

# The Impact of National-scale Railway Connections on the Accessibility of Local Labor Markets: The Case of the Lelylijn

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## Colophon

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## Abstract

The railway accessibility in the Northern Netherlands is notably lacking when compared to other Dutch regions. In the proposed construction of the Lelylijn railway project lies an opportunity to address these accessibility issues, potentially transforming the Northern Netherlands' transportation system and labor market. This purpose of this thesis was to examine the local impacts of the Lelylijn project specifically on labor market accessibility, with a focus on intra-regional commuting patterns and thereby contribute to the broader understanding of how transportation infrastructure can drive local economic growth and impact regional disparities. The theory underlying this thesis was based on classic economic theory on spatial clustering as well as previous empirical evidence of accessibility changes through railway infrastructure projects. By gravity model analysis and the calculation of accessibility scores for different urban cores and labor market sectors in the province of Fryslân, this study investigates changes in accessibility with the Lelylijn introduction. Within the study, the impacts between different sectors in the local labor market are distinguished. The findings of this research indicate that although accessibility improves for all the labor market sectors and urban cores that are taken into account, inequalities are identified, as accessibility for labor market sectors typically associated with lower levels of education show smaller increases in accessibility to local labor markets compared to labor market sectors typically associated with higher levels of education, which can also lead to relative increases in cost of living for low-income workers. In conclusion, the introduction of the Lelylijn may lead to unequal changes in accessibility across labor market sectors, yet improves accessibility for the investigated cores overall. Recommendations include decreasing potential inequalities by rent controls and affordable or social housing quotas for new developments as well as (partly) subsidizing travel costs for lower-income workers.

**Key words:** Railway Infrastructure, Labor Market, Accessibility, Inequalities, Mobility

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## List of abbreviations

<b>Abbreviation</b>	<b>Meaning</b>
SCBA	Social Cost-Benefit Analysis
HS1	High Speed 1
HSR	High-speed rail
LISA	Landelijk Informatiesysteem van Arbeidsplaatsen
BAG	Basisregistratie Adressen en Gebouwen

# 1. Introduction

## 1.1 Background

The railway accessibility of the Northern Netherlands is lacking, compared to other Dutch regions (Van Dijk, 2023). Differences in railway accessibility between the Northern Netherlands and other regions of the country highlight disparities in infrastructure provision. Although bus connections between cores in the north are in many cases available, the frequency and travel time are not comparable when considering potential train connections between the same cores (Gezamenlijke Analyse Deltaplan Voor Noordelijk Nederland (Deel B) Eindrapport, 2022). A railway line between Groningen and the Randstad - the densely populated western region of the Netherlands home to cities such as Amsterdam, Rotterdam, The Hague, and Utrecht- has the potential to solve some of the connectivity issues with a direct connection. The rail connection is often discussed from a national point of view with the focus on the improved connection between the Northern part of the Netherlands and the Randstad. Within this study however, the local impacts of the project are considered, through an analysis focused on intra-regional commuting.



Figure 1: Railway connections as part of the Deltaplan, including the Lelylijn (Gezamenlijke Analyse Deltaplan Voor Noordelijk Nederland (Deel B) Eindrapport, 2022)

As shown in figure 1, the aforementioned potential railway connection is called the Lelylijn, after former Dutch politician Cornelis Lely, who is responsible for a number of large infrastructure projects in the Netherlands (Omrop Fryslan, 2018). The Lelylijn is part of an overarching project called Deltaplan voor Noord Nederland (Delta Plan for the Northern Netherlands), which also involves a plan to improve the current railway system as well as another railway connection through the Eastern part of the country, called the Nedersaksenlijn (Gezamenlijke Analyse Deltaplan Voor Noordelijk Nederland (Deel B) Eindrapport, 2022a). The necessity and urgency for increased accessibility in the Northern Netherlands is therefore not solely present in the Lelylijn plan, but also in related projects.

