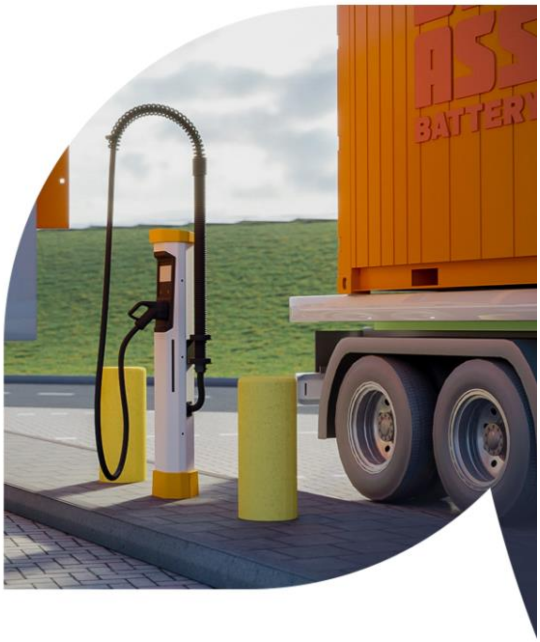

THE ECONOMIC IMPACT OF ALTERNATIVE FUEL STATIONS ON INDUSTRIAL PARKS: CASE STUDY IN THE PROVINCE OF GELDERLAND

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ABSTRACT

The push towards sustainable energy sources has gained significant momentum due to global environmental challenges and the urgent need to reduce greenhouse gas emissions. This research explores the economic impact of alternative fuel stations on industrial parks in the province of Gelderland. By employing a quantitative analysis, this study examines the spatial distribution of these stations and their correlation with the economic growth of industrial parks. The analysis utilises an extensive dataset on the locations and characteristics of alternative fuel stations, as well as economic indicators such as employment, net surface area, added value, and number of firms. Based on the used dataset, the research finds that proximity to alternative fuel stations generally enhances the economic growth of industrial parks in Gelderland. While the analysis suggests a relationship between alternative fuel stations and industrial park economic growth, the results should be interpreted cautiously. There is a possibility of omitted variable bias, as not all relevant variables may have been included in the model. This omission could lead to an overestimation or underestimation of the actual effect. Additionally, the direction of the observed relationship may not fully align with reality, indicating that further research is necessary to confirm these findings and to explore any additional influencing factors that may not have been accounted for in this research.

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CHAPTER 1: INTRODUCTION

1.1 Topic and Context

The push towards sustainable energy solutions has gained significant momentum in recent years, driven by global environmental challenges and the urgent need to reduce greenhouse gas emissions. Among these solutions, establishing alternative fuel stations has emerged as an essential aspect of the renewable energy transition. Numerous logistic firms are fully betting on this transition (Renault Trucks, 2023; PostNL, 2023; Redactie Transport & Logistiek, 2023; SmartWays, 2023; Willems, 2020). This thesis explores the impact of these alternative fuel stations on the economic growth of industrial parks in the province of Gelderland. By examining the spatial distribution of fuel stations and their correlation with industrial park economic growth, this research aims to provide a comprehensive understanding of how sustainable energy infrastructure can drive economic growth in industrial areas.

1.2 Focus and Scope

This study aims to conduct a quantitative analysis of the effects of alternative fuel stations on the economic growth of industrial parks in the province of Gelderland. By analysing several variables, such as the geographic distribution of these stations and their specific characteristics, the study seeks to investigate the relationship between alternative fuel stations' presence and industrial parks' economic growth. The study makes use of a relatively large dataset that contains details on the locations of alternative fuel stations, the availability of alternative fuels and additional services at stations, and economic indicators of industrial parks like employment, net surface area, added value, and number of firms. In order to quantify the economic trends related to the mobility energy transition, the study uses fixed effects regression models and spatial analyses.

1.3 Relevance and importance

The relevance and importance of this research lie in its potential to inform policy and strategic decisions regarding the locational choices behind alternative fuel stations to impact economic growth at industrial parks positively. By quantitatively analysing the impact of these stations on the economic growth of industrial parks in Gelderland, the study provides evidence-based insights that can guide infrastructure development and investment. This research highlights the critical role of alternative fuel stations in supporting sustainable economic development and reducing environmental impacts. Therefore, it is expected to contribute to the renewable energy transition and regional economic growth.

Besides societal relevance, there is also scientific relevance to this thesis. The current knowledge gaps in the existing literature are highlighted. Subsequently, a rationale is given for the research questions and hypotheses complementing the existing literature. So far, there is no consensus on the spatial-economic impact of renewable energy developments. This research aims to contribute to further clarification on this topic. Thereby, it is assumed that there is no, or very limited, existing literature on the economic impact of alternative fuel stations. The study focuses on alternative fuel stations to explore the potential nuanced effects of different types of infrastructural investments. This research also incorporates the economic effect of these alternative fuel stations since there is no consensus in the existing literature on the spatial-economic effect of clean energy developments. In line with the other highlighted gaps in the literature, the current study also tries to better understand the potential synergy between environmental initiatives, economic growth, and spatial components at the industrial park level.

The research aims to address the spatial-economic effect of alternative fuel stations on the economic growth of industrial parks. The relation between the availability of alternative fuel locations and the economic growth of industrial parks is quantitatively analysed from a spatial perspective. The current study does not analyse fossil fuels but solely focuses on alternative fuels and energy carriers. The current policy focus in the province of Gelderland is on firms and freight carriers rather than private use. Therefore, focusing on industrial parks in the research is considered suitable.

The findings offer valuable insights for policymakers and industry stakeholders looking to increase sustainable development and economic resilience by implementing alternative fuel(s). Strategic choices must be made on alternative fuels' demand and supply sides, which requires a solid body of research and insights regarding alternative fuels and the stations at which they are being provided.

1.4 Research questions

The main research question is: **To what extent do alternative fuel stations affect the economic growth of industrial parks in the province of Gelderland?**

Sub-question(s):

- General:
  - What are alternative fuel stations and their specific characteristics currently operational in the province of Gelderland?
- Spatial:
  - What is the spatial distribution pattern of alternative fuel stations across the province of Gelderland, and how does that relate to the economic growth of industrial parks?
- Economic:
  - What is the quantitative relationship between the presence of alternative fuel stations and the economic growth of industrial parks?
  - What is the quantitative relationship between specific characteristics of alternative fuel stations and the economic growth of industrial parks?
- Industrial park dynamics:
  - What is the quantitative relationship between alternative fuel stations and the economic growth of industrial parks with varying characteristics?

1.5 Reading guide

This thesis is structured to guide the reader through a comprehensive exploration of the research topic, beginning with an introduction that outlines the topic, focus, and significance of the research. The literature review follows, presenting fundamental theories and identifying gaps in existing research. The methodology chapter details the research design, data collection, and analysis techniques. The results chapter presents findings for each sub-question. The conclusion and discussion chapter summarises the findings, discusses their implications, and suggests areas for future research. Lastly, chapters on references and the appendix provide supporting information and data.

CHAPTER 2: LITERATURE REVIEW

2.1 Theoretical Framework

This subchapter discussed general economic theories regarding spatial-economic analysis relevant to this study. For a fair part of the recent history, economists have tried to understand the forces behind economic progress. Even today, it is not yet possible to conclude that these economists have reached a consensus on the exact cause of economic growth. However, they agree that the economy's development goes beyond the accumulation of capital and labour. It is often claimed that knowledge spillover(s) play a significant role in the economic growth of a given region. Alternative/sustainable fuel stations provide access to relatively new and innovative developments for mobility. This could be seen as one of the drivers of innovation regarding the sustainability and economic growth of firms in industrial parks. Some fundamental theories will be discussed in this subchapter.

2.1.1 Theory: Hirschman (1958)

Both Hirschman and Nurske have been the subject of research in public policy, economics, and planning for an extended period. Hirschman published his theory in a book called ‘The strategy of economic development’. In this book, he argues that he believes in unbalanced growth instead of balanced growth (Hirschman, 1958). According to Hirschman, it is desirable if some regions or sectors of the economy are ahead of others.

In his book ‘Strategy of economic development’, he states: “*It is one of the paradoxes of development that poor countries cannot always afford to be economical.*” (Hirschman, 1958, p. 129). This could be translated into different scales, such as national and regional contexts. In practice, this could mean that some industrial parks are more economically thriving than others. He underpins this in the following quote: “*Development is a chain of disequilibria that must be kept alive rather than eliminate the disequilibrium of which profits and losses are symptoms in a competitive economy*.” (Hirschman, 1958, p. 76). Hirschman finds that there should be done as much as possible regarding the process of the (economic) growth process, also when imbalances arise. He stresses that investments in given industries or regions would accelerate the pace at which economic development takes place.

The presence of backwards-forward linkages is favoured between the developed and less developed regions so that the developed regions would pull along the other regions in the process of (economic) growth (Hirschman, 1958). Alternative fuel stations are considered public infrastructure investments. In the province of Gelderland, the road network is relatively good, and therefore, the connection and accessibility over the road are expected to be sufficient enough for backwards-forward linkages to be present between regions with and without such an alternative/sustainable fuel station. Thereby, it is likely that firms in one industrial park have business-to-business connections with at least one other firm in another industrial park, too. Hirschman writes that shortages created by unbalanced growth offer good incentives for innovations. Imbalances incentivise increased economic activity and push economic growth (Hirschman, 1958).

Once development has begun, spatial concentration of economic growth around the initial starting points arises (Hirschman, 1958). In the context of alternative fuel stations, it can be seen that these are starting points for development at or near industrial parks. Thus influencing further economic growth of that given region. A second positive effect occurs if the given region absorbs unemployed or skilled workers from other regions. Subsequently, the marginal productivity of labour and per capita consumption increases (Hirschman, 1958). This gives ground to hypothesise that more economically thriving industrial parks experience an increase in marginal productivity of labour due to investments in public infrastructure, such as alternative fuel stations. This is then likely reflected in the industrial park's added value.

2.1.2 Theory: Roback's spatial equilibrium model

Roback's spatial equilibrium model confirms positive interactions between infrastructure investment and regional economic outcomes (Schiff, 2021). The rise of an alternative fuel station on, or near, an industrial park can be seen as an infrastructure investment for that given region. Rosen-Roback's model is important to urban economics and local labour markets, the pricing of environmental amenities, markets, and industry concentration and migration (Schiff, 2021). Therefore, it is important that there be a link with this research since this study delves into the impact of alternative fuel stations. In other words, the impact of an environmental amenity on industry concentration.

2.1.3 Theory: Allyn Young (1928)

Young (1928) writes that there are also economies that accompany other economies through a division of labour. One economy creates demand and supply through the industry for other economies when firms buy inputs and sell outputs. Firms, sectors, industries and economies interact (Young, 1928). If the firm produces large units of output through the indirect method of production, then its derived demand will also be high, creating demand in the economy (Young, 1928). Translating this to practice could mean that when a freight carrier firm increases output, it drives more and requires more fuel for its fleet. Next, according to Young (1928), there is sufficient empirical evidence concerning the fact that economic progress correlates with resource endowment, which is dependent on the quality of the institutions. Whether a given resource, such as an alternative fuel station, bears the most fruit could depend on the present firms and institutions in that region.

2.1.4 Theory: Endogenous growth theory versus Exogenous growth theory

Endogenous growth theory describes that economic growth is primarily the result of internal and not external forces. Investments in human capital, innovation and knowledge are seen as the most significant contributors to economic growth (Groot, 2022). According to Groot (2022), the theory stresses the presence of positive externalities and spillover effects. External factors are often seen as unexplained technical progress, whereas endogenous growth focuses on the opposite. Groot (2022) stresses that we need to understand technological progress better. From an endogenous growth point of view, technology finds itself in a relatively small and open economy. Changing the view on the role of the government due to the externalities of public goods (Groot, 2022). This could be interpreted as valid for investment in alternative fuel vehicles since these are part of the firm's internal business.

A contrasting neoclassical economic point of view explains exogenous growth theory. The theory states that economic progress is caused by technological progress without the direct influence of other economic forces (Ganti, 2023). This could be interpreted as true for investment in alternative fuel stations since these are part of the firm's external business.

It is argued that sustainable levels of wealth are influenced by internal processes such as human capital, innovation, and investment capital rather than external, uncontrollable forces, challenging the view of neoclassical economics (Liberto, 2023). People often refer to the so-called chicken and egg problem within the energy transition field. Without the right amount of alternative fuel stations (supply side), there will not be enough alternative fuel vehicles (demand side). At the same time, alternative fuel stations will not increase without an increasing number of alternative fuel vehicles. To some extent, transitioning the vehicle fleet of firms can be seen as an endogenous process since it is the result of innovation and development of the firm itself. Accordingly, investments in alternative fuel infrastructure can be seen as an external force in economic progress because these are uncontrollable for most firms (Ganti, 2023). An important takeaway is that both exogenous and endogenous economic growth theories state that technological progress is necessary for the economy in a given region to grow.

2.1.5 Theory: Solow growth model

The Solow model tries to better understand economic growth dynamics (Groot, 2022). It makes a distinction between catching up with growth and cutting-edge growth. It is seen that catching up can be much faster than growing on the cutting edge. This means that regions that are relatively lagging behind experience relatively more substantial growth (catching up growth) than regions already relatively well developed (cutting-edge growth). This does not mean more developed regions do not grow, but their growth curve is less steep than those experiencing catching-up growth (Groot, 2022). Therefore, it could be expected that one alternative fuel station on or near a business park will have a greater impact in a region with relatively few stations.

If the economic model by Robert M. Solow is approached simplistically, it can break economic growth down into a couple of variables. A vital part of the model is the production function. Resources and labour inputs are used to produce outputs. Labour (L) is one of these input variables. The more educated labourers there are, the more effective their labour is (human capital). Next to that, there is physical capital (K), our factories and tools. Furthermore, the last variable represents our knowledge (A) (Tabarrok & Cowen, 2016). Regarding all of these individual variables, the development of the built infrastructure and the knowledge about alternative fuels can directly affect them. It is therefore hypothesised that the investments in alternative fuel stations can be tracked in the economic performance data of firms on business parks. Economic growth can be measured using total factor productivity, as shown by Groot (2022).

The Solow model dives into the long-term growth of an economy and shows, as technology advances, how depreciation and investment eventually reach an equilibrium called the steady state. This means it determines a country's capital ratio to labour (Weidinger, 2022). The growth of the GDP is constant in a steady state. Furthermore, growth is endogenous, but technological progress is exogenous (Groot, 2022). Since the available data is over a more extended period, a potential steady state can be observed in Gelderland as technology advances regarding alternative fuel stations and infrastructure. This can help understand a region's, or industrial park's, growth rate. The model assumes that technological progress is one of the key determinants of economic growth because it increases the production and efficiency of the labour force. Developments and innovations regarding alternative fuelling infrastructure can be seen as factors needed for the economy to grow further in regions where the 'steady state' has been reached. On the other hand, technology and innovations regarding alternative fuel usage, such as fuelling stations and alternative fuel vehicles, can be costly, which can cause a sustainable transition to be counterproductive. This could be learned by analysing the data at hand.

2.4 Existing literature on the spatial aspect

2.4.1 Spatial Patterns and Environmental Amenities

Currently, most of the used energy comes from unsustainable fossil fuels. This way of generating energy pollutes the environment, changes the climate and harms public health (Outka, 2012). There is a vast interdependency between energy production and land use, so-called energy-land use nexus. According to Outka (2012), people should minimise the point of conflict between energy goals, land conservation and land use efficiency. However, so far, suitable laws to make sure projects land in the right locations are relatively premature (Outka, 2012). Conversely, our society is slowly shifting away from fossil fuels; this creates a situation in which land previously used for unsustainable energy generation can now be redirected for more sustainable energy generation and implementation. Alternative locations are a perfect example of such a movement.

In urban economics, an amenity is considered any benefit that increases the attractiveness of a given location by increasing comfort and convenience (Wu, 2006). The study by Wu (2006) shows that the spatial distribution of environmental amenities strongly influences development patterns and community characteristics. This implies that a high concentration of environmental amenities increases the development of a given region. Next to that, specific types of communities concentrate in areas with a relatively high number of environmental amenities.

It has been found that spatiotemporal regularity, spatial correlation and spillover effects are present at renewable energy production sites (Xu et al., 2022). The analysis of Xu et al. (2022) shows that renewable energy production in China strongly affects neighbouring areas. From another spatial perspective, Chen et al. (2015) find spatially correlated latent variables and neighbour effects on electric vehicle purchase decision-making. This shows that when one neighbour is transitioning from a fossil fuel vehicle to an electric vehicle, his neighbour is more likely to follow. This could also be applicable to business parks where one firm swaps its fossil fuel fleet for an electric vehicle fleet, for example. This trend could break the mentioned chicken and egg problem in the mobility energy transition. A disclaimer to make here is that a firm is not likely to swap its entire fleet at once but is more likely to take small steps, considering the financial investment and reliability issues.

It is also found that regions often affect one another’s energy production and consumption (Shan et al., 2018). This effect is observed strongest concerning electric vehicles (Chen et al., 2022). However, Wang et al. (2023) find that clean energy developments have no significant impact on the economic growth in China. The study found that there is a positive spatial spillover effect on the economic growth of the neighbouring provinces. These findings align with other studies that show the spatial spillover effect is larger than the direct effect (Bai et al., 2020; Romanello, 2022). When looking at alternative energy consumption, Chica-Olmo et al. (2020) also emphasise that a 1% increase in alternative energy consumption in one country will increase its neighbouring country's economic growth (GDP) by 0.054%. When both countries increase their usage of alternative energy, this will likely lead to synergies, causing the effect to be relatively more significant (Bracco et al., 2018).

On the contrary, Bai et al. (2020) find that renewable energy has a negative spatial spillover effect on the economic growth of neighbouring areas. The leading cause is spatial agglomeration characteristics (Bai et al., 2020). The study shows a positive effect on the economic development of a given area but inevitably a negative spatial spillover effect on neighbouring areas (Bai et al., 2020). It can be said that there is no consensus in the existing scientific literature on the spatial(-economic) effect of alternative energy carriers.

2.5 Existing literature on the economic aspect

2.5.1 General economic impact of (environmental) amenities

Cochrane et al. (2010) find that increasing the stock of public infrastructure in a region will improve the productivity of existing firms and induce new firms to locate in the region. Consequently, regional output and employment will grow (Lall, 2007). Investments in public infrastructure and policy emphasis play a crucial role. They are considered proper tools for regional development and economic growth (Cochrane et al., 2010).

Next, it is found that one region may induce firms to use the improved infrastructural endowments in that region. This could then mean that the output of that region would have a positive correlation with the infrastructural situation at that given industrial park (Cochrane et al., 2010). It should also be considered that public infrastructure investments related to transportation, such as alternative fuel stations, may positively impact the specific industrial park and neighbouring regions due to the network characteristic of infrastructure (Cochrane et al., 2010).

Another study also assessed the economic impact of the EU climate package through the EU biofuel target. Regarding the welfare implications and developments in the biofuel sectors, it was found that the biofuel target has positive welfare effects in some scenarios (Kretschmer et al., 2009).

If the use of hydrogen increases, needless to say, the production needs to go up. In Germany, congestion costs on the electricity grid go up by approximately 17% when hydrogen production increases (Scheidt et al., 2022). It is also stressed that spatial electricity prices strongly impact whether or not hydrogen infrastructure investments are being made (Scheidt et al., 2022). This could indicate that inefficient investment incentives are created without considering, for example, a spatial subsidy, causing hydrogen production and redistribution locations not to be present at favourable locations due to financial reasons (Scheidt et al., 2022). Hydrogen refuelling locations are currently negatively impacting the electricity bills and congestion in industrial parks, and a so-called chicken and egg problem arises. In this case, the supply of hydrogen refuelling locations will not increase if the demand does not increase. At the same time, hydrogen demand does not increase if the supply does not increase.

