explanatory variable is average travel time to areas with at least 100,000 jobs. This variable operationalises proximity to economic hubs and therefore potential access to agglomeration benefits. Control variables include population density, total employment on industrial estates, average industrial estate size, and provincial identifiers. Together, these variables account for urbanisation rate, economic scale, the spatial structure of industrial land supply, and regional institutional context (Han et al., 2019 & Liu et al., 2020).

Several variables display strong right-skewness. To reduce the influence of extreme values and allow interpretation in elasticities, the dependent variable and the main explanatory variables are transformed using natural logarithms.

Variable name	Desciption
popdens	Population density per municipality, as a measure of urbanity
jobs2023	Total number of jobs in business parks in 2023, as a measure of scale
job_growth	Relative growth in jobs between 2012 and 2023, as a measure of local economic dynamics
GSI	Ground Space Index, as an indicator of spatial structure and building intensity
prov	Provincial dummies, to control for regional and institutional differences

Table 2.2 Overview of used variables in the regressions.

The empirical analysis is based on a sequence of linear regression models. The baseline specification relates land-use intensity to proximity to economic centres:

$$\ln(\text{coverage}_i) = \alpha + \beta_1 \ln(\text{travel time}_i) + \varepsilon_i$$

in which $\ln(\text{coverage}_i)$is the log of industrial land-use intensity in municipality i, $\ln(\text{travel time}_i)$ is the log of average travel time to 100,000 jobs, α is a constant, and ε_i is the error term.

Control variables are then added:

$$\ln(\text{coverage}_i) = \alpha + \beta_1 \ln(\text{travel time}_i) + \beta_2 \ln(\text{population density}_i) + \beta_3 \ln(\text{jobs}_i) + \beta_4 \ln(\text{avgsize}_i) + \varepsilon_i$$

To account for regional structure, provincial fixed effects are introduced:

$$\ln(\text{coverage}_i) = \alpha + \beta_1 \ln(\text{travel time}_i) + \beta_2 \ln(\text{population density}_i) + \beta_3 \ln(\text{jobs}_i) + \beta_4 \ln(\text{avgsize}_i) + \sum_p \gamma_p D_{ip} + \varepsilon_i$$

where D_{ip} is a dummy variable indicating whether municipality $i$belongs to province p.

In an extended specification, a variable measuring growth in industrial employment between 2012 and 2023 is added to test whether recent local economic dynamics are associated with more intensive land use. All models are estimated using robust standard errors to account for heteroskedasticity.

Several robustness checks have been performed. First, models are estimated including only population density or only employment, both with and without provincial fixed effects. Second, subsample analyses are conducted excluding municipalities with limited economic activity: municipalities with fewer than 1000 jobs on industrial estates and a stricter subsample consisting only of large municipalities. These checks assess whether observed relationships are driven by small or atypical municipalities or whether they persist in economically relevant contexts. Together, this methodological design provides a systematic test of the hypothesis that proximity to economic core areas leads to more intensive use of industrial land in the Netherlands.

3. Results

In this chapter, the results of the regression analyses are presented and discussed. The outcomes are structured in three steps. First, a baseline specification is estimated in which land-use intensity is related solely to proximity to economic centres. Second, local control variables are added. Third, provincial fixed effects are introduced to account for structural regional differences. The main results are summarised in Table 3.1.

3.1 Basic specification

Column 1 of table 4.1 reports the result of a regression of land use intensity (ln_dekking) on travel time to 100.000 jobs (ln_tt). The estimated coefficient is negative, which is in line with the hypothesis that municipalities located further away from major concentrations of employment show lower levels of land-use intensity on their industrial estates. However, the coefficient is small and statistically insignificant. The explanatory power of the model is negligible ($R^2 \approx 0.001$), indicating that travel time to large job concentrations alone explains basically nothing of the observed variation in coverage across Dutch municipalities. This suggests that proximity to economic centres, in isolation, is not a strong predictor of how intensively industrial land is used.

3.2 Addition of local controls

In column 2, population density (ln_pop), the number of jobs on industrial estates (ln_banen), and the average size of industrial estates within a municipality (ln_avgsize) have been added. The coefficient of travel time (ln_tt) remains negative and statistically insignificant. Neither population density nor the scale of employment on industrial estates displays a significant relationship with land-use intensity.