### 1.1.1 Historical context

The Lelylijn project itself however is not entirely new either. With the first related plans coming into existence during the 1980's, the plan to build a high-speed rail line called the Zuiderzeelijn would have connected the northern provinces of Groningen, Friesland, and Drenthe to the rest of the country (RTV Drenthe, 2021). The goal of the project was to boost economic growth and enhance the transportation network in the Netherlands' Northern region, as well as decreasing congestion in the Northern wing of the Randstad (Raad voor de leefomgeving en infrastructuur, 2006). Improving connections between the northern provinces and the Randstad was therefore the main objective of the Zuiderzeelijn project. The improved transportation connections as a result of this project, were expected to enhance economic development in the Northern Netherlands. However, discussion and disagreement around the Zuiderzeelijn project played a large role. Critics worried about the environmental impact and cost-effectiveness of the Zuiderzeelijn. Adding to that, as the SCBA (Social Cost-Benefit Analysis) showed, enhancing economic growth in the Netherlands was best served by improving local connections (ECORYS Nederland BV, 2006). The project was therefore eventually canceled in 2007 by the Dutch government. Eventually, the funds that were reserved for the project, were distributed among the municipalities that were intended to be connected through the Zuiderzeelijn, and invested in enhancing the railway lines that were already there



(RTV Drenthe, 2021). With the final decision to cancel the project in 2007, the need for better railway connectivity in the North did not completely disappear, and the plan was eventually altered, renamed and restarted under the Lelylijn name.

## 1.2 Relevance and research questions

### 1.2.1 Regional impact

In recent years, the expansion of transportation infrastructure, particularly the potential development of the Lelylijn, has become a much-debated topic in regards to regional development strategies in the Netherlands. However, regarding the discussion surrounding the potential benefits of enhanced connectivity, questions relating to the equitable distribution of these advantages remain, particularly concerning access to the labor market on a regional scale. Most literature in the field of transportation and labor market studies tends to focus on these broad impacts that are investigated on a large scale. The emphasis is often on how railway infrastructure projects influence economic development in general and labor market outcomes across entire countries or between major regions. This national or interregional focus is crucial for understanding the overarching benefits and challenges associated with large-scale infrastructure investments. However, this focus could potentially overlook the impacts that such infrastructure projects can have at the intra-regional and local levels. While (intern)national studies do provide valuable insights into the general trends and benefits of railway investments, the localized effects that are equally important for understanding potential inequalities and for comprehensive policy-making may be overlooked or underestimated. For instance, the displacement of lower-skilled workers due to rising rents in accessible areas, as highlighted by Sobieralski (2021), is a local issue that requires targeted interventions.

### 1.2.2 Sectoral effects

Besides looking at the project with a regional lens, the focus on effects on regional economic performance as a whole requires critical assessment as well. This thesis argues for the

importance of distinguishing between different economic sectors when assessing the impact of infrastructure improvements. Theoretical and empirical studies suggest that some sectors are more sensitive to reductions in transport costs and improvements in connectivity than others (McCann, 2013). For instance, sectors reliant on high levels of labor mobility or those with significant economies of scale may benefit more from labor market integration enabled by infrastructure improvements. The distinction between sectors is of interest because the benefits of infrastructure investments may not be evenly distributed. Manufacturing sectors, for instance, may gain more from reduced transport costs and improved supply chain efficiency, while services sectors, especially those reliant on face-to-face interactions, may benefit more from enhanced labor market integration (McCannm 2013). This sectoral differentiation is crucial in understanding the full economic impact of projects like the Lelylijn and in tailoring policy responses to maximize these benefits. By distinguishing between sectors, this thesis aims to highlight the nuanced effects of infrastructure projects, with in this case, the Lelylijn.

### 1.2.3 Theoretical background

The Lelylijn project, much like other large infrastructure projects, can also be analyzed through the lens of New Economic Geography (NEG), which emphasizes the role of transport costs and spatial externalities in shaping economic outcomes (Vickerman, 2018). This theory is related to the idea that reducing transport costs through improved infrastructure can lead to greater economic integration, also by facilitating labor market integration (Messina, 2011). This integration, in turn, can enhance economic growth by allowing for more efficient allocation of resources, increased specialization, and economies of scale. Infrastructure projects like the Lelylijn are therefore not just about improving connectivity but also about enhancing labor market integration. By reducing travel times and costs, labor market catchment areas can grow, enabling firms to access a larger pool of workers and vice versa. This can lead to a better matching of skills to jobs, increased productivity, and, ultimately, economic growth. Empirical evidence from similar infrastructure projects globally supports these outcomes, showing