The same is applicable with regard to the electric vehicle stations. A study by He et al. (2022) shows that an efficient electric vehicle charging network is the main way to manifest the popularisation of the electric vehicle charging network. An economically attractive way to increase the charging network efficiency is by avoiding the fixed costs of new charging locations (He et al., 2022). Instead, more chargers should be installed at existing locations instead of fossil fuel locations.

Empirical evidence from China shows spatial spillover effects of ‘green finance’ (a policy in China) and clean energy developments on green economic development (Zhang et al., 2023). In line with this, it is also found that municipalities benefit most in GDP per capita, indicating that the spatial spillover effect is more significant than the direct effect (Romanello, 2022). It is concluded by Zang et al. (2023) that more resources invested in clean energy development, in combination with the spatial spillover effect, will cause economic transformation and development both in practice and in theory. This is also argued by Salim et al. (2024), who state that renewable energy production factors stimulate economic growth. Also, from the consumption perspective, Inglesi-Lotz (2016) finds that, specifically in OECD countries, renewable energy consumption has a positive impact on economic growth. Lastly, this is also found by Soava et al. (2018) for many European countries, which makes it more likely and generalisable for the conducted case study in the province of Gelderland in the Netherlands. The research findings show that using more renewable energy helps the economy grow. They also say there is a connection between renewable energy use and economic growth, showing that one can affect the other differently. This supports the decisions made by the EU to boost renewable energy use, proving it is good for the economy (Soava et al., 2018).

On the other hand, when considering the scale effect, it is also found that renewable energy consumption has a significant impact only on developing economies or non-OECD countries (Chen et al., 2020). The Netherlands is considered an OECD country. However, when dealing with the high initial costs of clean energy (Bhattacharya et al., 2016), government subsidies might mess up the energy market and push out other options (Dong et al., 2022).

Regarding specific types of alternative fuels, hydroelectricity has also been found to negatively impact economic growth in a given region (Schembri & Radja, 2023). The same study also emphasises that variables such as labour, the quality of institutions, and human capital are critical factors in assessing economic growth (Schembri & Radja, 2023). Schembri and Radja (2023) show that individual renewable sources have a significant positive impact on economic growth since they find that there is a significant positive correlation between (bio)mass and wind energy production and GDP per capita.

Furthermore, Al-mulali et al. (2014) show that renewable electricity consumption has a more substantial and significant effect on economic growth in the short and long run than non-renewable electricity. Radmehr et al. (2021) verify that there is a bidirectional causality between renewable energy and economic growth. The results also show that an increase in renewable energy usage significantly improves the GDP of, amongst others, the Netherlands between 1995 and 2014 (Radmehr et al., 2021).

As Wang et al. (2022) show, there are relatively many different findings and views on the spatial-economic impact of clean energy consumption and production in a region and other regions in the vicinity. Global panel data from an empirical study by Pereira et al. (2021) shows that clean energy development has a negative or insignificant impact on economic growth in the short term and possibly a positive impact in the long term. Opposed to this, a study from China finds a positive correlation between clean energy developments and economic growth (Yang & Wang, 2021). Li et al. (2022) analyse the effects of clean energy developments, economic growth, renewable energy consumption and environmental pollution. The study finds an N-shaped curve relationship between economic growth and clean energy developments (Li et al., 2022). Partially in line with these findings, Hou et al. (2022) find that economic development increases in the short term but decreases along the way with clean energy developments. Lastly, there are studies where no statistically significant causal relationship was found between renewable energy usage and economic growth (Bao & Xu, 2019).

Some studies claim there is a two-way causal relationship between clean energy developments and economic growth (Wang et al., 2022). Mohsin et al. (2022) found there is a positive correlation between alternative energy usage and economic growth, both in the short and long term, in 25 Asian countries between the years 2000 and 2016. This has also been found in an African context, namely Ghana (Gyimah et al., 2022). Next to positive correlation, some studies find a bidirectional causality between renewable energy consumption and economic growth (Chang et al., 2015; Acaravzi & Ozturk, 2010; Apergis & Payne, 2010).

Transportation infrastructure can optimise resource allocation and also strengthen regional integration in cities. This promotes economies of scale and will improve productivity and efficiency (Wang et al., 2023). It is thereby emphasised that investments in transportation infrastructure, such as refuelling stations, cause a positive spatial spillover effect (Wang et al., 2023). Subsequently, mutual growth in local or neighbouring regions is achieved.

Variations significantly influence the spatial distribution of economic activity among cities and regions in terms of productivity and amenities, as well as various spatial barriers, including local infrastructure (Redding & Rossi-Hansberg, 2017). For instance, improvements in transport infrastructure that lower trade costs can lead to population shifts between different locations. In an ideal scenario with perfect population mobility, such improvements would result in population reallocations until wages are equalised across regions from the initial equilibrium to the subsequent equilibrium (Redding & Rossi-Hansberg, 2017).

When considering environmental and technological change, the competition is not necessarily between similar technologies but is more focused on an existing dominant polluting fuel and a new clean energy carrier (Mulder & Bergh, 2001). This is defined as replacing existing trajectories of consumption and production with more sustainable ones. It requires the development of new technology systems (such as bio-based fuels, electricity, and hydrogen) that offer substantial environmental improvements. These sustainable technological innovations drive fluctuations in prices, wages and output that can be analysed (Mulder & Bergh, 2001).

2.6 Existing literature on industrial park dynamics

2.6.1 Industrial parks and (environmental) amenities

Zao et al. (2020) find that the Not In My Backyard issue is associated with the presence of fuelling stations. The study by Zao et al. (2020) shows that 86% of the respondents believed that a fuelling station would devalue the properties in the surroundings, even when safety management was being done (Zao et al., 2020). The results show that prices of the nearby built environment increase significantly with every additional kilometre from the nearest fuelling station, and the closer to the station, the more negative the impact on the housing price. According to Zao et al. (2023), a fuelling station is a type of NIMBY facility; since these stations store hazardous substances, such as petroleum, in underground tanks, and they are also power supply stations for cars and other motor vehicles.

A study by Liu et al. (2019) shows that the number of alternative fuel stations positively correlates with alternative fuel vehicle ownership. This provides information on consumer preferences regarding the ownership of alternative fuel vehicles or vehicle fleets from a firm perspective. The results show that the correlation between alternative fuel vehicle ownership and fuel stations can vary significantly between regions; however, on a national level, the correlation is significant in the United States (Liu et al., 2019).

Moreover, it is emphasised that big (logistic) firms with relatively large fleets will not want to invest in alternative fuel vehicles unless they have the assurance of plentiful fuelling stations for all of their travelling routes (Yueyue et al., 2017; Wang & Lin, 2009). It is assumed that every route starts and ends at the firm. Therefore, a refuelling station near the firm could be favourable. Firms are willing to transition to alternative fuel vehicles if the costs, performance and reliability are in order (Steenberghen & Lopez, 2008). Bae et al. (2022) performed a qualitative analysis on firms' alternative fuel adoption decisions in the United States. The list shows that fuel infrastructure is one of the most recurring factors (Bae et al., 2022).

2.6.2 Industrial parks and their economic performance

It has been found that increasing the public infrastructure, such as fuelling stations, in a region will increase the productivity of the firms and cause new firms to be located in the respective region (Cochrane et al., 2010). Analysing how much money is spent on these investments and their importance for regional growth plays a significant role. Research regarding public policy, economics, and planning on how infrastructure affects economic growth dates back to the work of Nurske (1953) and Hirschman (1958), as discussed beforehand. Public infrastructure, particularly transportation infrastructure, can bring about positive effects within the region it serves and neighbouring areas. This occurs because certain types of infrastructure operate as networks, where each component contributes to the functioning of the entire transport network (Cochrane et al., 2010). Cochrane et al. (2010) also emphasise that previous studies often analyse the effect of public infrastructure investments using administrative boundaries. However, these boundaries do not represent functional economic areas in specific contexts. Analysing IBIS-industry parks instead of municipality administrative boundaries can prevent measurement errors in this case. Lastly, it is found that in line with Roback's spatial equilibrium model, there is a positive two-way interaction effect between infrastructural investment and regional economic status quo (Cochrane et al., 2010).

Stojcic et al. (2022) focus their study on attributes outside firm boundaries that potentially influence their entrepreneurial ecosystems. It is stated that the competitive advantage of a firm's day-to-day business is dependent on the local context of political and economic elements (Audretsch & Belitski, 2017). Among these economic elements are amenities such as physical infrastructure, which are considered relevant factors for improving economic performance. The physical infrastructure, such as energy infrastructure, improves organizational competitiveness and performance and increases returns on local investments through knowledge-sharing, interactions, and resource accumulation (Stojcic et al., 2022). Besides the positive effects on the industry parks themselves, it is assumed that spill over into other areas is likely to occur. Due to firms' vertical up- and downstream linkages and interactions across space, amenities such as fuelling stations likely provide service to a more extensive range than only the industrial park they are located at or near (Stojcic et al., 2022).

Finally, Falahatdoost & Wang (2022) advocate for the transition from the traditional development of industrial parks towards a green development plan. It is argued that the industrial park situation will be improved mainly through economic growth when the use of renewable energy is increased (Falahatdoost & Wang, 2022).

2.7 Gaps in the existing literature

2.7.1 Summary Key Findings Existing Literature

Key findings from the economic theories and literature discussed above discuss the impact of infrastructure investment on regional economic growth, focusing mainly on the influence of alternative fuel stations. Hirschman's theory emphasises the importance of unbalanced growth, suggesting that investments in given industries or regions can increase economic development. Roback's spatial equilibrium model highlights the positive interaction between infrastructure investment and economic outcomes. Young's theory suggests that economic progress is linked to resource endowment and institutional quality. Additionally, the theory distinguishes endogenous and exogenous growth theories, which respectively emphasise internal versus external factors in economic progress. Next, it suggests that a shift towards a more evolutionary perspective may provide better insights into the effects of infrastructure investment on employment and environmental sustainability, particularly in the context of clean energy hubs and alternative energy infrastructure. Lastly, the Solow model distinguishes between catching up and cutting-edge growth. Additionally, it stresses the importance of technological progress in driving long-term economic growth. Challenges such as the costs and practicality of alternative fuel infrastructure may hinder sustainable transitions.

The literature reveals contrasting perspectives on the spatial-economic impact of infrastructure development and environmental amenities. The positive influence of environmental amenities on community characteristics and development patterns is emphasised (Wu, 2006). Existing literature research highlights the significant impact of renewable energy production on neighbouring areas, with infrastructure, regulation, and urbanisation playing crucial roles in implementation (Xu et al., 2022). Conversely, conflicting findings emerge regarding the spatial spillover effects of clean energy developments on economic growth, with some studies suggesting positive impacts while others identify adverse spatial spillover effects (Wang et al., 2023; Bai et al., 2020). Furthermore, while alternative energy consumption is shown to have positive economic impacts, there is disagreement regarding the magnitude of these effects and the potential synergies between countries increasing their usage of alternative energy sources (Chica-Olmo et al., 2020).

The literature underscores several significant points regarding the relationship between infrastructure development, environmental initiatives, and economic growth. Cochrane et al. (2010) and Lall (2007) highlight the positive impact of public infrastructure investment on regional productivity and economic growth, suggesting that such investments attract new firms and stimulate existing ones. Studies by Zhang et al. (2023) and Romanello (2022) emphasise the positive spatial spillover effects of green finance policies and renewable energy investments, driving economic development beyond their immediate vicinity. Salim et al. (2024) and Soava et al. (2018) discuss how clean energy initiatives contribute to economic transformation and development, with renewable energy consumption positively linked to economic growth. Additionally, investments in hydrogen and electric vehicle infrastructure are crucial for promoting their usage and efficiency, as Scheidt et al. (2022) and He et al. (2022) highlight. However, Wang et al. (2022) and Yang & Wang (2021) present mixed findings regarding the short-term and long-term effects of clean energy on economic growth, suggesting that further research is needed to understand these dynamics fully. Furthermore, Mulder and Bergh (2001) emphasise sustainable development and ecological modernisation, which drive the transition towards cleaner energy sources and technologies, influencing prices, wages, and output.

There are also several key findings from the literature on the built environment. Firstly, fuelling stations are perceived as NIMBY facilities due to their potential negative impact on property values and safety concerns (Zao et al., 2020; Zao et al., 2023). Secondly, the presence of alternative fuel stations is positively correlated with the ownership of alternative fuel vehicles, influencing consumer preferences and firm fleet decisions (Liu et al., 2019; Yueyue et al., 2017; Wang & Lin, 2009; Bae et al., 2022). Thirdly, public infrastructure investments, such as fuelling stations, enhance firms' productivity and attract new businesses to a region, with transportation infrastructure playing an essential role in regional economic growth (Cochrane et al., 2010). Lastly, studying industrial parks instead of municipal boundaries can provide more accurate insights into the economic impact of infrastructure investments, aligning with theories such as Roback's spatial equilibrium model (Cochrane et al., 2010). These findings underscore the importance of infrastructure development in shaping regional economic dynamics and highlight the need for targeted policies to support sustainable and efficient transportation systems.

2.7.2 Identification of gaps in the existing literature

Firstly, regarding regional economic growth and infrastructure investment, the existing literature highlights the positive impact of this investment on economic growth. However, there seems to be a gap in understanding the nuanced effects of different types of infrastructure investments, such as fuelling stations, in various sectors and regions. Therefore, the current research aims to delve into the role of a specific type of infrastructure in fostering economic growth, in this case, in industrial parks.

Secondly, there seems to be a lack of census on the spatial-economic implications of clean energy developments. Most studies acknowledge the importance of the renewable energy transition, but the existing literature shows conflicting findings on the spatial spillover effects of clean energy developments on economic growth. This suggests the need for more robust empirical research to better understand the situation at hand.

Thirdly, the existing literature seems to understand the potential synergy between environmental initiatives and economic growth, such as green finance policies and renewable energy investments, but there still is limited understanding of the mechanism through which interaction takes place.

Further research can focus on the relationship between environmental investments, such as alternative fuel stations, and economic growth.

Fourthly, the existing literature seems to show there is a need for more methodological approaches and data sources to facilitate more studies and strengthen the robustness of the findings. The complex interactions between infrastructure development, environmental initiatives and economic growth should be analysed using rich datasets.

Lastly, existing literature highlights the correlation between alternative fuel locations and consumer preferences for alternative vehicles. There seems to be a gap in understanding the perceptions and behaviours at this base. Future research could delve into this and explore the barriers, facilitators, cultural differences and regulatory contexts. It is assumed that qualitative studies perform best on this specific topic therefore there is no focus on this in the current research.

2.7.3 Conceptual model

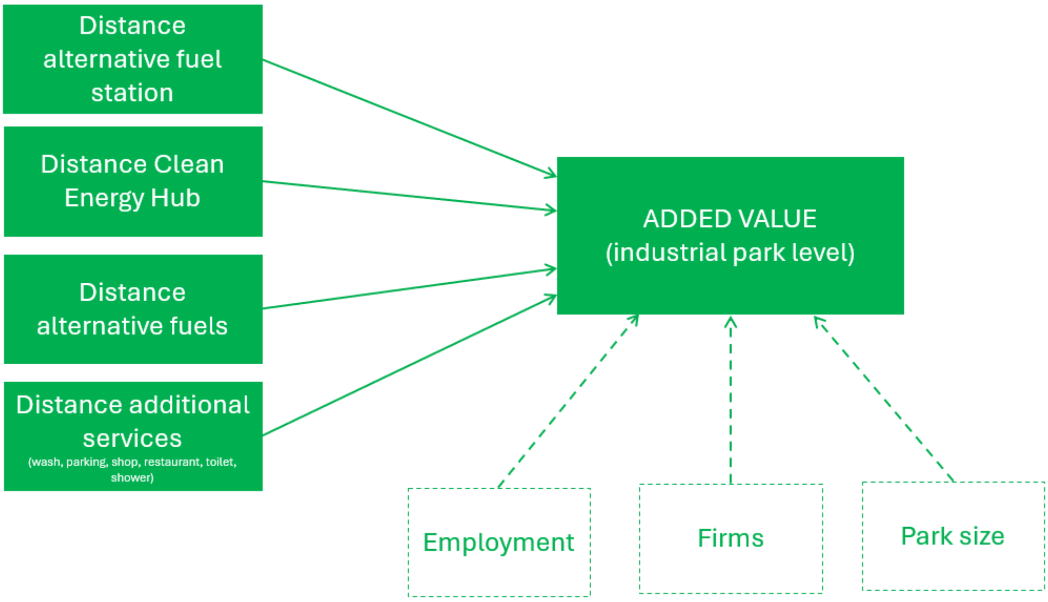

Figure 1: Conceptual model of the performed analysis.

2.7.4 Operationalisation

The concept of 'Distance alternative fuel stations' is measured through quantitative data on all exact distances between industrial parks and the nearest alternative fuel location in the province of Gelderland, where at least one alternative energy carrier is being provided.

The concept of 'Distance Clean Energy Hubs' is measured through quantitative data on all exact locations in the province of Gelderland where at least one alternative energy carrier is being provided. Subsequently, the distances between industrial parks and the nearest Clean Energy Hub is measured.

The concept of 'Distance alternative fuels' is also measured through the quantitative data on all exact locations in the province of Gelderland, where a variety of characteristics are documented. Amongst these station characteristics, dummy variables indicate which alternative fuels and energy carriers are being provided at each location. The year since the given fuel or energy carrier is being provided is also included. Subsequently, the distance between industrial parks and the nearest alternative fuel stations with a given alternative fuel or energy carrier is measured and registered in the dataset for each industrial park and year. The analysis includes the following alternative fuels or energy carriers: CNG, LNG, HVO, EV charging, and hydrogen.

The concept of 'Distance additional services' is measured through the quantitative data on all exact locations in the province of Gelderland, where a variety of characteristics are also documented. Amongst these station characteristics, indicated through dummy variables, are additional services provided at alternative fuel stations. Subsequently, the distance between industrial parks and the nearest alternative fuel stations with a given additional service is measured and registered in the dataset for each industrial park and year. The analysis includes the following additional services: accessibility, truck parking, carwash, truck wash, shop facility, restaurant, toilet and shower.

The concept of 'Added value industrial parks' is primarily measured through the LISA economic added value data. This data is determined by combining data from the LISA file and CBS. It is calculated by distributing the regional totals available from CBS by sector among the LISA establishments in that region and sector. The model is based on the lowest available level of detail per sector. The industrial park added value equals the value of all goods and services produced, also known as the production value or output, minus the value of goods and services consumed during this production (Bureau Louter, 2023). The production is the sum of all produced and sold goods and services (Bureau Louter, 2023).

The concept of 'Employment' is measured at the industrial park level. The statistics department of the province of Gelderland provides data on the number of jobs for each industrial park from 2013 to 2022.

The concept 'No. Firms' is also measured on an industrial park scale. Data on the exact number of firms in each sector from 2013 to 2022 is provided for each industrial park in the province of Gelderland.

The concept 'Park Size' is also measured on an industrial park scale. For each industrial park in the province of Gelderland, data is provided on the exact net and gross surface area from 2013 to 2022.