In contrast, the coefficient of the average size of industrial sites per municipality (ln_avgsize) is positive, although not yet statistically significant in this specification. The overall explanatory power of the model increases only marginally ($R^2 \approx 0.009$). This indicates that, when considered jointly, differences in urbanisation and economic scale remain weakly related to variation in coverage rates.

3.3 Provincial fixed effects

Column 3 introduces provincial fixed effects, which in this case allows for absorbing all time-invariant differences between provinces, such as institutional settings, planning traditions, and historical spatial structures. The regression is estimated with robust standard errors.

The coefficient on travel time (ln_tt) remains negative and statistically insignificant. Similarly, the mean population density (ln_pop) and the mean amount of jobs per industrial site (ln_banen) continue to show no meaningful association with building intensity (ln_dekking). By contrast, the mean size of industrial estates (ln_avgsize) now becomes strongly positive and statistically significant at the 1 per cent level. This implies that, within provinces, municipalities that house larger industrial estates tend to exhibit substantially higher levels of land-use intensity.

The explanatory power of the model increases notably ($R^2 \approx 0.054$). This rise is driven both by the inclusion of provincial effects and by the systematic contribution of average estate size. The results suggest that structural regional differences matter, but that within these regions, the scale of industrial estates plays an important role in shaping how intensively land is used.

3.4 Expansion with employment growth

Column 4 extends the model by including employment growth on industrial estates between 2012 and 2023 (groei_banen). This variable has a positive coefficient that is statistically significant at the 5 per cent level. Municipalities in which employment on industrial estates has grown more strongly, tend to display higher levels of land-use intensity.

The inclusion of job growth hardly alters the coefficient of the land use intensity (ln_tt), which remains negative and insignificant. The coefficient on the average size of industrial estates per municipality (ln_avgsize) remains large and highly significant. The explanatory power of the model increases slightly ($R^2 \approx 0.057$). These results indicate that economic development is associated with more intensive land use, whereas spatial proximity to major job centres is not.

Agglomeration and land use intensity on industrial estates

	(1) Baseline	(2) + Controls	(3) + Province FE	(4) + Growth
ln_tt	-0.164	-0.147	-0.074	-0.035
	(0.253)	(0.434)	(0.121)	(0.120)
ln_pop		-0.015	-0.039	-0.034
		(0.149)	(0.047)	(0.046)
ln_banen		0.059	0.036	0.031
		(0.097)	(0.075)	(0.073)
ln_avgsize		0.056	0.114***	0.117***
		(0.041)	(0.023)	(0.021)
groei_banen				0.279**
				(0.137)
_cons	1.770	1.333	1.305	0.985
	(1.968)	(4.237)	(1.219)	(1.245)
Observations	349.000	345.000	341.000	341.000
R2	0.001	0.009	0.054	0.057

Standard errors in parentheses
Robust standard errors in parentheses. Province fixed effects included in columns (3) and (4).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.1 Results from the first regressions performed.

3.5 Robustness analyses

To assess whether the results are driven by municipalities with very limited industrial activity, the main specification was re-estimated for subsamples with a minimum number of jobs on industrial estates. Table 4.2 reports the results for municipalities with at least 1,000 jobs and at least 5,000 jobs in 2023.

Across both subsamples, the coefficient on ln_tt remains statistically insignificant and unstable in sign. Population density and employment scale likewise show no robust relationship with ln_dekking. In contrast, ln_avgsize remains positive and highly significant in both specifications. The magnitude of this effect is comparable to that observed in the full sample.

These findings indicate that the central pattern of the analysis is not driven by small or marginal municipalities. Instead, the association between the scale of industrial estates and land-use intensity persists within economically more relevant subsets of municipalities.

Robustness checks: minimum size subsamples

	(1) N>=1000 jobs (2023)	(2) N>=5000 jobs (2023)
ln_tt	-0.022	0.065
	(0.153)	(0.370)
ln_pop	-0.052	-0.091
	(0.057)	(0.152)
ln_banen	0.089	-0.041
	(0.122)	(0.143)
ln_avgsize	0.117***	0.126***
	(0.019)	(0.013)
_cons	0.388	0.938
	(1.850)	(3.972)
Observations	300.000	153.000
R2	0.060	0.093

Standard errors in parentheses
Robust standard errors in parentheses. Province fixed effects included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.2 Results from the second mode checking robustness.