CHAPTER 3: METHODOLOGY

3.1 Research design

This study is approaching the main and sub-questions quantitatively. The applied research method aims to explore the impact of the provision of alternative fuels on the economic growth of industrial parks. This means a spatial-economic analysis of the presence of environmental amenities is performed. The study will focus on industrial parks in the Netherlands through a case study of the 497 industrial parks in the province of Gelderland. For this type of analysis, a quantitative approach seems best. Firstly, because there is relatively much data available in the province of Gelderland regarding the economic development(s) of industrial parks over the last decade. Secondly, a quantitative method ensures a relatively more objective measurement. This allows for a precise numerical data analysis to help achieve the study's goal: quantifying the economic relationships in the mobility energy transition. Compared to a qualitative approach, the study is more likely to have higher generalizability and replicability due to the bigger sample size. The study uses data on 497 industrial parks and over 114 alternative fuel locations. Getting this number of respondents in qualitative research can be more challenging in the given time for a master's thesis.

3.3 Data collection methods

The underlying data for this study was collected in multiple ways. The province of Gelderland has got vast statistical datasets on the economic development of IBIS industrial parks for the past decade, approximately from 2010 until now. The IBIS data is used because it is a generally accepted geographical demarcation of industrial parks. Within the organisation, there is a bureau of economic research that provides data through the provincial employment survey (PWE), a statistical pocketbook called “Gelderland in figures”, an employment and economic activity dataset from LISA and the dataset from ‘Integral Bedrijventerrein Informatie Systeem’ (IBIS).

Data on alternative fuel stations is used in addition to the data on industrial parks. The dataset on all of the operational alternative fuel stations in the study area has been self-assembled using various sources. The clean energy hub locations and alternative fuel locations have been gathered from a disclosed dataset from Rijkswaterstaat. This dataset was last updated in 2022. On top of that dataset, all fuelling station and EV charging operators have been contacted regarding the most recent data on all fuelling and energy carrier stations in the study area. So, the statistical data for the alternative fuel station information is self-assembled based on available information at the operator platforms and direct contact with the fuel station's contact department and employees. This type of data collection ensures the collection and validation of a detailed set of information on the following: provided fuel(s) and energy carriers, starting date, coordinates, and additional services of all alternative fuel stations in the province of Gelderland.

The study area consists of the province of Gelderland, including a 10km buffer around the provincial border. T. Heinink, Clean Energy Hub business developer, states that this 10km buffer is most practical since, on average, firms are willing to take a detour of a maximum of 10km to get to an alternative fuel station. Therefore, a firm at the edge of the province of Gelderland can also go to an alternative fuel station in the province of Utrecht, for example. This emphasises the importance of using a 10km ‘buffer’ at the provincial border of Gelderland concerning data collection for alternative fuel station locations.

Dependent and independent variable data is assembled by combining these datasets. The dataset for this study contains the following variables: alternative fuel station coordinates, alternative fuel station fuel provision, alternative fuel station starting date, alternative fuel station additional services, industrial park employment, industrial park added value, industrial park gross area, industrial park net area, industrial park jobs per sector, industrial park firms per sector, alternative fuel stations per municipality, industry added value per municipality, traffic per municipality and population per municipality.

Wang et al. (2022) perform a study in which the impact of clean energy on economic growth is analysed. Within this study, economic growth is the dependent variable, measured by GDP per capita. In the respective analysis, clean energy developments and a number of the labour force are independent variables. Stojcic et al. (2022) use population density as a variable for labour force insights. In the province of Gelderland, direct data on the number of jobs and firms at industrial parks is included in this research.

The use of statistical data for the data collection method is justified due to several factors. Firstly, the research question has a quantitative nature. It seeks to measure the extent to which the alternative fuel stations have an economic effect. Statistical data analysis provides a robust framework for quantifying relationships and assessing their significance. Secondly, relatively large datasets of relevant information and economic indicators are available for the province of Gelderland. Thirdly, a statistical analysis enables an objective measurement of the possible relationship between the variables of interest. This strengthens valid conclusions about the economic impact of alternative fuel stations. Fourthly, spatial regressions quantify the strength and direction of correlations. This provides valuable insights into the spatial-economic dynamics. Statistical data analysis can effectively address the main research question and contribute to evidence-based decision-making in alternative energy infrastructure and economic development(s).

3.3 Sampling strategy

The sampling strategy for this study is relatively straightforward, given the specific focus on the province of Gelderland in the Netherlands. As the research aims to report on the economic impact of alternative fuel stations on industrial parks within Gelderland, the entire population of alternative fuel stations and industrial parks within the province is included in the sample. This approach allows for a comprehensive analysis of all relevant objectives within this research. The sample panel data contains input for the years 2013 until and including 2022. The exact distances in each year have been generated. This enables the comparison of economic outcomes between industrial parks with and without proximate alternative fuel stations for every thinkable distance, facilitating a robust analysis of the impact of these stations on industrial park development.

The specific sampling strategy used in this research is the purposive sampling strategy, where the selection of alternative fuel stations and industrial parks is based on their relevance to the research question(s). Purposive sampling allows for a targeted selection of units that are most likely to provide meaningful insights into the impact of alternative fuel stations on industrial park economic growth. The study aims to maximise the relevance and applicability of its findings to the research context. Therefore, emphasising the purposive nature of the sampling strategy provides clarity on the rationale behind the selection of stations and parks. This enhances the methodological transparency of the study.

3.4 Data analysis techniques

3.4.1 Data analysis techniques in existing literature

Dubé et al. (2014) perform a spatial analysis that includes spatial and temporal aspects. The current research also includes both the spatial and temporal aspects of data. This improves how possible spatial spillover effects are dealt with; the phenomena are observed across different (neighbouring) areas. Next to that, the temporal aspects capture changes over time. This enhances the accuracy and robustness of the analysis. In this regard, the net impact of an environmental amenity (alternative fuel station) on the economic development of industrial parks is approached effectively.

Gaubert (2018) and Wang et al. (2013) show that taking production as one of the independent variables is valuable when assessing economic development or growth. The study shows that the 'Total Factor Production' can be used to analyse firms sorting and agglomeration. A new spatial equilibrium arises if local congestion decreases, leading to higher welfare and Total Factor Production (Gaubert, 2018). A widespread provision of alternative fuels can potentially increase the welfare and total production at industrial parks. At the same time, the interrelation between the variables of interest possibly means that providing alternative fuel stations only at given locations could attract firms, increase congestion, and decrease the welfare and total production at industrial parks. In line with Gaubert (2018), this research uses industrial park added value, representing the difference between total production revenue and costs.

Gottlieb (1994) also uses amenities to explain employment growth. The study shows that employment growth can be one of the explanatory variables in finding a potential effect of amenities. As can be seen in the conceptual model, this research also controls for employment numbers.

This research includes the variable 'Year' to control for temporal effects. This ensures that the analysis controls for time-varying shocks, such as macroeconomic fluctuations and related policies. This is also done in the study by Chen et al. (2016). The regression analysis incorporates (spatial) fixed effects, clustered standard errors and time-fixed effects. The clustered standard errors recognizes that data within clusters (such as firms and regional characteristics) might be correlated. It adjusts the standard errors accordingly to avoid underestimating the true variability of the coefficients. Chaisemartin and Ramirez-Cuellar (2022) also incorporated this in a working paper on clustered standard errors. Fixed effects are included to control for time-invariant characteristics in the panel data. It allows the isolation of the impact of variables that change over time by accounting for the industrial park or municipality characteristics that do not change. Controlling for fixed effects strengthens the regression analysis; it will likely omit variables that have industrial park-specific characteristics that do not change over time. Numerous scientific papers use fixed effects in various contexts (Akram et al., 2021). Time-fixed effects control for unobserved variables that vary over time but are constant across entities. It is included to address potential biases caused by time-varying omitted variables. Opuku & Aluko (2021) also implement this methodology to strengthen their spatial-economic analysis. Including both temporal and regional fixed effects is also in line with the study by Cochrane et al. (2010). Fan et al. (2016) emphasise that spatial (spillover) effects are often present in alternative fuel infrastructure. Therefore, the study includes fixed effects to incorporate the potential spatial spillovers in the dependent variable.

Chen et al. (2016) conducted research in which the amenity effect of protected forest land on economic growth is quantified. The methodological choices in the respective research provide insight into how an amenity effect can be quantified on economic development. In the same way, this study is trying to quantify the effect of alternative fuel stations (amenities) on economic growth at industrial parks. The independent variable of primary interest in this research is the distance to alternative fuel stations, which represents the proximity of an industrial park to the exact locations of an alternative fuel station. The analysis includes a set of independent variables, such as the number of jobs and firms, to control for exogenous regressors. This ensures that the potential of omitted variable bias is limited for the variables of interest, and it reduces the amount of noise in the error term.

Next to that, the data includes the size of industrial parks through net surface area. These fixed effects are included to control for time-invariant unobservable aspects and reduce omitted variable bias. This is in line with the methodological approach of Lee et al. (2020), where the distance decay effect and local effect are discussed. Controlling for the size of industrial parks, number of (logistic) firms, and number of jobs incorporates a possible local effect.

A variable on the industrial park net surface area is also included in the model. It is expected it will be omitted in all of the regressions of interest, because the model that is estimated is a fixed-effects regression model. Any constant variable within every unit is redundant and will be omitted. The net surface area is constant for each industrial park. In practice, industrial parks can grow over time in the number of jobs and firms, but not in surface area. If an industrial park is expanded, the added part to this industrial park will get a new industrial park name. For example, in Barneveld, there is an industrial park called 'Harselaar'; if this given industrial park is then expanded, the new part will be called 'Harselaar 2' for example. This will then be added to the list of industrial parks and treated as a unique industrial park with its own unique identifier in the dataset. So, any variable that is constant for each industrial park, such as net surface area, is perfectly collinear with other variables for industrial parks. The fixed effects model already adjusts for industrial park size, so there is no more variation to be explained by the variable on industrial park surface area.

For theoretical reasons, the variable is left in the regression analyses on purpose because, in practice, the net surface area could change over time for a given industrial park. The Dutch government implemented policies on restructuring and intensification of industrial parks in the Netherlands. This could cause the net surface area to increase even if the industrial park does not expand outwards, meaning that, in theory, the net surface area of a given industrial park could change over the years. This is not expected to be very common so far, but a valid reason for the variable to be left in the analysis for possible extra control, thus higher validity and reliability of the results.

Furthermore, alternative fuel stations consider two types: alternative fuel stations and clean energy hubs. Alternative fuel stations provide at least one alternative fuel or energy carrier. Clean energy hubs (CEH) provide at least two alternative fuels or energy carriers, often providing additional services. Regressions are run on all stations, alternative fuel stations, and clean energy hubs separately but also combined since both alternative fuel stations and CEHs are forms of alternative fuel stations. Running the regression on the full dataset provides a larger sample size, leading to more precise estimates and a smaller standard error. This can result in a p-value indicating significance. Dividing the dataset into subsets reduces the sample size for each regression. Smaller sample sizes typically result in larger standard errors, which can lead to higher p-values, indicating reduced statistical significance. This is done to draw reliable and valid conclusions from the analyses.

Based on the above and the formulated sub-questions in the introduction, three main regression models are used to answer the sub-questions. Sub-question 3 will be answered using Equation 1, sub-question 4 will be answered using Equation 2, and sub-question 5 will be answered using Equation 3. Lastly, sub-question 6 will be answered using subsets on all the equations shown.

Equation 1: Fixed effects regression on the effect of distance to alternative fuel stations on industrial park added value.

$$\log(\text{Added\_Value}_{it}) = \beta_0 + \beta_1 \text{Distance\_All\_Stations}_{it} + \beta_2 \log(\text{Employment}_{it}) + \beta_3 \log(\text{Firms}_{it}) + \beta_4 \log(\text{Net\_Surface\_Area}_{it}) + \sum_{j=1}^{T-1} \gamma_j \text{Year}_j + \alpha_i + \epsilon_{it}$$

Equation 2: Fixed effects regression on the effect of distance to alternative fuels on industrial park added value.

$$\log(\text{Added\_Value}_{it}) = \beta_0 + \beta_1 \text{Distance\_CNG}_{it} + \beta_2 \text{Distance\_LNG}_{it} + \beta_3 \text{Distance\_HVO}_{it} + \beta_4 \text{Distance\_Electric\_Slow}_{it} + \beta_5 \text{Distance\_Electric\_Fast}_{it} + \beta_6 \text{Distance\_Hydrogen}_{it} + \beta_7 \log(\text{Employment}_{it}) + \beta_8 \log(\text{Firms}_{it}) + \beta_9 \log(\text{Net\_Surface\_Area}_{it}) + \sum_{j=1}^{T-1} \gamma_j \text{Year}_j + \alpha_i + \epsilon_{it}$$

Equation 3: Fixed effects regression on the effect of distance to additional services on industrial park added value.

$$\log(\text{Added\_Value}_{it}) = \beta_0 + \beta_1 \text{Distance\_Truckparking}_{it} + \beta_2 \text{Distance\_Carwash}_{it} + \beta_3 \text{Distance\_Truckwash}_{it} + \beta_4 \text{Distance\_Shop}_{it} + \beta_5 \text{Distance\_Restaurant}_{it} + \beta_6 \text{Distance\_Toilet}_{it} + \beta_7 \text{Distance\_Shower}_{it} + \beta_8 \log(\text{Employment}_{it}) + \beta_9 \log(\text{Firms}_{it}) + \beta_{10} \log(\text{Net\_Surface\_Area}_{it}) + \sum_{j=1}^{T-1} \gamma_j \text{Year}_j + \alpha_i + \epsilon_{it}$$

$log(Added\_Value_{it})$ is the natural logarithm of the added value for industrial park i at time t.

$Distance\_All\_Stations_{it}$ is the distance to the nearest alternative fuel station for industrial park i at time t.

$log(Employment_{it})$ is the natural logarithm of employment for industrial park i at time t.

$log(Firms_{it})$ is the natural logarithm of the number of firms for industrial park i at time t.

$log(Net\_Surface\_Area_{it})$ is the natural logarithm of the net surface area for industrial park i at time t

$Distance\_CNG_{it}$ is the distance to the nearest station with CNG for industrial park i at time t.

$Distance\_LNG_{it}$ is the distance to the nearest station with LNG for industrial park i at time t.

$Distance\_HVO_{it}$ is the distance to the nearest station with HVO for industrial park i at time t.

$Distance\_Electric\_Slow_{it}$ is the distance to the nearest station with slow electric charging for industrial park i at time t.

$Distance\_Electric\_Fast_{it}$ is the distance to the nearest station with fast electric charging for industrial park i at time t.

$Distance\_Hydrogen_{it}$ is the distance to the nearest station with hydrogen for industrial park i at time t.

$Distance\_Truckparking_{it}$ is the distance to the nearest station with truck parking for industrial park i at time t.

$Distance\_Carwash_{it}$ is the distance to the nearest station with a carwash for industrial park i at time t.

$Distance\_Truckwash_{it}$ is the distance to the nearest station with a truck wash for industrial park i at time t.

$Distance\_Shop_{it}$ is the distance to the nearest station with a shop for industrial park i at time t.

$Distance\_Restaurant_{it}$ is the distance to the nearest station with a restaurant for industrial park i at time t.

$Distance\_Toilet_{it}$ is the distance to the nearest station with a toilet for industrial park i at time t.

$Distance\_Shower_{it}$ is the distance to the nearest station with a shower for industrial park i at time t.

$Year_j$ represents the year fixed effects.

α_i represents the industrial fixed effects.

ϵ_{it} is the error term clustered by industrial park.

3.5 Validity and reliability

In this research, several measures are taken to enhance validity and reliability. By carefully addressing the validity and reliability of this research, the integrity and robustness of the research findings are ensured as well as possible. Thus, the research contributes to the existing knowledge on the spatial-economic impact of environmental amenities, specifically the spatial-economic impact of alternative fuel infrastructure/stations on industrial parks.

Firstly, the research design, including the sampling strategy and data collection methods, is carefully designed to approach the research questions as well as possible. The research performs a case study on the province of Gelderland. The dataset contains panel data on over 400 industrial parks. The fact that all industrial parks in the province of Gelderland are included enhances the internal validity significantly. The quantitative case study and statistical analysis can establish a causal relationship between the variables of interest, thus enhancing internal validity, too.

Secondly, efforts are made to minimise bias and confounding variables that could distort the results. The dataset is a panel data set that controls for time-varying shocks, such as macroeconomic fluctuations and related policies, by including a dummy variable for the year the data is from. Multiple control variables are included, such as numerical data on jobs, firms, employment, population size, industrial park size, traffic movements and income. In this way, the analysis is trying to control as much as possible for omitted variable bias using the available data at hand. In line with the methodological choices of similar studies, this research also incorporates additional methods that deal with potential spatial correlation.

Thirdly, multiple data sources are employed to establish findings and enhance the robustness of the conclusions. The external validity of a quantitative case study can be more challenging. To ensure that this research's findings allow for generalisation to similar contexts, the dataset includes all industrial parks in the province of Gelderland. This ensures all industrial parks are included, including diverse sectors, firms, sizes, and locations. It is expected that this will resemble the real-world setting relatively well. Thus increasing the generalizability of the findings to different provinces or countries. However, it has to be noted that this research is a case study in the Dutch context. As stated above, the research is longitudinal, enabling the findings to be based on numerical data over time. This provides insights into the stability and generalizability of the findings and thus enhances external validity.

On the other hand, reliability refers to the consistency and stability of the research findings over time and across different conditions. This research uses confidence intervals of 90%, 95%, or 99% in the statistical analysis. This enhances reliability by providing a range of plausible values for the variables of interest rather than a single-point estimate. This range accounts for the uncertainty in the sample data and the estimation, thereby offering a measure of the precision and reliability of the estimate(s). By quantifying the level of uncertainty around the point estimate, confidence intervals allow the findings to be more stable and robust.

Next to that, the nature of the quantitative dataset uses standard procedures, which improves the consistency of the data collection, causing relatively higher reliability. In line with this, this type of data collection should facilitate replication fairly well. As stated above, omitted variable bias is considered as much as possible; however, it can still play a role in data accuracy and completeness. Since the data originates from professional data departments at the province of Gelderland, the instrument reliability of the data is considered to be relatively high.

3.5.1 Reproducibility of the research

To further enhance reliability, a copy of a ‘reproduction package for the empirical results’ is provided. This includes the raw data as used, a syntax that leads from the raw data to the final result in a Stata17 Do-File, and some additional data scraping and GIS elements.

3.6 Ethical considerations

This research followed some ethical principles throughout the research process, such as anonymity, confidentiality, results communication, minimisation of harm and integrity in data collection and reporting. Anonymity is guaranteed since no personally identifiable information is collected in the data-gathering process, meaning no full names, phone numbers, email addresses, IP addresses, physical characteristics, photos, and videos (Bhandari, 2023). If names are used, permission is granted by the specific person. The results section only contains output from the statistical analysis on the whole sample, not specifically on a given firm or personal information. This ensures the confidentiality of the research, too. The results are also communicated honestly, reliably and credible. In this way, the research findings are reported transparently. Plagiarism and research misconduct are actively avoided. Lastly, the minimisation of harm is also considered in the research process. Data security is ensured and processed confidentially to minimise risk for industrial parks, municipalities or regions. This is not published or included in the final report to prevent any form of speculation in the numerical data, such as the added value in Euros per industrial park.

This subchapter clarifies the above elements, demonstrating the research's commitment to conducting research with integrity and adherence to ethical principles.

3.7 Limitations

This research contains a couple of limitations that should be considered. Firstly, the case study only examines industrial parks in the province of Gelderland. All alternative fuel stations considered within the study are located within the provincial borders or at a maximum of 10 kilometres from the provincial border. This distance was specifically chosen based on the maximum detour distance firms are willing to take on average. This means that the sample does not contain industrial parks and alternative fuel stations from very different parts of the Netherlands, which could be a limitation due to the relatively restricted scope of the ability to explore nuanced relationships and capture diverse perspectives. In this light, sampling bias is applicable since non-random sampling is applicable in this research.

Some data is missing for given industrial parks in a given year due to limited intervals of data actualisation each year. Pointing out resource constraints as one of the possible limitations of this research may limit the scope or rigour of the study and affect the quality of the findings.

Thirdly, only data is available on given variables of interest at the industrial park level. This points out the contextual limitations to some extent since firm-level data could have been even more insightful. The province of Gelderland is located in the east of the Netherlands; thus, it also partially borders Germany. Due to the unavailability of data on German alternative fuel stations, these are not included in the dataset.

Lastly, the research approaches the research questions at hand quantitatively, meaning no qualitative aspects of the research context are incorporated. Quantitative research relies on standardised measurement tools, analyses, and methods. This may not always accurately capture the constructs or variables of interest, and measurement errors can affect the validity and reliability of the findings. The inclusion of qualitative insights into the spatial-economic effect of alternative fuel stations on the industrial/firm level can be valuable for future research.

3.8 Hypotheses

Main research question:

> *Null hypothesis (H0)*: Alternative fuel stations have no significant effect on industrial parks' economic growth in the Gelderland province. ($\beta = 0$)
>
> *Alternative hypothesis (H1)*: Alternative fuel stations have a significant effect on the economic growth of industrial parks in the province of Gelderland. ($\beta \neq 0$)

Sub question 3: Economic: Distance to alternative fuel station

> *Null hypothesis (H0)*: There is no significant quantitative relationship between alternative fuel stations and the economic growth of industrial parks. ($\beta = 0$)

Alternative hypothesis (H1): There is a significant quantitative relationship between the presence of alternative fuel stations and industrial parks' economic growth. $(\beta \neq 0)$

Sub question 4: Economic: Distance to types of fuel/energy carriers

Null hypothesis (H0): There is no significant quantitative relationship between the specific fuel types at alternative fuel stations and the economic growth of industrial parks. (β=0)

Alternative hypothesis (H1): There is a significant quantitative relationship between the specific fuel types at alternative fuel stations and the economic growth of industrial parks. $(\beta \neq 0)$

Sub question 4: Economic: Distance to additional services

Null hypothesis (H0): There is no significant quantitative relationship between the specific additional services at alternative fuel stations and the economic growth of industrial parks. $(\beta = 0)$

Alternative hypothesis (H1): There is a significant quantitative relationship between the specific additional services at alternative fuel stations and the economic growth of industrial parks. $(\beta \neq 0)$

Sub question 5: Industrial park dynamics

Null hypothesis (H0): There is no significant quantitative relationship between alternative fuel stations and the economic growth of industrial parks, regardless of their varying characteristics. $(\beta = 0)$

Alternative hypothesis (H1): There is a significant quantitative relationship between the presence of alternative fuel stations and the economic growth of industrial parks, influenced by their varying characteristics. $(\beta \neq 0)$

CHAPTER 4: RESULTS

In this section, the results from the QGIS spatial analysis and the STATA regression analyses are shown, elaborated on, and interpreted structurally by answering the sub-questions. This provides a solid basis to answer the main research question in conclusion: '*To what extent do alternative fuel stations affect the economic growth of industrial parks in the province of Gelderland?*'. A description of all variables in the analysis can be found in *Table 5* in the *Appendix*.

4.1 Sub-question 1: General

This subchapter will answer the question: *What are alternative fuel stations and their specific characteristics currently operational in the province of Gelderland?*

In this research, fuel stations are considered 'alternative' when at least one alternative fuel or energy carrier is provided at the given fuel station. Diesel, gasoline (E5) and gasoline (E10) are considered traditional fossil fuels. Alternative fuels currently provided in the Netherlands are (bio-)CNG, (bio-)LNG, electricity, HVO20, HVO30, HVO50, HVO100, Hydrogen and Ammonia. These types of fuels or energy carriers are produced using renewable energy sources. The main difference between alternative fuels and traditional fossil fuels is that green energy comes from natural sources and is sustainably sourced; on the other hand, fossil fuels can take millions of years to replenish and cause significant harm to our environment. In other words, alternative fuels are the product of solar, wind, hydro, geothermal, or biomass energy. Fossil fuels are the product of natural gas, coal and oil (Hive Energy, 2017).

Clean Energy Hubs are one of the building blocks of sustainable heavy goods transport. Many provinces in the transport corridor (routes from Rotterdam Port through Gelderland towards the hinterland in the rest of Europe), the State and the Port of Rotterdam are jointly developing a strategy for this (Provincie Gelderland, 2023). An alternative fuel station is considered a Clean Energy Hub when at least two alternative fuels or energy carriers are provided.

When talking about 'fuel,' it can be used for vehicles that move forward and backward because of some form of combustion, such as HVO and (bio-)LNG. Energy carriers can be used for vehicles that move forward because the wheels are turning due to an energy supply. However, no combustion takes place to make it happen, such as electricity.

Table 1: Brief description of all available fossil and alternative fuels in, or near, the province of Gelderland.

Name of fuel / energy carrier	Type of fuel / energy carrier	Description
Diesel	Fossil	Any liquid fuel specifically designed for use in a diesel engine.
Euro95	Fossil	Unleaded motor gasoline with an octane rating of less than 98.
Euro98	Fossil	Unleaded motor gasoline with an octane rating of more than 98.
LPG	Fossil	Liquefied petroleum gas.
(bio-)CNG	Alternative	Compressed natural gas.
(bio-)LNG	Alternative	Liquified natural gas.

Electric (<50k Kw; slow)	Alternative	Electricity vehicle charger with power up to a maximum of 50 kW.
Electric (50 Kw - 174 Kw; moderate)	Alternative	Electric vehicle charger with a power between 50 kW and 174 kW.
Electric (>175 Kw; fast)	Alternative	Electric vehicle charger with a power equal to or higher than 175 kW.
HVO100	Alternative	This type of diesel is, next to the vegetable oils, produced from waste, residue oils and fats, such as used cooking oil. 0% diesel, 100% vegetable oils.
Hydrogen	Alternative	Hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water.
Ammonia	Alternative	This is not part of the data, since this is not provided at a public station in or near Gelderland.

Within the study area, 32 unique stations qualify as Clean Energy Hubs (CEH) and 82 unique stations provide at least one alternative fuel or energy carrier, see Figure 6 in the Appendix.

Next to the variety of energy carriers that are considered alternative, multiple additional services can be provided at the given locations, such as a truck parking, carwash, truck wash, shop facility, restaurant, toilet, and shower.

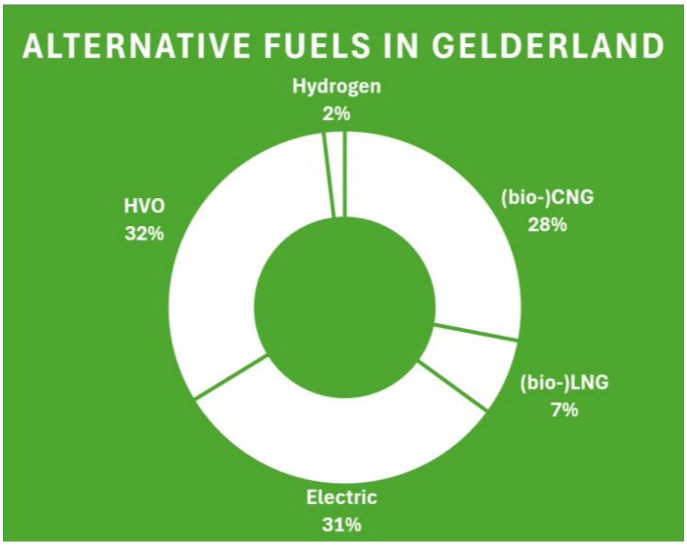

Figure 2: Percentage of alternative fuels across all alternative fuel stations in Gelderland.

As shown in *Figure 2* above, approximately 1/3 of the alternative fuel stations in the study area provide HVO, (bio-)CNG and electric charging point(s). Hydrogen and (bio-)LNG are represented relatively less; these alternative fuels are at 2% and 7% of the alternative fuel stations, respectively. These divisions are approximately equal when solely looking at Clean Energy Hubs; see *Figure 7* in the *Appendix*.

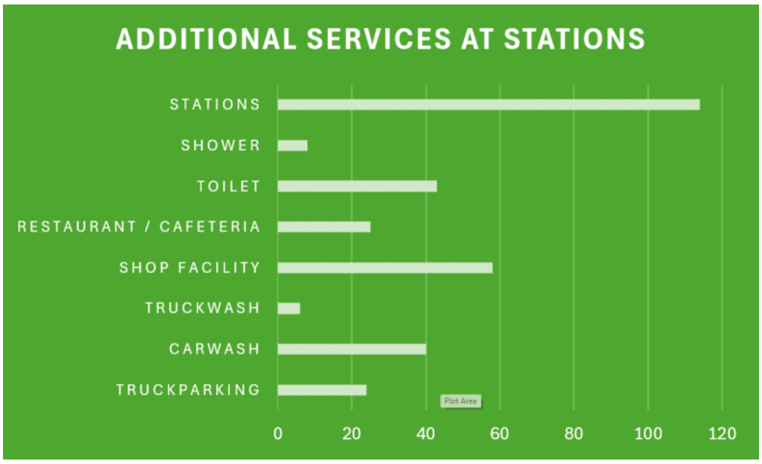

Figure 3: Number of additional services at alternative fuel stations and Clean Energy Hubs (CEH) in the province of Gelderland; incl. a 10km boundary around the provincial border.

In *Figure 3* above, the number of additional services at stations compared to the total number of alternative fuel stations. The total number of stations is the sum of all alternative fuel stations in the study area. It can be seen that at approximately half of all stations, a shop facility is present. This is often the case at 'staffed' stations, where an employee is present. Due to a growth in digitalisation, many alternative fuel stations are 'unstaffed'. Only a given fuel pump, charging point, and digital payment terminal can be found on-site at these stations. Additional services, such as a toilet and carwash, are often present at alternative fuel stations. Additional services such as a truck wash, shower, restaurant, and truck parking seem relatively underrepresented in the study area, as seen in *Figure 3* above. Matching percentages can be found in the *Appendix* in *Figure 8* and *Figure 9*.

4.2 Sub-question 2: Spatial

This subchapter will answer the question: What is the spatial distribution pattern of alternative fuel stations across the province of Gelderland, *and how does that relate to the economic growth of industrial parks?*

Figures 10 and 11 in the Appendix show a map with all the exact locations of the alternative fuel stations in the study area. When converting this map into a heatmap, see *Figure 4* below, it becomes clear where most alternative fuel stations are concentrated in the study area. There are four major concentrations of alternative fuel stations: north of the municipality of Culemborg, in the eastern part of the municipality of Ede, north of the municipalities of Voorst and Lochem, and west of the municipality of Nijkerk.

The map also shows the industrial parks, identifiable by the green polygons. The concentration in the municipality of Ede is strongest in and around the industrial parks. Furthermore, there seems to be a medium concentration of alternative fuel stations around the industrial parks in Harderwijk, Barneveld, Arnhem, Duiven, Nijmegen, and south of the municipality of West Maas en Waal.

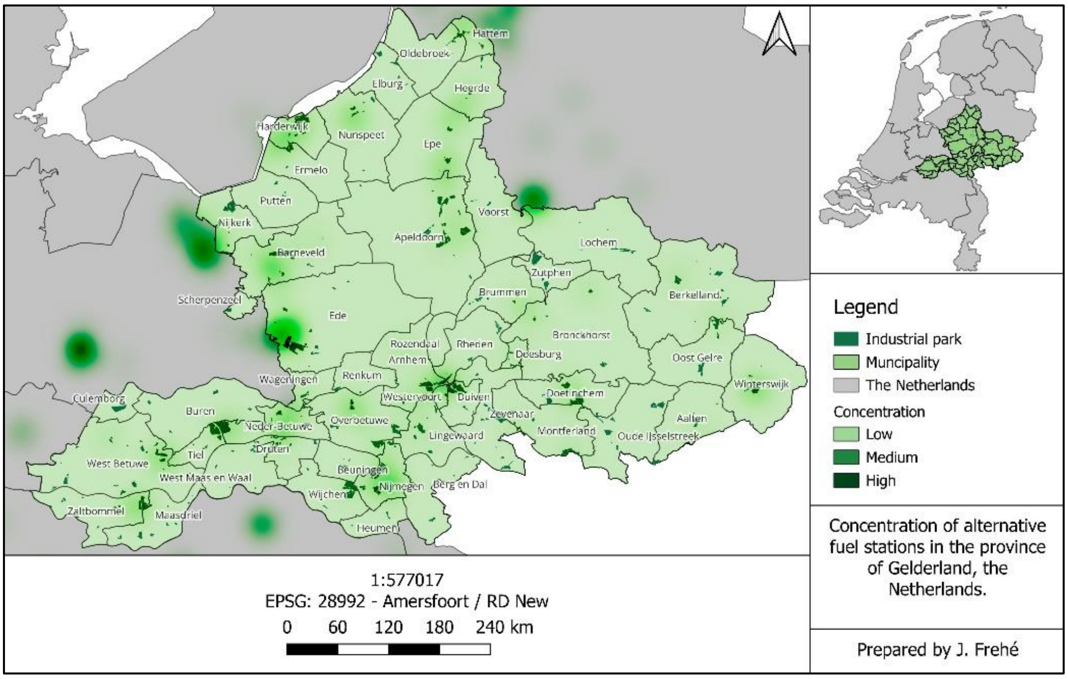

Figure 4: Concentration of alternative fuel stations in the province of Gelderland, the Netherlands.

When analysing the concentration of industrial park added value, see *Figure 5* below, it can be seen that the highest concentration can be found in the cluster of municipalities Arnhem, Duiven and Westervoort, the adjacent border of the municipalities Zaltbommel and Maasdriel, in the western part of the municipality Nijmegen, in the adjacent border of municipalities Ede and Wageningen, in the municipality Harderwijk and the north-eastern part of the municipality Apeldoorn. The industrial parks in this area find themselves in the third and fourth quartiles of the industrial park added value distribution.

Linking this to the concentration of alternative fuel stations, it is observed that there is a match in the cluster of municipalities Arnhem and Duiven, Harderwijk, and the municipality of Ede. Alternative fuel stations seem to be less concentrated in the municipalities of Zaltbommel, Maasdriel, Nijmegen, and the northeast of Apeldoorn, where the industrial park's added value is relatively high.

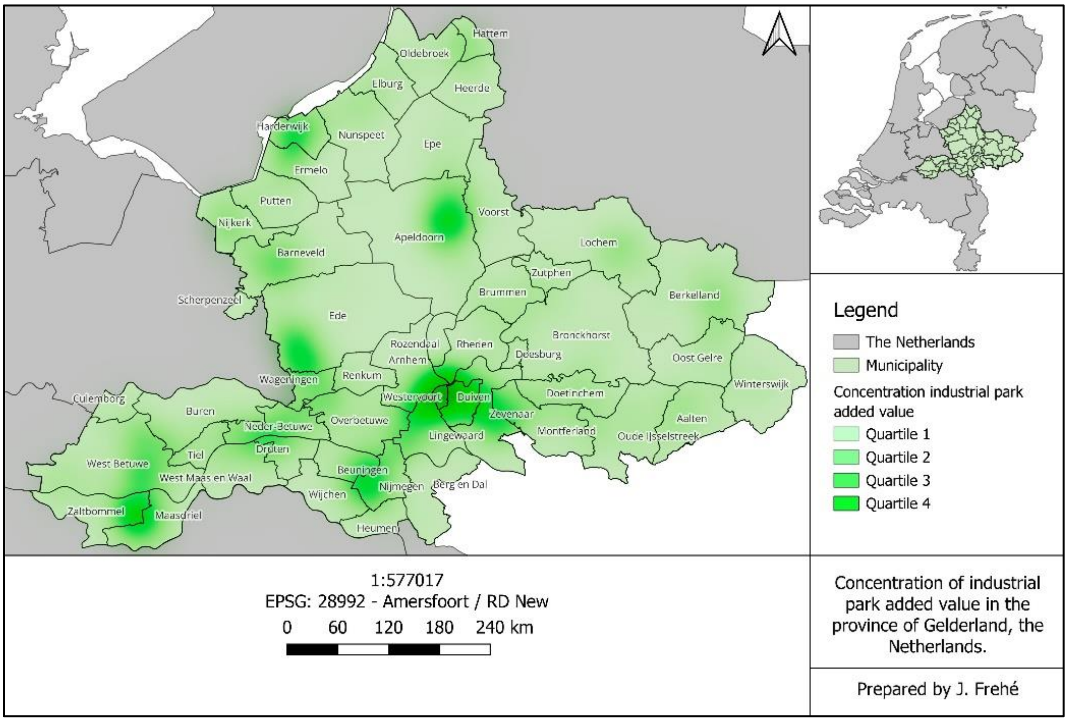

Figure 5: Concentration of industrial park added value in the province of Gelderland, the Netherlands.

The area north of Arnhem in the municipalities Apeldoorn, Ede, and Barneveld is relatively underrepresented in both the number of alternative fuels stations and industrial parks. This can be explained by the fact that the 'De Veluwe' can be found there. "De Veluwe" is a diverse and extensive natural area located in the province of Gelderland, Netherlands. The region is a Natura 2000 area, indicating its importance for conserving rare and endangered European species and habitats. No industrial developments can take place in this area. Lastly, the eastern part of the province of Gelderland has a low concentration of both industrial park added value and alternative fuel stations.

Additional in-depth insights on the municipal level into the distribution of alternative fuel stations and industrial park added value can be found in *Figure* 12 and *Figure* 13 in the Appendix. These figures also show that there is a strong match between the spatial distribution of stations and the economic performance of industrial parks in the municipalities of Barneveld, Ede, Arnhem, and Nijmegen.

4.3 Sub questions 3: Economic

This subchapter will answer the question: *What is the quantitative relationship between the presence of alternative fuel stations and economic growth on the industrial park level?*

As described in the methodology chapter, this analysis examines the data through three categories: all stations, alternative fuel stations, and Clean Energy Hubs (CEH). 'All stations' include all alternative fuel stations present in the study area, so both alternative fuel stations (minimum 1 alternative fuel or energy carrier) and CEHs (minimum 2 alternative fuels or energy carriers) are included.

In the main regression, the dependent variable is the logarithm of industrial park added value. The independent variables are the distance to all stations, distance to alternative stations, distance to clean energy hubs, the logarithm of the number of jobs at an industrial park (log_Employment), the logarithm of the number of firms at an industrial park (log_Firms), and the logarithm of the industrial park's net surface area (log_Net_Surface_Area).

Table 2: Regression of distance (in metres) between industrial parks and all alternative fuel stations, control variable(s): employment, firms, net surface area and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_All_ Stations	-1.990e-06	9.300e-07	-2.13	.033	-3.820e-06	-1.500e-07	**
log_Employment	1.014	.030	33.19	0	.954	1.074	***
log_Firms	.024	.030	0.79	.427	-.035	.084	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.944	.146	74.48	0	10.655	11.232	***

Mean dependent var	16.673	SD dependent var	1.733
R-squared	0.869	Number of obs	4557
F-test	209.396	Prob > F	0.000
Akaike crit. (AIC)	-3735.530	Bayesian crit. (BIC)	-3658.437

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

The beta coefficient regarding the distance to alternative fuel stations equals -1.99e-06 and is statistically significant at a 5% level. This indicates that the relationship between the distance to alternative fuel stations regarding the industrial park added value is statistically significant. The negative sign of the beta coefficient indicates that as the distance increases, the industrial park added value decreases. For each one-unit increase in the distance to the nearest alternative stations, the industrial park's added value decreases by 1.990e-06 units, ceteris paribus. This means that for each metre, an alternative fuel station is further away from an industrial park, and the added value of the industrial park is expected to decrease by 0.00019%, ceteris paribus. At first glance, the magnitude suggests a very small impact; however, the added value is about relatively large values. The dataset's average added value of an industrial park equals approximately 50 million Euros per year. An 0.19% decrease in added value for every additional kilometre distance at an 'average' industrial park from the dataset means that the industrial park added value decreases by approximately 100,000.00 Euros per year per additional kilometre distance. It marks both statistical and economic significance.