3.6 Single-variable specifications

Additional regressions were estimated including only one explanatory variable at a time, both with and without provincial fixed effects. The results of these regressions can be found in the appendix (Appendix A). Neither population density nor the number of jobs shows a statistically significant relationship with land-use intensity in any specification. The inclusion of provincial fixed effects increases explanatory power, but does not affect this conclusion.

On the other hand, the mean size of industrial estates in a municipality (ln_avgsize) displays a positive and statistically significant coefficient once provincial fixed effects are included. This confirms that the relationship between estate size and land-use intensity is not an artefact of multicollinearity with other covariates.

To conclude, the results show that differences in land-use intensity on industrial estates across Dutch municipalities are only weakly related to proximity to economic centres, population density, or the scale of local employment. Instead, variation is primarily associated with structural regional differences and, within provinces, with the average size of industrial estates and with local employment dynamics. The implications of these findings are discussed in the next chapter.

4. Discussion

This chapter discusses the main implications of previous chapter and relates them to the theoretical expectations formulated in the introduction. It will also reflect on methodological choices and limitations. First off, the main findings in relation to the research question from the introduction will be addressed. After that, the role of mean industrial estate size and local dynamics is discussed. Thirdly, the limitations of the study are addressed, followed by some brief suggestions on future research and possible policy implications.

4.1 Main findings

The research question asked to what extent proximity to economic centres explains variation in the intensity of space use on industrial estates across Dutch municipalities. Based on the regression results, proximity (measured as travel time to areas with at least 100,000 jobs) does not appear to be a strong predictor of municipal variation in land-use intensity. Across the baseline model, the extended specifications with controls, and the models including provincial fixed effects, the coefficient of travel time(ln_tt) remains statistically insignificant and is not stable in magnitude. This suggests that, at least at the municipal scale, spatial pressure associated with large job concentrations does not always translate into a higher observed coverage ratio on industrial estates.

On the other hand, two variables stand out once regional structure is accounted for. First, the average size of industrial estates within municipalities (ln_avgsize) shows a clear and robust positive association with land-use intensity in the fixed effects models. Additionally, employment growth on industrial estates between 2012 and 2023 (groei_banen) is positively related to land-use intensity in the extended specification. These patterns remain present in the subsample analyses that exclude municipalities with limited industrial estate employment, indicating that they are not driven by small or marginal cases.

In summary, the results indicate that factors which capture the aforementioned structure of industrial land supply and local economic dynamics are more relevant than an explanation which solely relies on the distance to the core of economic centres such as the Randstad area.

4.2 Proximity to economic centres as a predictor

As posed before, one would expect stronger land scarcity near economic cores to lead to more intensive land use (Broitman & Koomen, 2020). The absence of a significant relationship between travel time (ln_tt) and building intensity (ln_dekking) does immediately imply that agglomeration mechanisms are irrelevant, but at least it suggests that this model set-up is not able to capture those effects. A possible explanation is that municipal averages may smooth out within-municipality variation. Municipalities contain a mix of estates with very different ages, sectoral compositions and development trajectories. Even if a “core-proximity effect” exists at the estate level, aggregation to a single municipal indicator may reduce the visibility of that effect.

A second explanation relates to how spatial planning has been set up in the Netherlands. Land allocation for business estates is strongly shaped by planning regimes and municipal choices. If supply is expanded in anticipation of demand, or if land pricing is used strategically to attract firms, proximity to economic centres may not be reflected in the physical intensity indicator in a simple way (Segeren et al., 2005 & Koomen & Claassens, 2022). This could explain why land-use

intensity can remain relatively moderate, even in areas where demand pressure is expected to be high, because supply conditions and development rules partly buffer that pressure.

A third point is that travel time to 100.000 jobs is able to capture proximity to an economic hub partly, but agglomeration benefits can be sector-specific and may depend on more detailed interactions (e.g., supply chain relations, logistics networks, or specialised labour markets). A single accessibility proxy may therefore be too broad to detect a consistent elasticity at the municipal scale (Liu et al., 2021 & Zhang et al., 2022).