The beta coefficient regarding the employment level is equal to 1.014 and is statistically significant at a 5% level. The positive sign of the beta coefficient indicates that as the employment level increases, the industrial park's added value also increases. A 1% increase in Employment is associated with approximately a 1.014% increase in the industrial park's added value, holding all other variables constant.

The coefficient regarding the number of firms equals 0.024. This means that a 1% increase in the number of firms is associated with an approximate 0.024% increase in the industrial park's added value. However, the coefficient is not statistically significant, suggesting that the relationship between the number of firms and added value at an industrial park is not statistically significant.

The variable on the industrial park's net surface area is omitted from the regression; please see *3.4.1 Data analysis techniques* for further explanation.

As the regression in *Table 2* mentions, all alternative fuel stations fall within 'All Stations'. In the regression in *Table 6,* see *Appendix*, a distinction is being made between alternative fuel stations and clean energy hubs. For areas with many clean energy hubs and alternative fuel stations, including both separately in the regression may lead to multicollinearity, making it difficult to isolate their individual effects. Using the total number of stations in the variable with all stations, as in the regression in *Table 2,* avoids this issue by aggregating both types.

The beta coefficient regarding the distance to the nearest alternative fuel stations equals -2.030e-06 and is statistically significant. In line with the regression in *Table 2,* the relationship between distance to alternative fuel stations and industrial park added value is statistically significant. For each one-unit increase in the distance to the nearest alternative stations, the industrial park added value decreases by 2.030e-06 units, ceteris paribus. This means that for an additional kilometre an alternative fuel station is further away from an industrial park, the added value of the industrial park is expected to decrease by 0.203% per year, ceteris paribus.

The beta coefficient regarding the distance to the nearest Clean Energy Hub equals -4.600e-06. The negative sign of the beta coefficient indicates that as the distance to the nearest Clean Energy Hub increases, the industrial park's added value decreases. However, the coefficient is not statistically significant. This indicates that the relationship between the distance to the nearest Clean Energy Hub and the added value of the industrial park is not statistically significant.

The same interpretation applies to the remaining variables in the regression as for the regression in *Table 2* above since the remaining regression output is one-to-one.

4.4 Sub question 4: Economic

The sub-question that will be answered in this subchapter is: *What is the quantitative relationship between specific characteristics of alternative fuel stations and the economic growth of industrial parks?*

Besides the location, there are two main specific characteristics of an alternative fuel station that can be unique: the provided fuel types/energy carriers and the additional services. Firstly, this subchapter explores the relationship between the industrial park's added value and the distance to a specific fuel pump or energy carrier. Secondly, the relationship between the industrial park's added value distance to a specific additional service will be explored. The list and description of all variables can be found in *Table 5* in the *Appendix*.

4.4.1 Fuel types at stations

The analysis on fuel types/energy carriers consists of two fixed effects regression analyses because the first hydrogen pump was only introduced and operational in the year 2017. This makes it only possible to apply year-fixed effects starting from 2017 when the variable on hydrogen is included. The dataset contains information on all variables for the years 2013 until and including 2022. Therefore, an extra regression is included without the variable on the distance to a station with a hydrogen pump, containing fixed effects for 2013 until and including 2022. This strengthens the reliability and validity of the overall findings.

Table 3: Regression output on the relationship between industrial park added value and the distance to a specific fuel type / energy carrier (Compressed Natural Gas, Liquefied Natural Gas, Hydrotreated Vegetable Oil, electric vehicle charger and hydrogen), control variable(s): employment, firms, *surface area and year fixed effects.*

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	-2.170e-06	3.000e-06	-0.72	.469	-8.070e-06	3.730e-06	
Distance_LNG	1.340e-06	2.300e-06	0.58	.561	-3.180e-06	5.860e-06	
Distance_HVO	2.120e-06	1.130e-06	1.87	.061	-1.000e-07	4.350e-06	*
Distance_Electric_ Slow	1.440e-06	1.450e-06	0.99	.323	-1.420e-06	4.290e-06	
Distance_Electric_ Fast	-2.100e-07	9.900e-07	-0.21	.832	-2.160e-06	1.740e-06	
Distance_ Hydrogen	8.600e-07	7.500e-07	1.15	.249	-6.100e-07	2.330e-06	
log_Employment	1.050	.028	37.15	0	.994	1.105	***
log_Firms	.027	.026	1.05	.294	-.024	.079	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.749	.180	59.58	0	10.395	11.104	***

Mean dependent var	16.765	SD dependent var	1.693
R-squared	0.862	Number of obs	2762
F-test	169.003	Prob > F	0.000
Akaike crit. (AIC)	-3658.835	Bayesian crit. (BIC)	-3581.826

*** $p<.01$, ** $p<.05$, * $p<.1$

This model includes year fixed effects, but they are not displayed in this table for brevity.

The beta coefficient regarding distance to the nearest station with a CNG pump equals -2.170e-06. The negative sign of the beta coefficient indicates that as the distance to the nearest station with a CNG pump increases, the industrial park's added value decreases. However, the coefficient is not statistically significant. This indicates that the relationship between the industrial park's added value and the distance to the nearest station with a CNG pump is not statistically significant.

The beta coefficient regarding distance to the nearest station with an LNG pump equals 1.340-06. The positive sign of the beta coefficient indicates that as the distance to the nearest station with a CNG pump increases, the industrial park's added value increases. However, the coefficient is not statistically significant. This indicates that the relationship between the industrial park's added value and the distance to the nearest station with an LNG pump is not statistically significant.

The beta coefficient on the distance to the nearest station with an HVO pump equals 2.120-06. The positive sign of the beta coefficient indicates that as the distance increases, the industrial park's added value is expected to increase. For each one-unit increase in the distance to the nearest station with an HVO pump, the industrial park's added value increases by 2.120e-06 units, ceteris paribus. The effect is statistically significant at a 10% level. The relationship is log-linear; this means that the industrial park added value is expected to increase by 0.000212% per year for every additional metre the nearest station with an HVO pump is further away. In other words, the industrial park's added value is expected to increase by 0,212% per year for every additional kilometre distance. The variable regarding the industrial park added value is defined in Euros. It can reach up to 90 million Euros per year, marking the statistical and economic significance of this seemingly small beta coefficient.

It has to be emphasised that these findings are based on the years 2017 until and including 2022, which covers the most recent years in the dataset but not the full range of years on which data is available. Performing the analysis of the past decade can provide a more robust and reliable insight.

The beta coefficient on the distance to the nearest station with a slow electric charging point equals 1.440-06. The positive sign of the beta coefficient indicates that as the distance to a station with a slow electric charging point increases, the industrial park's added value also increases. For each one-unit increase in the distance to the nearest station with an electric charging point with a maximum power of 50 kW, the industrial park added value increases by 1.440e-06 units, ceteris paribus. However, it is not statistically significant, which indicates that the relationship between the industrial park's added value and the distance to the nearest station with an electric charging point with a maximum power of 50 kW is not statistically significant.

The beta coefficient on the distance to the nearest station with a fast electric charging point equals -2.100-06. The negative sign of the beta coefficient indicates that as the distance to a station with a fast electric charging point increases, the industrial park's added value decreases. For each one-unit increase in the distance to the nearest station with an electric charging point with a minimum power of 175 kW, the industrial park added value decreases by 2.100e-06 units, ceteris paribus. However, it is not statistically significant, which indicates that the relationship between the industrial park's added value and the distance to the nearest station with a fast electric charging point is not statistically significant.

The beta coefficient regarding distance to the nearest station with a hydrogen pump equals 8.600e-07. The positive sign of the beta coefficient indicates that as the distance to the nearest station with a hydrogen pump increases, the industrial park's added value increases. However, the coefficient is not statistically significant. This indicates that the relationship between the industrial park's added value and the distance to the nearest station with a hydrogen pump is not statistically significant.

The beta coefficient on the number of jobs (Employment) equals 1.050 and is statistically significant at a 1% level. This indicates that the relationship between the employment level and industrial park added value is statistically significant. The positive sign of the beta coefficient indicates that as the number of jobs increases, the industrial park's added value also increases. A 1% increase in Employment is associated with approximately a 1.050% increase of the industrial parks added value, holding all other variables constant. This is in line with expectations since extra full-time employees are expected to increase a firm's productivity in the industrial park, thus increasing the industrial park's added value.

The coefficient on the number of firms equals 0.027. This means that a 1% increase in the number of firms is associated with an approximate 0.027% increase in the added value of an industrial park in the dataset. The coefficient is not statistically significant nor at a 10% level. This suggests that the relationship between the number of firms and added value at an industrial park is not statistically significant.

The omitted variable, industrial park surface area, is discussed in the methodology subchapter. The interpretation and explanation of its omission apply to all other regressions performed and are discussed in the results section.

Table 7 in the Appendix shows the regression, including fixed effects on all years in the dataset, meaning 2013 until and including 2022. This regression is on all years due to the exclusion of the variable on hydrogen, which is included in the first regression output in *Table 3* above.

When performing the regression without the variable on the distance to a station with a hydrogen pump, thus year fixed effects for 2013 until and including 2022, the statistical significance of the variable on the distance to a station with an HVO pump disappears, see *Table 7* in the *Appendix*. However, when performing the regression on the past decade, instead of the last five years, both types of electric charging points at stations show a statistically significant effect on the industrial park's added value.

The distance to the nearest station with a vehicle charging point with a maximum power of 50 kW shows a coefficient of 1.540e-06 that is statistically significant at a 10% level. This would indicate that for every additional metre in the distance to a station with an electric charging point with a maximum power of 50 kW, the industrial park added value will increase by 0.000154%, or 0.154% for every additional kilometre in the distance, ceteris paribus.

The distance to a station with a vehicle charging point with a minimum power of 175 Kw shows a coefficient of -1.250e-06, which is statistically significant at a 5% level. This would indicate that for every additional metre in the distance to a station with an electric charging point with a minimum power of 175 kW, the industrial park added value will decrease by 0.000125%, or 0.125% for every additional kilometre in the distance, holding all else constant.

A difference in signs can be observed between slow and fast electric charging points. Distance to stations with fast electric charging points was shown to decrease the industrial park's added value with increasing distance. In contrast, the distance to stations with relatively slow electric charging points increased the industrial park's added value with increasing distance. Again, from the point of view that increasing industrial park added value is a good thing, industrial parks would benefit from fast charging points nearby and experience a disadvantage from nearby slow electric charging points, from an industrial park added value point of view.

All other variables remain unchanged and insignificant, similar to the regression output shown in *Table 3* above.

4.4.2. Additional services at stations

The analysis on additional services also consists of two fixed effects regression analyses because the first station with a shower was only introduced and operational in 2016. This makes it only possible to apply year-fixed effects starting from 2016 when the variable on a station with a shower is included. The dataset contains information on all variables for the years 2013 until and including 2022. Therefore, an extra regression is included without the variable on the distance to a station with a shower, containing fixed effects for 2013 until and including 2022. This strengthens the reliability and validity of the overall findings.

Table 4: Regression output on the relationship between industrial park added value and the distance to a specific additional service at the station location (truck parking, carwash, truck wash, shop, restaurant, toilet and shower), control variable(s): employment, firms, *surface area and year fixed effects.*

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_ Truckparking	-1.600e-07	8.500e-07	-0.19	.847	-1.840e-06	1.510e-06	
Distance_Carwash	3.030e-06	1.720e-06	1.76	.078	-3.500e-07	6.410e-06	*
Distance_ Truckwash	-2.400e-07	1.750e-06	-0.14	.889	-3.680e-06	3.200e-06	
Distance_Shop	-1.230e-06	1.640e-06	-0.75	.453	-4.440e-06	1.990e-06	
Distance_ Restaurant	9.300e-07	1.990e-06	0.47	.638	-2.970e-06	4.840e-06	
Distance_Toilet	-3.180e-06	2.520e-06	-1.26	.207	-8.140e-06	1.770e-06	
Distance_Shower	-4.000e-08	6.600e-07	-0.07	.945	-1.340e-06	1.250e-06	
log_Employment	1.038	.027	37.96	0	.984	1.092	***
log_Firms	.035	.025	1.37	.172	-.015	.085	
Log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.847	.155	69.94	0	10.542	11.152	***

Mean dependent var	16.744	SD dependent var	1.699
R-squared	0.864	Number of obs	3211
F-test	214.275	Prob > F	0.000
Akaike crit. (AIC)	-3817.290	Bayesian crit. (BIC)	-3726.175

*** $p<.01$, ** $p<.05$, * $p<.1$

This model includes year fixed effects, but they are not displayed in this table for brevity.

The beta coefficient on the nearest station with a truck parking equals -1.600e-07. The negative sign of the beta coefficient indicates that as the distance to a station with truck parking increases, the industrial park's added value increases. However, the coefficient is not statistically significant for data from 2016 until 2022. This indicates that the relationship between the industrial park's added value and the distance to a station with a truck parking is not statistically significant. So, no significant conclusions can be drawn from these specific findings.

The beta coefficient on the distance to the nearest station with a carwash equals 3.030e-06. The positive sign of the beta coefficient indicates that as the distance to a station with a carwash increases, the industrial park's added value increases. For each one-unit increase in the distance to a station with a carwash, the industrial park added value increases by 3.030e-06 units, ceteris paribus. The relationship between the industrial park's added value and the distance to a station with a carwash is statistically significant. For every additional kilometre that the nearest alternative fuel station with a carwash is further away from an industrial park, the industrial park's added value will increase by approximately 0.3%.

The beta coefficient on the distance to the nearest station with a truck wash equals -2.400e-07. The negative sign of the beta coefficient indicates that as the distance to a station with a truck wash increases, the industrial park's added value decreases. For each one-unit increase in the distance to a station with a truck wash, the industrial park's added value decreases by 2.400e-07 units, ceteris paribus. However, the relationship between the industrial park's added value and the distance to the nearest station with a truck wash is not statistically significant. So, no valid conclusions can be drawn from these specific findings.

The beta coefficient on the distance to the nearest station with a shop equals -1.230e-06. The negative sign of the beta coefficient indicates that as the distance to a station with a shop increases, the industrial park's added value decreases. For each one-unit increase in the distance to a station with a shop, the industrial park's added value decreases by 1.230e-06 units, ceteris paribus. However, the relationship between the industrial park's added value and the distance to the nearest station with a shop is not statistically significant. So, no valid conclusions can be drawn from these specific findings.

The beta coefficient on the distance to the nearest station with a restaurant equals 9.300e-07. The positive sign of the beta coefficient indicates that as the distance to a station with a restaurant increases, the industrial park's added value increases. For each one-unit increase in the distance to a station with a restaurant, the industrial park's added value decreases by 9.300e-07 units, ceteris paribus. However, the relationship between the industrial park's added value and the distance to the nearest station with a restaurant is not statistically significant. So, no valid conclusions can be drawn from these specific findings.

The beta coefficient on the distance to the nearest station with a toilet equals -3.180e-06. The negative sign of the beta coefficient indicates that as the distance to a station with a toilet increases, the industrial park's added value decreases. For each one-unit increase in the distance to a station with a toilet, the industrial park's added value decreases by 3.180e-06 units, ceteris paribus. However, the relationship between the industrial park's added value and the distance to the nearest station with a toilet is not statistically significant. So, no valid conclusions can be drawn from these specific findings.

The beta coefficient on the distance to the nearest station with a shower equals -4.000e-08. The negative sign of the beta coefficient indicates that as the distance to a station with a shower increases, the industrial park's added value decreases. For each one-unit increase in the distance to a station with a shower, the industrial park's added value decreases by -4.000e-08 units, ceteris paribus. However, the relationship between the industrial park's added value and the distance to the nearest station with a shower is not statistically significant. So, no valid conclusions can be drawn from these specific findings.

The beta coefficient on the variable regarding number of jobs (employment) equals 1.038 and is statistically significant. This indicates that the relationship between the number of jobs and the industrial park's added value is statistically significant. The positive sign of the beta coefficient indicates that as the employment level increases, the industrial park's added value also increases. A 1% increase in Employment is associated with approximately a 1.038% increase in the added value of an industrial, holding all other variables constant. This is in line with expectations since extra full-time employees are expected to increase a firm's productivity in the industrial park, thus increasing the industrial park's added value. This proves the strength of the variable as a control variable to prevent unrightfully designating predictive power to one of the variables on additional services. This reduces the risk of omitted variable bias in the regression.

The coefficient on the variable regarding the number of firms equals 0.035. This means that a 1% increase in firms is associated with an approximate 0.035% increase in the annual industrial park added value. The coefficient is not statistically significant nor at a 10% significance level. This suggests that the relationship between the number of firms and added value at an industrial park is not statistically significant.

Subchapter 4.3 discusses the omitted variable, industrial park surface area. The interpretation and explanation of its omission apply to all other regressions performed and discussed in the results section.

Table 8 in the Appendix shows the regression, including fixed effects on all years in the dataset, meaning 2013 until and including 2022. This is due to the exclusion of the variable on stations with a shower as an additional service, which is included in the first regression output in *Table 4* above.

When performing the regression without the variable on the distance to the nearest station with a shower as additional service, thus year fixed effects for 2013 until and including 2022, only the variable on employment remains statistically significant. The variable of the distance from an industrial park to a station with a carwash now also does not show statistical significance. None of the additional services provided at stations were shown to statistically affect the industrial park's added value per year.

4.5 Sub questions 5: Industrial park dynamics

This subchapter will answer the question: *What is the quantitative relationship between alternative fuel stations and the economic performance of industrial parks with varying characteristics?*

This sub-question is mainly included for sensitivity analysis purposes. It performs the same regressions as discussed in the previous subchapters: fixed effects regression models on the potential effect of distance to alternative fuel stations, distance to alternative fuels/energy carriers, and distance to additional services on the industrial park added value. However, the upcoming regression models test subsets of industrial park characteristics to see if there is a different effect for different types of industrial parks. Four quartiles are generated for each industrial park characteristic: net surface area, number of firms, number of firms in the transport sector, number of jobs and industrial park added value. This reveals whether the same results are found for the first, second or third quartiles with regard to these specific industrial park characteristics. For example, the effect of distance to alternative fuel stations is stronger or weaker for the smallest 50% of industrial parks in terms of the number of firms.

This subchapter will, therefore, only discuss findings that differ from the main regression in the previous sub-questions; see *Subchapter 4.3* and *Subchapter 4.4*.

4.5.1 Industrial park subset(s) on net surface area

A subset regression on the analysis regarding fuel types/energy carriers shows that the variable on the distance to the nearest alternative fuel stations with a hydrogen pump is statistically significant for 25% of the smallest industrial parks in terms of net surface area. The variable has a coefficient of 4.410e-06. This indicates that for every additional kilometre a station with a hydrogen pump is further away from an industrial park, the added value of an industrial park is expected to increase by 0.44% per year. It has to be emphasised that this is based on the years 2017-2022, since before 2017, there was no hydrogen pump station in the study area. The regression output can be find in *Table 10* in the *Appendix*.

For this same period, it is found that for 75% of the smallest industrial parks in terms of net surface area, the variable on the distance to the nearest station with an HVO pump is statistically significant with a coefficient of 2.990e-06. This indicates that for every additional kilometre an alternative fuel station with an HVO pump is further away from an industrial park, the industrial park's added value is expected to grow by 0.3% per year.

The above subsets are also run on the full dataset in terms of years (2013-2022), excluding the variable on the distance between an industrial park and an alternative station with a hydrogen pump. This regression shows that for the smallest 25% of the industrial parks in terms of net surface area, the variable on the distance to a station with an LNG pump is statistically significant with a coefficient of 3.950e-06. This means that it is expected that the industrial park's added value will increase by 0.39% every year for every additional kilometre an alternative fuel station with an LNG pump is further away. The regression output can be found in *Table 12* in the *Appendix*.

Different from the main regression in sub-question 4, for the 25% smallest industrial parks in terms of net surface area, statistically significant coefficients are found for distance to a toilet and truck parking as additional service at alternative fuel stations. The coefficient for distance to a station with a toilet equals 5.610e-06 and is statistically significant at a 5% significance level. For the subset of industrial parks, the industrial park's added value is expected to increase by 0.56% per year for every additional kilometre an alternative fuel station with a toilet is further away. The coefficient for truck parking equals -4.690e-06 and is statistically significant. This means that for every additional kilometre an alternative fuel station with a truck parking is further away from the industrial park, the industrial park's added value is expected to decrease by 0.47% per year. Rejecting the null hypothesis regarding additional services is partially justified by the significant result on the distance to stations with a toilet or truck parking for a subset of the industrial parks in terms of net surface area.

4.5.2 Industrial park subset(s) on number of firms

Regressions on the subsets industrial parks regarding the number of firms show no significantly different results from the main regression on the distance to alternative fuel stations. The same result is found for all subsets except for the 25% smallest industrial parks subset. This could be twofold: either the sample is too small to get statistically significant results, or the smaller industrial parks, in terms of a number of firms, are not experiencing statistically significant impacts from alternative fuel stations on their added value.

Other subsets regarding the number of firms in industrial parks do not provide statistically significant results from the main regression for other variables of interest.

4.5.3 Industrial park subset(s) on the number of firms in the transport sector

An extension of the above subset analysis is performing regression on the variables of interest with subsets on quartiles based on a number of firms in the transportation sector.

The fixed effects regression on the subset of the 25% smallest industrial parks in terms of the number of transportation firms shows the most prominent economic effect for this subset. The coefficient equals -4.000e-06, see *Table 15* in the *Appendix*, whereas the coefficients of the other subsets show approximately half the coefficient's size. All coefficients are statistically significant. This means that for the 25% smallest industrial parks in terms of the number of transportation firms, the industrial park added value is expected to decrease by 0.4% per year for every additional kilometre an alternative fuel station is further away from the industrial park.

Other subsets regarding the number of transportation firms in industrial parks do not provide statistically significant different results from the main regression for any of the other variables of interest.

4.5.4 Industrial park subset(s) on number of jobs

No statistically significant different result is found in the subsets on the number of jobs with regards to distance to alternative fuel stations, however the fixed effects regression on the smallest 25% of industrial parks in terms of jobs shows no statistically significant result for distance to alternative fuel stations. In the full dataset and other quartiles, there is a statistically significant effect.

The subset on the 50% smallest industrial parks in terms of jobs shows statistically significant different results from the main regression for some alternative fuels/energy carriers. The coefficients for distance to LNG pumps, HVO pumps and hydrogen pumps are statistically significant, with coefficients equal to 7.070e-06, 3.070e-06, and 2.100e-06, respectively. Indicating that it is expected that annual industrial park added value will increase with 0.71% (LNG pumps), 0.31% (HVO pumps), and 0.21% (hydrogen pumps) for every additional kilometre an alternative fuel station with these types of pumps is further away from the industrial park, holding all else constant. The regression output can be found in the *Appendix, Table 16*.

Other subsets regarding the number of jobs on industrial parks do not provide statistically significant different results from the main regression for any of the other variables of interest.

4.5.5 Industrial park subset(s) on added value

In line with the above subset regression, no statistically significant different result is found in the subsets on industrial park added value with regards to distance to alternative fuel stations however again the fixed effects regression on the smallest 25% of industrial parks in terms of added value shows no statistically significant result for distance to alternative fuel stations. There is a statistically significant effect in the full dataset and for other quartiles.

Also, for the subsets in terms of added value, a similar effect is found for fuel types/energy carriers as in the main regression model. The variables on the distance to alternative fuel stations with an LNG, HVO, and hydrogen pump show approximately similar coefficients and significance for the effect on annual industrial park added value (see Table 17 in the Appendix). The same interpretation and possible theoretical reasoning behind the effect apply as in *Subchapter 4.5.4* above.

In contrast to the main regression, a regression model on the smallest 75% of the industrial park in terms of industrial parks shows statistical significance for the variable on the distance to an alternative fuel station with a toilet as an additional service. The coefficient equals -4,990e-06 and is statistically significant. This indicates that it is expected that the annual industrial park added value decreases by 0.5% for every additional kilometre an alternative fuel station with a toilet is further away from the industrial park, ceteris paribus. As further clarified in Subchapter 4.4.2, the model combines cross-sectional and time series data; if no data on time series is available, it cannot be run. This is the case for the variable on stations with a shower before the year 2016 since there was no shower as an additional service at a station in the study area before that year. Therefore, the effect represented in the regression output in *Table 18*, see *Appendix*, is only applicable to the years 2016 until and including 2022.

Other subsets regarding the industrial park added value do not provide statistically significant different results from the main regression for any of the other variables of interest.

CHAPTER 5: CONCLUSION AND DISCUSSION

5.1 Conclusion

This research answers the main question: '*To what extent do alternative fuel stations affect the economic growth of industrial parks in the province of Gelderland?*'. The research question will be answered using sub-questions that build an overall answer and conclusion on the main research question.

The first and second sub-questions, see 2.7.7 Research questions, explore the general and spatial aspects of alternative fuel stations in the province of Gelderland. Alternative fuel stations and their specific characteristics in the province of Gelderland are briefly described here. In answering the second sub-question, the spatial distribution of alternative fuel stations and industrial parks in the province of Gelderland is shown. Subsequently, it relates these distributions to the economic performance of industrial parks.

At alternative fuel stations, one alternative fuel or energy carrier is provided, such as bio-CNG, bio-LNG, EV charging, HVO and hydrogen. A second type of alternative fuel station is a Clean Energy Hub (CEH). This is a station where at least two alternative fuels or energy carriers are being provided. Additional services can be offered at alternative fuel stations, such as a truck parking, carwash, truck wash, shop facility, restaurant, toilet and shower.

For several municipalities, such as Arnhem, Duiven, Harderwijk, and Ede, there is a relatively high number of alternative fuel stations and a relatively high added value for industrial parks. On the contrary, there are also municipalities, such as Zaltbommel, Maasdriel, Nijmegen and Apeldoorn, where the added value of industrial parks is relatively high. However, the number of alternative fuel stations is relatively low. Lastly, regions are also identified with relatively low added value on industrial parks as a relatively low number of alternative fuel stations, such as 'Veluwe' and 'Achterhoek'.

The third and fourth sub-questions, *see 2.7.7 Research questions*, aim to explore the relationship between industrial park added value and the distances to alternative fuel stations, specific alternative fuel types/energy carriers, and additional services at stations.

The fixed effects regression output shows a statistically significant effect of distance to an alternative fuel station on the industrial park's added value. When the distance to an alternative fuel station increases with an additional kilometre, the industrial park added value decreases by 0.19% per year, holding all else constant, indicating that a more considerable distance between industrial parks and alternative fuel stations harms the industrial park added value.

The data on all alternative fuel stations can be divided into stations with one alternative fuel or energy carrier and stations with multiple alternative fuels or energy carriers (CEH's). Regarding the effect of distance to a station on industrial park added value, a statistically significant effect is found for alternative fuel stations but not for Clean Energy Hubs. The effect of alternative fuel stations is in line with the main regressions.

The full dataset covers the years 2013 through and including 2022. Two regressions on fuel types/energy carriers are included because the first hydrogen pump was installed in the study area in 2017.

From 2017 until 2022, the distance between industrial parks and alternative fuel stations with a CNG pump, LNG pump, EV charging, and hydrogen pump shows no statistically significant effect on the industrial park's annual added value. For this same subset of years, there is a statistically significant effect on the industrial park's annual added value with regard to the distance to alternative fuel stations with an HVO pump. The coefficient has a positive sign, indicating that the industrial park added value will increase when an alternative fuel station with an HVO pump is further away.

For the subset, excluding the variable on the distance to alternative fuel stations with a hydrogen pump, the statistical significance of distance to an alternative station with an HVO pump disappears. Distance to stations with EV charging points shows statistically significant effects. The output shows that for every additional kilometre in the distance to a station with an electric charging point with a maximum power of 50 kW, the industrial park added value will increase by 0.154%, ceteris paribus. And for every additional kilometre in the distance to a station with an electric charging point with a minimum power of 175 kW, the industrial park added value will decrease by 0.125%, holding all else constant. Stations with a fast EV charging point show a negative effect with increasing distance, indicating a decrease in industrial park added value the further away the station is. Stations with a slow EV charging point show the opposite.

The same is true with the data on alternative stations with hydrogen pumps, which applies to stations with a shower as an additional service. The results for the analysis, including stations with a shower, are performed for the years 2016 until and including 2022. This regression shows that stations with a carwash as an additional service statistically affect the industrial park's annual added value. For every additional kilometre that an alternative fuel station with a carwash is further away from an industrial park, the industrial park’s added value will increase by approximately 0.3%.

When performing the regression without the variable on the distance to a station with a shower as an additional service, thus year fixed effects for 2013 until and including 2022, none of the additional services show a statistically significant effect on the industrial park added value.

The fifth and last sub-question also explores the relationship between industrial park added value and distances to alternative fuel stations and their fuels and additional services. However, it aims to analyse industrial parks with varying characteristics regarding added value, number of jobs, number of (transport) firms and surface area.

Subset results show that for the 25% smallest industrial parks in terms of surface area, alternative fuel stations with hydrogen pumps have a statistically significant effect on the added value of industrial parks. The sign of the coefficient is positive, indicating that increased distance to alternative stations with a hydrogen pump increases the industrial park's added value. The same is true for alternative fuel stations with an LNG pump, truck parking, or toilet. Stations with truck parking show the opposite effect, where the industrial park's added value decreases when a station with truck parking is further away.

The regression on the subsets based on the number of firms in the transport sector shows that the found effect for the 25% smallest industrial parks has the strongest effect on industrial park added value. The coefficient here is twice as big as the coefficient in the main regression.

A number of subsets show no significantly different results from the main regression. However, in contrast to the main regression on all data, the subsets do reveal that there is no statistically significant effect of distance to alternative fuel stations on industrial park added value for the smallest 25% of the industrial parks in terms of the number of firms, number of jobs, and added value.

In contrast to the main regression, where no statistically significant effect of additional services was found, the subset on the smallest 75% of the industrial parks in terms of industrial park added value does reveal that alternative fuel stations with toilets have a statistically significant positive effect on the industrial park added value.

Overall, regarding the main research question, a statistically significant relationship is found, indicating that increasing distance from alternative fuel stations decreases industrial parks' economic performance. Specifically, for each additional kilometre in distance, the added value of industrial parks decreases by 0.19% per year.

Distances to stations with CNG, LNG, EV charging, and hydrogen pumps show no significant effect on industrial park value. The economic growth of industrial parks is measured using industrial park added value (turnover of total production minus cost of total production). With the thought that an increase in industrial park added value is economically positive and a decrease in added value is economically harmful, a significant negative effect was found for stations with HVO pumps and slow EV charging points (≤50 kW). In contrast, stations with fast EV charging points (≥175 kW) had a positive impact, where increased distance correlates with decreasing economic performance.

Stations offering car wash services negatively impact the economic growth of nearby industrial parks. Specifically, for each additional kilometre an alternative fuel station with a carwash is further away, the industrial park's added value increases by approximately 0.3%. No significant impact was found for other additional services.

Smaller industrial parks, bottom 25% by surface area, show a negative economic impact from increasing distance to stations with a hydrogen pump, a LNG pump, or a toilet. Regarding truck parking, there is a positive economic impact. For the smallest 25% of industrial parks in terms of the number of firms, jobs, and added value, the relationships are not statistically significant, suggesting that the effect of alternative fuel stations may vary based on specific characteristics of the industrial park.

The research indicates that alternative fuel stations complexly influence the economic growth of industrial parks in the province of Gelderland. Being close to alternative fuel stations often supports economic performance; however, the extent to which this is the case depends on the kind of fuel and services offered and the specific features of the industrial parks. Consequently, by considering these aspects and strategically placing alternative fuel stations, industrial parks in the area can become more economically vibrant.

5.2 Discussion

5.2.1 Validity of the research

The primary objective of the study is to investigate to what extent alternative fuel stations affect the economic development, using industrial park added value, of industrial parks in the province of Gelderland. This is accomplished using extensive statistics on industrial parks and alternative fuel stations in a spatial-economic analysis. In order to ensure accurate measurement, the methodology section provides a clear and logical way to answer the research questions. Robust data collection methodologies and statistical analysis techniques are used to answer the main and sub-questions.

The result of this research can be used in a somewhat broader context. Although the study is primarily concerned with industrial parks located in the province of Gelderland, the approach and analysis techniques employed may find application in situations comparable to those across other NUTS regions. The extensive dataset lends credence to the generalizability within the Dutch setting, as it encompasses all industrial parks in the province of Gelderland. Nevertheless, as a case study centred on solely one province, its conclusions might not adequately represent the variety of industrial parks and alternative fuel stations in other regions.

The research is expected to be both valid and reliable. Several steps were made to improve reliability, including applying robust statistical approaches, utilising an extensive dataset, and including control variables and (year) fixed effects to reduce bias. The use of confidence intervals and standard procedures in data collection further supports the reliability of the findings. Furthermore, the reliability of the research is strengthened by ensuring high transparency in the methodology, which includes an extensive explanation of and elaboration on the steps involved in data collection and analysis. A reproduction package, in the form of a Stata17 Do-File, is provided.

5.2.2 Further interpretation of the results

The first economic sub-question focuses on the effect of distance to alternative fuel stations on the economic growth of industrial parks, measured using industrial park added value. Stations have a positive economic impact on industrial parks. The null hypothesis regarding the overall distance to alternative fuel stations is rejected since a statistically significant effect is found on the distance to alternative fuel stations on industrial park added value.

As stated in the literature review, there is no consensus in the existing scientific literature on the spatial-economic effect(s) of alternative energy developments. The study by Wu (2006) shows that the spatial distribution of environmental amenities strongly influences development patterns and community characteristics. They indicate that the vicinity of an alternative fuel station is expected to increase the development pattern of an industrial park. Zang et al. (2023) also find that the more resources are invested in clean energy development, combined with the spatial spillover effect, the more economic transformation and development in practice and theory. It is argued that the industrial park situation will be improved mainly through economic growth when the use of renewable energy is increased (Falahatdoost & Wang, 2022; Cochrane et al., 2010; Inglesi-Lotz, 2016; Soava et al., 2018; Al-mulali et al., 2014; Lall, 2017). The study by Pereira et al. (2021) nuances this by finding that clean energy development has a negative or insignificant impact on economic growth in the short term and possibly positive in the long term. This underlines the importance of future research in the long term. More effects or more substantial effects can become visible.

The second economic sub-questions focus on the effect of distance to specific alternative fuels or energy carriers. From 2017 until 2022, there has been a statistically significant effect on the industrial park's annual added value concerning the distance to alternative fuel stations with an HVO pump. Stations with HVO pumps have a negative economic impact on industrial parks. For all years in the dataset, stations with EV charging points have a statistically significant effect on the industrial park's added value. Slow EV charging points have a negative impact; fast EV charging points have a positive impact. The null hypothesis regarding fuel types, stating there is no statistically significant effect, is rejected.

Starting from the point of view that a growth in industrial park added value is a good thing, the sign of the coefficient can be striking. it is expected that the further away a station with an HVO pump is, the higher the industrial park's added value. This would mean that an industrial park would want to be further away from stations with an HVO pump for growth in added value. From a policy perspective, a sufficient and accessible supply of alternative fuels, such as HVO, is expected to make it more practical and cheaper for companies to undergo the energy transition. The conclusion from the regression output shown in *Table 3* seems contradicting. To better understand the sign of the coefficient, the definition of added value is explained again: the total value of all goods and services produced minus the value of goods and services consumed during this production. For the added value of an industrial park to increase, either the value of the goods and services produced must increase or the value of the goods and services needed for production must decrease. Further research is needed to show which scenarios occur when the distance between an industrial park and a station with an HVO pump increases.

In the existing literature, it is also emphasised that big (logistic) firms with relatively large fleets will not want to invest in alternative fuel vehicles unless they have the assurance of plentiful fuelling stations for all of their travelling routes (Yueyue et al., 2017; Wang & Lin, 2009). The so-called chicken-and-egg problem could mean that supply remains low for alternative fuel types if demand is low. In the second sub-question on the spatial distribution, it can be seen that there are relatively more stations with EV charging points and an HVO pump. This could be one of the primary reasons why significance is found for this type of alternative fuel and energy carrier.

The third economic sub-question focuses on the effect of distance to stations with specific additional services on the added value of industrial parks. A statistically significant result for stations with a carwash is found in the subset for the years 2017-2022. The null hypothesis is not rejected for the full range of data across all years since none of the additional services shows a statistically significant effect on the industrial park's added value per year.

The positive value of the coefficients that represent the distance of an industrial park to a station with a carwash indicates that the further away a carwash is, the higher the added value per year for an industrial park is. There can be several possible theoretical arguments for this: reduced traffic congestion, optimal land use, and reduced noise and pollution. Having the carwash relatively further away from an industrial park can reduce traffic congestion in and around the industrial park. This could make it more accessible for trucks and other vehicles at the industrial park to move around. Subsequently, this can lead to more efficient traffic handling and firms' operational processes at the industrial park. Land in industrial parks is typically more valuable and better suited for core industrial activities. When a carwash is relatively further away from an industrial park, there is likely more valuable space within the industrial park for more critical industrial functions. This could lead to higher overall productivity and efficiency, thus, the higher added value of the industrial park. Lastly, a station with a carwash can generate noise and water pollution. Having this type of additional service further from the industrial park can help mitigate these types of issues. It will likely create a more pleasant working environment and potentially higher productivity of the employees.

The fourth economic sub-question performs the above analyses on distance to alternative fuel stations, alternative fuel types, and additional services in varying industrial park subsets. For the smallest 25% of industrial parks in terms of number of firms, jobs, and added value, the relationships in subsets are not significantly different from the main regression. Smaller industrial parks, bottom 25% by surface area, show a significant negative economic impact from increasing distance to stations with a hydrogen pump, a LNG pump, or a toilet. Regarding truck parking, there is a positive economic impact. This suggests that the effect of alternative fuel stations is expected to vary based on specific characteristics of the industrial park. Thus, the null hypothesis regarding industrial park dynamics is rejected.

On the contrary, the truck parking facility further away decreases the industrial park's added value per year. Several aspects can play a role here: logistics, convenience for truck drivers, and safety and security. Firms at industrial parks benefit from efficient logistics and transportation. A relatively nearby truck parking facility provides easy access for trucks to park. This can facilitate smoother and quicker supply chain operations. When the truck parking is further away, it can cause delays and increase transportation costs, thus decreasing the added value of industrial parks. Next, a nearby truck parking can provide a safe and secure location for trucks to park, reducing the risk of theft or damage to goods. These goods are directly part of the firm's supply chain and thus influence the added value of firms in the industrial park.