This would align with the pattern that the inclusion of provincial fixed effects improves the model fit. It indicates that structural regional differences matter, but it does not immediately imply that distance-based agglomeration pressure is the key explanation for within-province drivers of land-use intensity.

4.3 Average estate size as a structural factor

The most consistent result in the analysis concerns the average size of industrial estates. Once provincial fixed effects are included, the mean size of industrial estates coefficient (ln_avgsize) becomes strongly positive and statistically significant, and this pattern could also be spotted in the minimum-size subsamples. This could suggest that municipalities characterised by larger industrial estates tend to display higher levels of land-use intensity, even when compared to other municipalities within the same province.

This finding can be interpreted as evidence that the organisation of industrial land supply matters. In addition, more contiguous estates may allow for different forms of development than fragmented landscapes with many small sites. Larger estates may attract different types of firms, may be subject to more coordinated planning, and may have infrastructure that supports more intensive use. The positive relationship also suggests that differences in land-use intensity are not only a matter of "how close a municipality is to a core," but also of how industrial land is structured locally.

At the same time, it should be noted that the average estate size indicator can capture multiple underlying mechanisms at once. For instance, it can reflect the historical development pattern of a municipality, the type of estates that were planned (and for which sectors), and the degree to which estates were designed as expansion locations rather than compact mixed-use sites. In other words, the size variable is informative, but it is not a direct causal indicator by itself. It functions primarily as a marker of how industrial land supply is organised.

4.4 Employment dynamics and intensity

The positive relationship between employment growth on industrial estates and land-use intensity provides an interesting additional insight. Municipalities where employment increased more strongly between 2012 and 2023 show, on average, higher land-use intensity in the 2023 cross-section results.

A possible interpretation is that stronger local demand pressure, reflected in employment dynamics, is associated with more intensive use of existing industrial land. This is consistent with the idea that where economic activity increases, there is either more development within existing estates or a stronger tendency to intensify the use of available space (Segeren et al., 2005) . The fact that this effect appears in addition to the estate size effect could suggest that both structural conditions (estate size) and more recent dynamics (employment growth) matter in shaping observed intensity outcomes.

At the same time, the analysis does not unravel the direction of causality. Higher intensity could facilitate growth, but growth could also cause intensification the other way round. The results therefore mainly indicate that intensity and growth co-occur, which is in itself relevant in the context of spatial scarcity.

4.5 Limitations

During the research, some limitations became apparent and these should be considered when interpreting the results.

First off, the study is cross-sectional and focuses on the 2023 municipal situation. This limits the ability of this research to draw conclusions about adjustment processes over time. Land-use intensity may respond slowly to economic pressure, especially if estates were developed recently and require time to fill and intensify. Without an explicit time dimension, these dynamics remain partly hidden.

Also, the dependent variable is constructed from built-up floor area and issued land. While this is a meaningful intensity indicator, it can also be influenced by measurement and definitional choices within the IBIS dataset. Values above one can occur due to multi-storey development, which fits the interpretation of intensity, but the measure remains an indirect proxy for “efficient land use” and does not fully capture other aspects such as layout and parking spots for example.

In addition to this, aggregation to the municipal level has both strengths and weaknesses. It aligns the analysis with the governance scale of land issuance and planning decisions, but it can disrupt estate-level heterogeneity. Different estates within the same municipality may respond differently to economic pressure depending on age, sector mix, and planning constraints.

Fourth, the proxy for agglomeration pressure is based on accessibility to large job concentrations. This captures one relevant dimension, but agglomeration benefits can be more localised and sector-specific than this proxy reflects. As a result, a null finding for travel time (ln_tt) does not rule out the presence of agglomeration effects entirely. It mainly indicates that they do not appear strongly in the present operationalisation and aggregation level.

Lastly, the analysis does not explicitly control for estate age, sectoral composition, or land pricing and planning instruments. These are variables that are frequently mentioned in the literature as relevant drivers of industrial land-use intensity, and their omission can limit interpretability of the results shown in this research.

4.6 Suggestions for future research

Based on these limitations and the observed results, some suggestions on future research can be provided.