It has to be emphasised that using subsets of the data can lead to issues such as reduced statistical power or Type I errors. The model uses statistical techniques to mitigate this problem as well as possible. The findings in answering this sub-question could be replicated with additional data or in different contexts to validate the results.

Existing literature shows that hydrogen refuelling locations negatively impact electricity bills and congestion in industrial parks (Scheidt et al., 2022; Schembri & Radja, 2023). There are also several key findings from the literature on the built environment. For example, Zoa et al. (2020) and Zoa et al. (2023) show that fuelling stations are perceived as NIMBY facilities due to their potential negative impact on property values and safety concerns. This could explain the negative economic impact found in the results regarding alternative fuel stations with a hydrogen pump.

From another perspective, the negative impact of stations with a given alternative fuel type can be because of land use efficiency. In general, LNG and hydrogen pump installations take up relatively much space. According to Outka (2012), people should minimise the point of conflict between energy goals, land conservation, and land use efficiency. However, so far, suitable laws to make sure projects land in the right locations are relatively premature (Outka, 2012). Conversely, our society surely but slowly shifts away from fossil fuels; this creates a situation in which land that was previously used for unsustainable energy generation can now be redirected for more sustainable energy generation and implementation. In some cases, such as hydrogen installation, this takes up relatively more space than original fossil fuel installations. This can increase the land use of stations, decreasing the available space for firms. This could explain the negative impact found in the results.

Theoretical reasoning behind this could be that hydrogen refuelling stations have relatively high safety regulations, noise and light pollution and, again, space utilisation. Hydrogen refuelling stations involve storing and handling flammable gases. Locating them further from an industrial park can alleviate employee safety concerns, making the park more attractive to potential employees and customers. Hydrogen stations can cause noise and light pollution, specifically during refuelling. Having them further away from an industrial park can ensure a relatively quieter and serene environment, increasing the industrial park's appeal. However, more in-depth qualitative research is preferred to draw proper conclusions.

Regarding the theoretical framework, the findings of the main regression on distance to alternative fuel stations seem to align with the theories of Hirschman, Roback, and Solow. The results support Hirschman's theory of unbalanced growth, where investments in specific regions (industrial parks with alternative fuel stations) drive overall economic growth. The significant relationship between infrastructure investments and economic outcomes aligns with Roback's model, confirming that such investments improve regional economic performance. Lastly, the findings align with the Solow model, indicating that technological progress (alternative fuel infrastructure) is a key determinant of economic growth.

5.2.3 Limitations of the research

Aspects that limit the research are the geographic limitations, incomplete data, the level of the data, and the quantitative focus. As explained above, the research only examines industrial parks in the province of Gelderland, limiting the geographic scope and potentially leading to biases. One of the primary reasons for this is that data is only available at municipal and industrial park levels, not at the firm level, which could provide more detailed insights. Thereby, other dependent and independent variables could be included to gain more insights into the topic; this requires higher accessibility to data on the industrial park level. For example, data on vehicle fleets, investments, innovation, infrastructure quality and energy consumption at industrial parks. Something that could also limit the research is the fact that research uses a quantitative approach, which does not capture qualitative aspects that could offer deeper context and insights into the topic.

Another research limitation could be the model and its approach to analysing the situation. As discussed in the literature review, there is no consensus on the economic impact of environmental amenities, for example, whether there is no effect, positive, negative, unidirectional or bidirectional. In the research context, the impact of an environmental amenity, namely an alternative fuel station, on the economic performance of industrial parks is analysed. At the same time, the economic performance of industrial parks can influence whether or not a given alternative fuel operator will exploit a station in its vicinity. Reflecting on the chicken-and-egg problem discussed multiple times in this research; there needs to be enough demand and supply for a significant effect of environmental amenities. With sufficient access to data, future research could further dive into this.

These limitations can be prevented or avoided by implementing a broader geographic scope, including firm-level data, and using a mixed methods approach. This strongly depends on whether enough data is available for relevant research.

5.2.4 Implications of the research findings

The research highlights the intricate relationship between alternative fuel stations' proximity and industrial parks' economic performance in the province of Gelderland. The main findings focus on three main types of economic impact: alternative fuel stations in general, specific alternative fuels and energy carriers, and additional services at stations. Increased distance from alternative fuel stations generally leads to a decrease in the added value of industrial parks. The type of alternative fuel and the additional services provided at these stations influence the economic impact. For instance, stations with fast EV charging points negatively impact the industrial park's added value when further away. In contrast, those with slow EV charging points and car wash services show a positive impact when further away. The effect varies based on the size and characteristics of the industrial parks. If the findings are not implemented, there can be three main consequences: suboptimal economic performance, inefficient resource allocation, and missed opportunities for sustainability. Industrial parks may not achieve optimal economic performance. Without utilising the insights from this research, resources may not be allocated efficiently, resulting in less impactful alternative fuel infrastructure development. Lastly, the potential for having a more sustainable and economically developed environment through strategically placed alternative fuel stations could be lost, which likely hinders efforts to reduce fossil fuel dependency and enhance greener energy solutions.

5.2.5 Future research

Future research in alternative fuels and economic development at industrial parks can be conducted on various topics. As stated in the subchapter on the limitations of this research, future research can use a broader geographic scope, such as conducting research for all industrial parks in the Netherlands or Europe. Next to that, if possible, future research can include firm-level data and use a mixed methods approach to explore the topic further. These types of research can be very time-consuming. This is one of the limiting factors with regard to this research since there is a given time frame to complete your MSc thesis. For example, future research could investigate the impact of new technologies in the production, storage, and distribution of alternative fuels such as hydrogen, biofuels, and electric batteries. It could explore how advancements can reduce costs and improve the efficiency and sustainability of industrial parks. Thereby, a more thorough analysis can be conducted in future research on the economic impact of alternative fuels by analysing the long-term economic effects of alternative fuels on firms or industrial parks. This research predominantly focused on the past decade (2013-2022), whereas some effects might only be visible in the longer term.

CHAPTER 6: REFERENCES

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APPENDIX

Table 5: A description of all variables of interest in the analysis.

Variable	Description	Unit
Added Value	This variable provides the total value of all goods and services produced, also known as the production value or output, minus the value of goods and services consumed during this production. The dataset provides the added value per industrial park per year in Euros.	Euros (€)
Employment	This variable provides the total number of jobs at an industrial park in a given year.	Count
Firms	This variable provides the total number of firms at an industrial park in a given year.	Count
Firms Transport	This variables provides the total number of firms in the transportation sector at an industrial park in a given year.	Count
Distance All Stations	This variable provides the distance in metres between an industrial park and the nearest alternative fuel station. All alternative fuel stations are included in calculating the distance to the nearest alternative fuel station. Distances are calculated as the crow flies.	Metres
Distance Clean Energy Hub	This variables provides the distance in metres between an industrial park and the nearest Clean Energy Hub (CEH). A CEH is a alternative fuel station at which at least 2 alternative fuels and/or energy carrier are provided.	Metres
Distance Alt Station	This variable provides the distance in metres between an industrial park and the nearest alternative fuel station. An alternative fuel station is a fuel stations at which an alternative fuel or energy carrier is being provided.	Metres
Net Surface Area	This variable provides the total net surface area of an industrial park in a given year. This variable is measured in hectares.	Hectares
Distance CNG	This variable provides the distance in metres between an industrial park and the nearest CNG-fuel pump in a given year. CNG is an alternative fuel / energy carrier, it stands for compressed natural gas.	Metres
Distance LNG	This variable provides the distance in metres between an industrial park and the nearest LNG-fuel pump in a given year. LNG is an alternative fuel / energy carrier, it stands for liquefied natural gas.	Metres

Distance HVO	This variable provides the distance in metres between an industrial park and the nearest HVO-fuel pump in a given year. HVO is an alternative fuel / energy carrier, it stands for hydrotreated vegetable oil.	Metres
Distance Electric Slow	This variable provides the distance in metres between an industrial park and the nearest 'slow' electric charger in a given year. 'Slow' electric charging is an alternative fuel / energy carrier, it is categorized as a 'slow' charger when the charger provides 50kW of power at is maximum.	Metres
Distance Electric Moderate	This variable provides the distance in metres between an industrial park and the nearest 'moderate' electric charger in a given year. 'Moderate' electric charging is an alternative fuel / energy carrier, it is categorized as a 'moderate' charger when the charger provides between 50kW and 174kW of power.	Metres
Distance Electric Fast	This variable provides the distance in metres between an industrial park and the nearest 'fast electric charger in a given year. 'Fast' electric charging is an alternative fuel / energy carrier, it is categorized as a 'fast' charger when the charger provides more than 174kW of power.	Metres
Distance Hydrogen	This variable provides the distance in metres between an industrial park and the nearest hydrogen fuel pump in a given year. Hydrogen is an alternative fuel / energy carrier.	Metres
Distance Truck Parking	This variables provides the distance in metres between an industrial park and the nearest truck parking at an alternative fuel station in a given year. Truck parking can be one of the additional services offered at an alternative fuel station.	Metres
Distance Carwash	This variables provides the distance in metres between an industrial park and the nearest carwash at an alternative fuel station in a given year. A carwash can be one of the additional services offered at an alternative fuel station.	Metres
Distance Truck Wash	This variables provides the distance in metres between an industrial park and the nearest truck wash at an alternative fuel station in a given year. A truck wash can be one of the additional services offered at an alternative fuel station.	Metres
Distance Shop	This variables provides the distance in metres between an industrial park and the nearest shop at an alternative fuel station in a given year. A shop can be one of the additional services offered at an alternative fuel station.	Metres

Distance Restaurant	This variables provides the distance in metres between an industrial park and the nearest restaurant at an alternative fuel station in a given year. A restaurant can be one of the additional services offered at an alternative fuel station.	Metres
Distance Toilet	This variables provides the distance in metres between an industrial park and the nearest toilet at an alternative fuel station in a given year. A toilet can be one of the additional services offered at an alternative fuel station.	Metres
Distance Shower	This variables provides the distance in metres between an industrial park and the nearest shower at an alternative fuel station in a given year. A shower can be one of the additional services offered at an alternative fuel station.	Metres

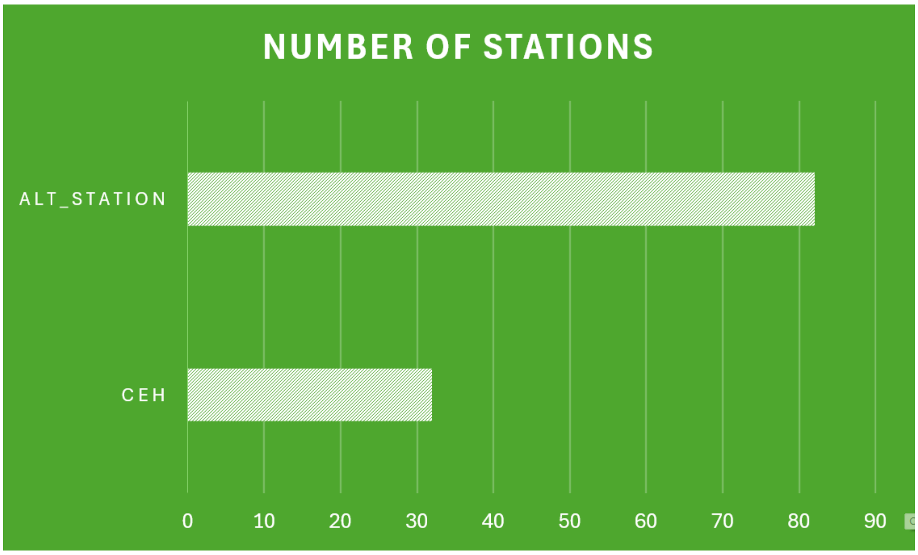

Figure 6: Number of alternative fuel stations and Clean Energy Hubs (CEH) in the province of Gelderland; incl. a 10km boundary around the provincial border.

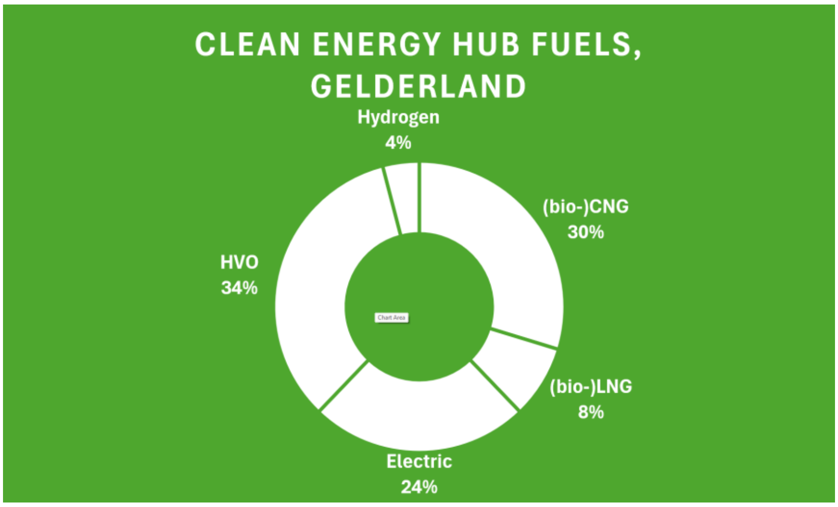

Figure 7: Percentage of alternative fuels across Clean Energy Hubs in Gelderland.

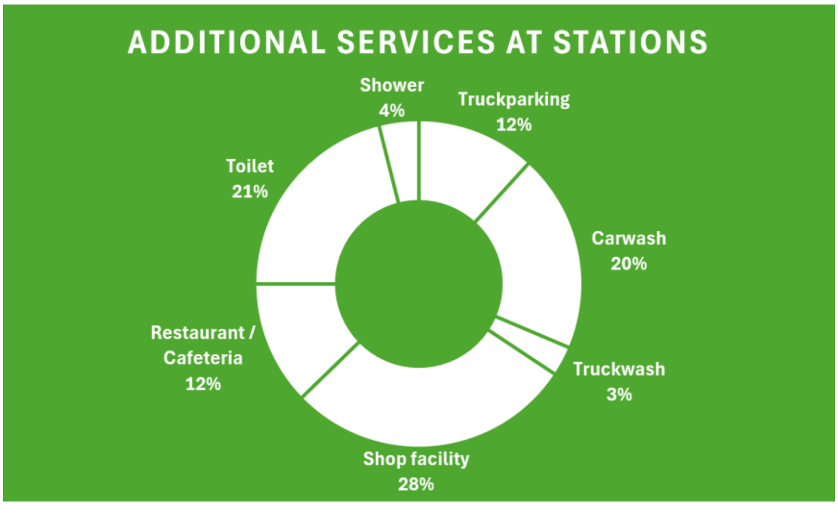

Figure 8: Percentage of additional services across all alternative stations in Gelderland.

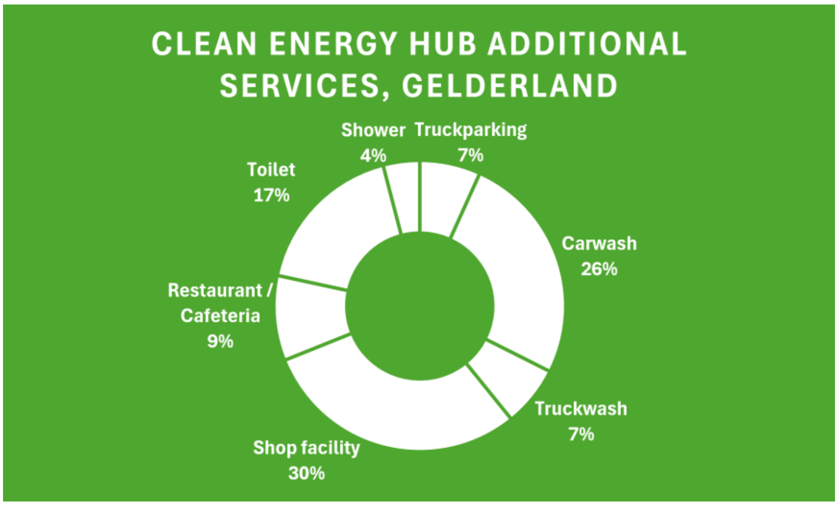

Figure 9: Percentage of additional services across Clean Energy Hubs in Gelderland.

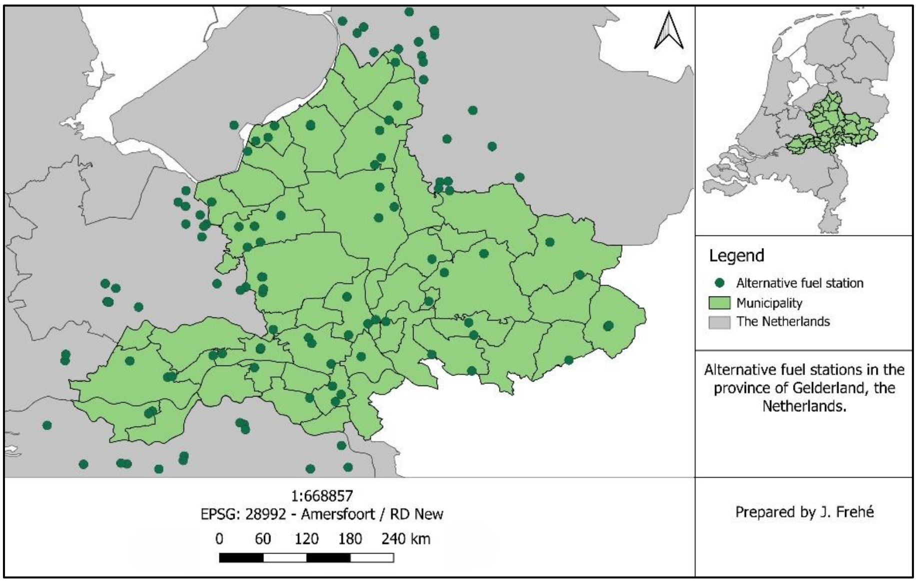

Figure 10: Alternative fuel stations in the province of Gelderland (incl. a 10km buffer at the provincial border)

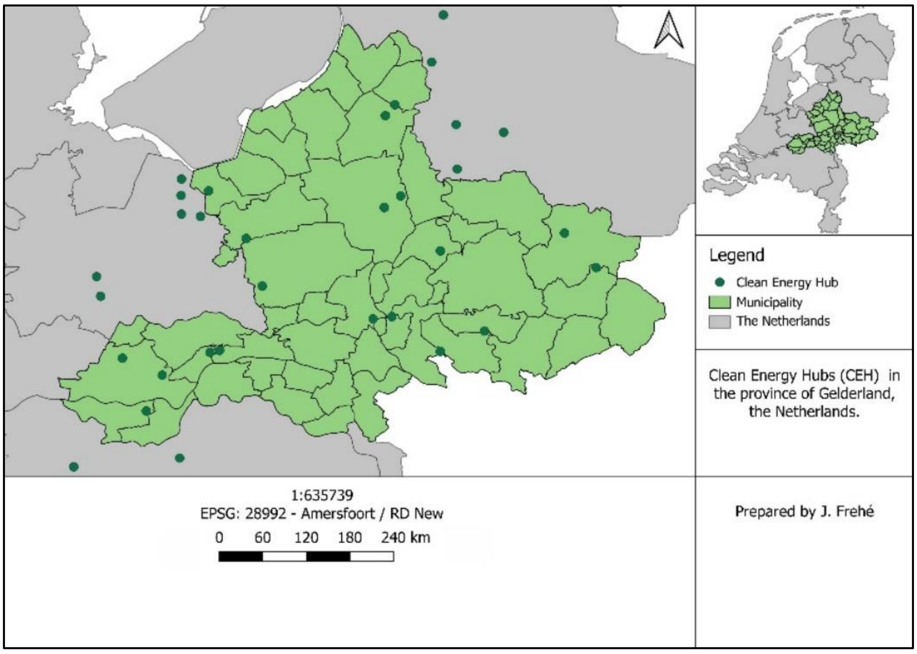

Figure 11: Clean Energy Hubs (CEH) in the province of Gelderland, the Netherlands.

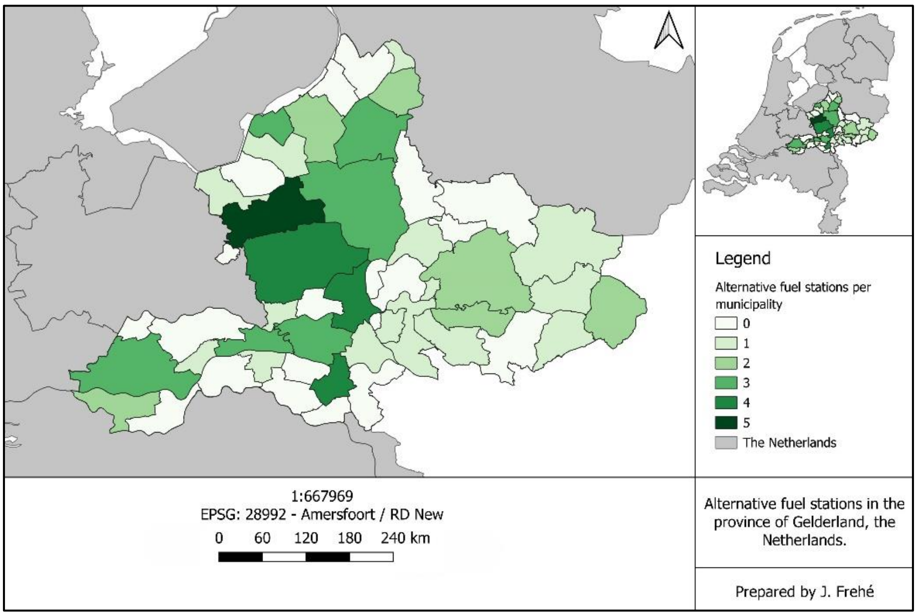

Figure 12: Alternative fuel stations per municipality in the province of Gelderland.

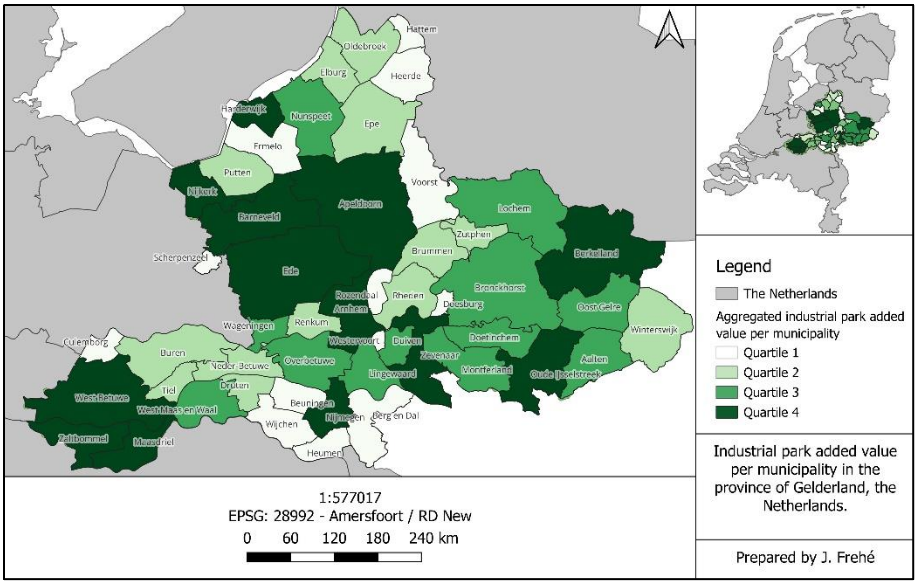

Figure 13: Industrial park added value per municipality in the province of Gelderland.

Table 6: Regression of distance (in metres) between industrial parks and alternative fuel stations and CEH's, control variable(s): employment, firms, net surface area and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_ Alternative_Fuel_ Station	-2.030e-06	1.090e-06	-1.87	.061	-4.170e-06	1.000e-07	*
Distance_Clean_ Energy_Hub	-4.600e-07	1.050e-06	-0.44	.658	-2.520e-06	1.600e-06	
log_Employment	1.014	.030	33.29	0	.954	1.074	***
log_Firms	.025	.030	0.84	.402	-.034	.085	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.955	.147	74.32	0	10.666	11.245	***

Mean dependent var	16.673	SD dependent var	1.733
R-squared	0.869	Number of obs	4557
F-test	203.124	Prob > F	0.000
Akaike crit. (AIC)	-3741.344	Bayesian crit. (BIC)	-3657.827

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 7: Regression output on the relationship between industrial park added value and the distance to a specific fuel type / energy carrier (Compressed Natural Gas, Liquefied Natural Gas, Hydrotreated Vegetable Oil and electric vehicle charger), control variable(s): employment, firms, surface area and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	-4.700e-07	1.160e-06	-0.41	.685	-2.750e-06	1.810e-06	
Distance_LNG	-1.000e-07	9.000e-07	-0.11	.908	-1.870e-06	1.660e-06	
Distance_HVO	4.600e-07	7.600e-07	0.61	.543	-1.030e-06	1.950e-06	
Distance_Electric_ Slow	1.540e-06	8.900e-07	1.73	.084	-2.100e-07	3.290e-06	*
Distance_Electric_ Fast	-1.250e-06	5.800e-07	-2.16	.031	-2.380e-06	-1.100e-07	**
log_Employment	1.015	.030	33.48	0	.955	1.075	***
log_Firms	.023	.031	0.74	.458	-.038	.084	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.935	.151	72.06	0	10.636	11.233	***

Mean dependent var	16.672	SD dependent var	1.734
R-squared	0.869	Number of obs	4550
F-test	184.475	Prob > F	0.000
Akaike crit. (AIC)	-3736.562	Bayesian crit. (BIC)	-3633.796

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 8: Regression output on the relationship between industrial park added value and the distance to a specific additional service at the station location (truck parking, carwash, truck wash, shop, restaurant, and toilet), control variable(s): employment, firms, surface area and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_ Truckparking	-4.400e-07	7.300e-07	-0.61	.541	-1.870e-06	9.900e-07	
Distance_Carwash	7.900e-07	8.700e-07	0.91	.364	-9.200e-07	2.500e-06	
Distance_ Truckwash	-2.900e-07	7.300e-07	-0.40	.689	-1.720e-06	1.140e-06	
Distance_Shop	-9.000e-07	1.370e-06	-0.65	.513	-3.590e-06	1.800e-06	
Distance_ Restaurant	-1.100e-06	8.300e-07	-1.32	.186	-2.740e-06	5.300e-07	
Distance_Toilet	1.010e-06	1.450e-06	0.69	.487	-1.840e-06	3.860e-06	
log_Employment	1.014	.030	33.25	0	.954	1.074	***
log_Firms	.023	.031	0.74	.459	-.038	.084	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.957	.152	72.00	0	10.658	11.256	***

Mean dependent var	16.672	SD dependent var	1.734
R-squared	0.869	Number of obs	4550
F-test	169.811	Prob > F	0.000
Akaike crit. (AIC)	-3737.818	Bayesian crit. (BIC)	-3628.629

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 9: Regression output on the relationship between industrial park added value and the distance to alternative fuel stations for the 75% smallest industrial parks in terms of net surface area, control variable(s): employment, firms, surface area and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_All_ Stations	-2.270e-06	1.200e-06	-1.89	.060	-4.640e-06	1.000e-07	*
log_Employment	.968	.036	26.77	0	.897	1.039	***
log_Firms	.054	.033	1.61	.107	-.012	.121	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	11.090	.163	67.97	0	10.769	11.411	***

Mean dependent var	16.114	SD dependent var	1.510
R-squared	0.832	Number of obs	3393
F-test	134.437	Prob > F	0.000
Akaike crit. (AIC)	-2306.274	Bayesian crit. (BIC)	-2232.720

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 10: Regression: output on the relationship between industrial park added value and the distance to alternative fuel types / energy carriers for the 25% smallest industrial parks in terms of net surface area, control variable(s): employment, firms, surface area, and year fixed effects (2017-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	1.560e-06	7.680e-06	0.20	.839	-.00001366	.00001677	
Distance_LNG	2.210e-06	2.900e-06	0.76	.447	-3.540e-06	7.960e-06	
Distance_HVO	3.070e-06	2.500e-06	1.23	.221	-1.880e-06	8.010e-06	
Distance_Electric_ Slow	-2.800e-06	2.960e-06	-0.95	.345	-8.660e-06	3.060e-06	
Distance_Electric_ Fast	-1.080e-06	2.160e-06	-0.50	.618	-5.360e-06	3.200e-06	
Distance_ Hydrogen	4.410e-06	1.620e-06	2.72	.007	1.200e-06	7.620e-06	***
log_Employment	1.051	.036	28.86	0	.978	1.123	***
log_Firms	-.023	.035	-0.68	.498	-.093	.045	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.808	.198	54.40	0	10.415	11.202	***

Mean dependent var	15.228	SD dependent var	1.400
R-squared	0.857	Number of obs	688
F-test	103.544	Prob > F	0.000
Akaike crit. (AIC)	-812.772	Bayesian crit. (BIC)	-753.833

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 11: Regression output: on the relationship between industrial park added value and the distance to alternative fuel types / energy carriers for the 75% smallest industrial parks in terms of net surface area, control variable(s): employment, firms, surface area, and year fixed effects (2017-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	-3.370e-06	3.950e-06	-0.85	.393	-.00001113	4.390e-06	
Distance_LNG	3.750e-06	2.870e-06	1.31	.192	-1.900e-06	9.400e-06	
Distance_HVO	2.990e-06	1.340e-06	2.24	.025	3.600e-07	5.620e-06	**
Distance_Electric_Slow	1.900e-06	1.780e-06	1.07	.285	-1.600e-06	5.400e-06	
Distance_Electric_Fast	-7.800e-07	1.210e-06	-0.65	.519	-3.170e-06	1.600e-06	
Distance_Hydrogen	1.370e-06	9.100e-07	1.50	.133	-4.200e-07	3.150e-06	
log_Employment	1.036	.033	30.95	0	.971	1.102	***
log_Firms	.036	.03	1.22	.225	-.022	.096	
log_Net_Surface_Area (omitted)	0	.	.	.	.	.	
Constant	10.744	.207	51.67	0	10.335	11.153	***

Mean dependent var	16.202	SD dependent var	1.48
R-squared	0.835	Number of obs	2061
F-test	104.921	Prob > F	0.000
Akaike crit. (AIC)	-2319.677	Bayesian crit. (BIC)	-2246.474

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 12: Regression output on the relationship between industrial park added value and the distance to alternative fuel types / energy carriers for the 25% smallest industrial parks in terms of net surface area, control variable(s): employment, firms, surface area, and year fixed effects (2013-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	-7.700e-07	2.600e-06	-0.30	.768	-5.920e-06	4.380e-06	
Distance_LNG	3.950e-06	1.850e-06	2.14	.034	3.000e-07	7.610e-06	**
Distance_HVO	7.500e-07	1.710e-06	0.44	.663	-2.640e-06	4.140e-06	
Distance_Electric_Slow	-2.000e-08	1.850e-06	-0.01	.989	-3.680e-06	3.640e-06	
Distance_Electric_Fast	-3.040e-06	1.250e-06	-2.43	.017	-5.520e-06	-5.600e-07	**
log_Employment	.939	.068	13.78	0	.804	1.074	***
log_Firms	-.0187	.053	-0.36	.723	-.123	.086	
log_Net_Surface_Area (omitted)	0	.	.	.	.	.	
Constant	11.376	.26	43.67	0	10.86	11.892	***

Mean dependent var	15.17	SD dependent var	1.406
R-squared	0.803	Number of obs	1125
F-test	35.744	Prob > F	0.000
Akaike crit. (AIC)	-660.693	Bayesian crit. (BIC)	-580.283

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 13: Regression output on the relationship between industrial park added value and the distance to additional services at alternative fuel station for the 25% smallest industrial parks in terms of net surface area, control variable(s): employment, firms, surface area, and year fixed effects (2013-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_ Truckparking	-4.790e-06	1.470e-06	-3.26	.001	-7.700e-06	-1.880e-06	***
Distance_Carwash	-2.860e-06	1.710e-06	-1.67	.097	-6.250e-06	5.300e-07	*
Distance_ Truckwash	2.860e-06	1.390e-06	2.06	.041	1.200e-07	5.610e-06	**
Distance_Shop	-1.040e-06	3.010e-06	-0.34	.731	-6.990e-06	4.920e-06	
Distance_ Restaurant	-2.070e-06	1.600e-06	-1.30	.196	-5.230e-06	1.090e-06	
Distance_Toilet	5.610e-06	2.820e-06	1.99	.049	2.000e-08	.0000112	**
log_Employment	.939	.068	13.79	0	.804	1.074	***
log_Firms	-.011	.052	-0.23	.822	-.114	.091	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	11.391	.247	46.08	0	10.901	11.881	***

Mean dependent var	15.170	SD dependent var	1.405
R-squared	0.806	Number of obs	1125
F-test	29.883	Prob > F	0.000
Akaike crit. (AIC)	-677.589	Bayesian crit. (BIC)	-592.154

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 14: Regression output on the relationship between industrial park added value and the distance to alternative fuel stations for the 25% smallest industrial parks in terms of number of firms, control variable(s): employment, firms, surface area, and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_All_ Stations	-2.440e-06	2.540e-06	-0.96	.337	-7.470e-06	2.580e-06	
log_Employment	.977	.041	23.63	0	.895	1.059	***
log_Firms	.064	.075	0.85	.396	-.084	.213	
log_Net_Surface_ Area	0	.	.	.	.	.	
Constant	11.111	.167	66.49	0	10.781	11.441	***

Mean dependent var	14.991	SD dependent var	1.702
R-squared	0.862	Number of obs	1132
F-test	79.350	Prob > F	0.000
Akaike crit. (AIC)	-108.811	Bayesian crit. (BIC)	-48.431

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 15: Regression on the relationship between industrial park added value and the distance to alternative fuel stations for the 25% smallest industrial parks in number of transportation firms, control variable(s): employment, firms, surface area, and year fixed effects.

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_All_Stations	-4.000e-06	1.730e-06	-2.32	.021	-7.400e-06	-6.000e-07	**
log_Employment	.996	.046	21.39	0	.904	1.088	***
log_Firms	.037	.041	0.90	.371	-.044	.118	
log_Net_Surface_Area (omitted)	0	.	.	.	.	.	
Constant	11.051	.191	57.64	0	10.674	11.429	***

Mean dependent var	15.807	SD dependent var	1.657
R-squared	0.841	Number of obs	2073
F-test	85.955	Prob > F	0.000
Akaike crit. (AIC)	-980.822	Bayesian crit. (BIC)	-913.181

**** p<.01, ** p<.05, * p<.1*

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 16: Regression on the relationship between industrial park added value and the distance to alternative fuel types / energy carriers for the 50% smallest industrial parks in number of jobs, control variable(s): employment, firms, surface area, and year fixed effects (2017-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	-4.160e-06	6.030e-06	-0.69	.490	-.00001604	7.710e-06	
Distance_LNG	7.070e-06	4.020e-06	1.76	.079	-8.400e-07	.00001499	*
Distance_HVO	3.070e-06	1.750e-06	1.76	.080	-3.700e-07	6.520e-06	*
Distance_Electric_Slow	1.670e-06	2.840e-06	0.59	.556	-3.920e-06	7.270e-06	
Distance_Electric_Fast	2.000e-08	1.630e-06	0.01	.989	-3.190e-06	3.230e-06	
Distance_Hydrogen	2.100e-06	1.190e-06	1.76	.080	-2.500e-07	4.450e-06	*
log_Employment	1.031	.034	30.02	0	.964	1.099	***
log_Firms	.061	.036	1.69	.093	-.010	.132	*
log_Net_Surface_Area (omitted)	0	.	.	.	.	.	
Constant	10.643	.204	52.08	0	10.241	11.045	***

Mean dependent var	15.381	SD dependent var	1.223
R-squared	0.849	Number of obs	1314
F-test	86.964	Prob > F	0.000
Akaike crit. (AIC)	-1111.621	Bayesian crit. (BIC)	-1044.271

**** p<.01, ** p<.05, * p<.1*

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 17: Regression output on the relationship between industrial park added value and the distance to alternative fuel types / energy carriers for the 50% smallest industrial parks in terms of added value, control variable(s): employment, firms, surface area, and year fixed effects (2017-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_CNG	-3.780e-06	5.780e-06	-0.65	.513	-.00001515	7.600e-06	
Distance_LNG	5.790e-06	3.470e-06	1.67	.095	-1.030e-06	.00001262	*
Distance_HVO	3.150e-06	1.660e-06	1.90	.058	-1.100e-07	6.410e-06	*
Distance_Electric_ Slow	4.250e-06	2.580e-06	1.65	.099	-8.200e-07	9.320e-06	*
Distance_Electric_ Fast	-7.200e-07	1.600e-06	-0.45	.655	-3.880e-06	2.440e-06	
Distance_ Hydrogen	2.940e-06	1.120e-06	2.64	.008	7.400e-07	5.140e-06	***
log_Employment	1.011	.029	34.73	0	.953	1.068	***
log_Firms	.052	.036	1.45	.149	-.019	.123	
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.634	.186	57.15	0	10.267	11.001	***

Mean dependent var	15.376	SD dependent var	1.196
R-squared	0.867	Number of obs	1331
F-test	117.741	Prob > F	0.000
Akaike crit. (AIC)	-1353.761	Bayesian crit. (BIC)	-1286.244

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.

Table 18: Regression output on the relationship between industrial park added value and the distance to additional services at alternative fuel station for the 75% smallest industrial parks in terms of net surface area, control variable(s): employment, firms, surface area, and year fixed effects (2016-2022).

Regression results

log_Added_Value	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Distance_ Truckparking	0	1.040e-06	0.00	.997	-2.030e-06	2.040e-06	
Distance_Carwash	4.270e-06	2.420e-06	1.76	.078	-5.000e-07	9.040e-06	*
Distance_ Truckwash	-5.600e-07	1.880e-06	-0.30	.767	-4.250e-06	3.130e-06	
Distance_Shop	-1.520e-06	1.980e-06	-0.77	.444	-5.410e-06	2.380e-06	
Distance_ Restaurant	1.620e-06	2.060e-06	0.79	.431	-2.420e-06	5.660e-06	
Distance_Toilet	-4.990e-06	2.660e-06	-1.88	.061	-.00001021	2.400e-07	*
Distance_Shower	-1.900e-07	8.400e-07	-0.22	.822	-1.830e-06	1.460e-06	
log_Employment	1.027	.028	37.13	0	.972	1.081	***
log_Firms	.054	.027	2.02	.044	.001	.108	**
log_Net_Surface_ Area (omitted)	0	.	.	.	.	.	
Constant	10.848	.1485	73.03	0	10.556	11.14	***

Mean dependent var	16.053	SD dependent var	1.373
R-squared	0.868	Number of obs	2382
F-test	199.218	Prob > F	0.000
Akaike crit. (AIC)	-2415.706	Bayesian crit. (BIC)	-2329.071

*** *p*<.01, ** *p*<.05, * *p*<.1

This model includes year fixed effects, but they are not displayed in this table for brevity.