A first step would be to move from municipal aggregates to estate-level analysis, or to combine both levels in a multilevel framework. This would allow testing whether proximity effects are visible at smaller spatial units, while still accounting for municipal planning context.

In addition, incorporating indicators on estate age and development phase could improve interpretation. If newer estates structurally have lower observed intensity because they are still in development, controlling for age would help separate maturity effects from agglomeration pressure.

Third, future work could incorporate sectoral composition or land-use typologies of estates. Different sectors have fundamentally different land requirements, which can mechanically influence intensity measures. Including sector shares could therefore clarify whether the size effect is partly driven by industrial composition.

Lastly, richer measures of accessibility and economic interaction could be tested, such as proximity to logistics corridors, ports, or specialised employment clusters, rather than a single threshold-based job accessibility measure.

4.7 Policy implications

Although the analysis is not designed as a direct evaluation of specific policies, the findings still provide several relevant insights for the Dutch spatial planning debate.

The limited role of proximity to large employment cores suggests that intensification is not automatically higher where spatial pressure is expected to be strongest. This underlines that planning regimes, local supply structures, and development trajectories likely matter in shaping outcomes.

The strong association between average estate size and intensity implies that the way industrial land is supplied and organised locally may influence how intensively it is eventually used. This points to the relevance of looking not only at total hectares of industrial land, but also at the configuration of that land: the fragmentation into many small sites versus the presence of larger, more coordinated estates.

Lastly, the positive link between employment growth and intensity suggests that demand dynamics are related to the realised use of space. In a context of scarce land and expected future demand growth, this highlights the importance of monitoring not only vacancy rates, but also the physical intensity with which land is used, as these are not equivalent outcomes.

5. Conclusion

This thesis set out to examine whether proximity to economic centres helps explain differences in the intensity of space use on industrial estates across Dutch municipalities. Building on the idea that higher spatial pressure near economic cores should lead to more compact and intensive development, a nationwide dataset of industrial estates was aggregated to the municipal level and enriched with indicators on travel time to large job concentrations, population density, employment on industrial estates, average estate size, and province. Regression models were estimated in a stepwise manner, including specifications with provincial fixed effects and a set of robustness checks.

The results provide a clear answer to the main question. Across all main specifications, travel time to areas with at least 100.000 jobs does not show a statistically significant relationship with municipal variation in land-use intensity. This means that, at the municipal scale and using the employed proxy for proximity, being closer to major job concentrations does not systematically translate into a higher observed coverage ratio on industrial estates.

At the same time, the analysis does identify two factors that are consistently associated with higher land-use intensity once regional structure is taken into account. First, the average size of industrial estates within a municipality shows a strong and robust positive relationship with land-use intensity in the models with provincial fixed effects, and this pattern remains present in the minimum-size subsamples. Second, employment growth on industrial estates between 2012 and 2023 is positively related to land-use intensity in the extended model. Together, these outcomes point towards the relevance of local supply structure and local economic dynamics, rather than a simple distance-to-core mechanism, in explaining observed differences in how intensively industrial land is used.

In practical terms, the findings suggest that intensification of industrial land in the Netherlands is not automatically strongest where proximity-based agglomeration pressure would be expected to be highest. Instead, intensity appears more closely connected to the way industrial land is organised locally and to recent economic developments on business parks. This reinforces the idea that, in a context of limited space and expected future demand, understanding industrial land-use outcomes requires looking beyond proximity alone and paying attention to local development patterns and the structure of industrial estate supply.

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Appendix A

Appendix A: single-variable specifications

	(1) ln_pop	(2) ln_pop + FE	(3) ln_jobs	(4) ln_jobs + FE	(5) ln_avgsize	(6) ln_avgsize + FE
ln_pop	0.028 (0.097)	0.014 (0.029)				
ln_banen			0.100 (0.085)	0.105 (0.065)		
ln_avgsize					0.062 (0.039)	0.123*** (0.017)
_cons	0.345 (0.547)	0.462*** (0.148)	-0.335 (0.714)	-0.309 (0.523)	0.608*** (0.129)	0.817*** (0.073)
Observations	345.000	341.000	349.000	345.000	349.000	345.000
R2	0.000	0.039	0.004	0.043	0.007	0.054

Standard errors in parentheses

Robust standard errors in parentheses. FE columns include province fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$