significant gains in regional economic performance following improvements in connectivity. As (Johansson et al., 2020) shows for example, improved transport infrastructure was found to enhance regional economic performance through better connectivity, integrating labor markets more effectively by improving access to job opportunities, and the alignment of skills with market demands across regions. What is not yet completely known however, is how these labor market dynamics interact in different sectors on a local labor market, with changes in infrastructure. Therefore, the focus in this thesis lies on distinguishing the labor market effects of large-scale railway infrastructure development for different labor market sectors. With a case study focusing on the impact of the Lelylijn on accessibility to local labor markets in the province of Fryslân, potential consequences can be identified and policy recommendations can be made. Besides this, societal relevance to this research may be more pronounced currently as the potential for labor market entry as a result of better accessibility to the labor market (Giuliano et al., 2011), may actually present opportunities for overcoming current labor market shortages (UWV, 2024).

#### 1.2.4 Academic relevance

Moreover, academically, this study contributes to the existing literature on transportation equity and regional development, providing insights into the dynamics of labor market accessibility disparities in the context of large railway infrastructure projects. The study adds to the existing body of literature by representing a focus on intra-regional effects on accessibility, in comparison to existing literature which is often focused on inter-regional and national impacts. By assessing accessibility impacts for different sectors in the local labor market, this study specifically examines how the Lelylijn affects accessibility to the labor market for different sectors and related education levels within the province of Fryslân, which increases theoretical understanding and empirical information in various areas.

### 1.2.5 Research questions

The primary objective of this research is to analyze the potential inequalities in accessibility to the labor market resulting from the implementation of the Lelylijn within the Northern Netherlands, and to discover the dynamics of labor market accessibility disparities in the context of regional infrastructure development.

The research therefore seeks to address the following overarching research question:

*How does the construction of national-scale railway connections impact accessibility to local labor markets?*

The sub-questions that are asked to answer the main research question are as follows:

1. How can accessibility to labor markets be conceptualized from a theoretical perspective?
2. What are the existing patterns of labor market accessibility for individuals with varying levels of education residing in the province of Fryslân prior to the implementation of the Lelylijn?
3. How does the introduction of the Lelylijn alter labor market accessibility for individuals with varying levels of education residing in the province of Fryslân?

## 2. Theoretical Framework

### 2.1 Economic impacts of railway infrastructure

#### 2.1.1. Theoretical perspectives on infrastructure and economic development

Regional economic growth is driven by several core factors. Regions grow when firms and workers within them can effectively share knowledge and innovate (McCann, 2013). Improved infrastructure, such as better transportation networks, facilitates the exchange of ideas by connecting people and firms across distances (Sebayang & Sebayang, 2020). This connectivity enables more frequent and diverse interactions, which foster innovation. When regions are well-connected, the flow of knowledge becomes more fluid, leading to the development of new technologies, products, and processes that drive regional economic performance. Improved infrastructure also reduces the costs of accessing resources, both physical and human (Crescenzi & Rodríguez-Pose, 2012). By lowering transport costs, infrastructure facilitates the pooling of resources across regions, enabling firms to benefit from agglomeration economies. These economies arise when firms cluster together, benefiting from shared suppliers, services, and a concentrated labor market. This clustering can lead to increased productivity and innovation, further driving regional growth. Economic geography theories furthermore emphasize the importance of transport costs in regional development. The concept of iceberg transport costs suggests that some portion of goods and services 'melts away' during transport, effectively increasing the cost of doing business over distances (Krugman, 1991). Infrastructure improvements that reduce these costs make it cheaper and more efficient for firms to trade, move goods, and access markets. This reduction in costs enhances firm performance and makes regions more competitive, fostering economic growth. Firms in well-connected regions are besides this, also more likely to benefit from the activities of neighboring firms, leading to a virtuous cycle of growth. Lastly, greater connectivity between regions through infrastructure development also generates positive externalities, such as increased investment and knowledge spillovers. Therefore, not only the clustering of firms is relevant,

but also the clustering of people (McCann, 2013). This was also given the name of the creative class, emphasizing how the composition of the workforce plays a role in economic outcomes (Florida, 2002). Summarizing, infrastructure plays a critical role in regional economic growth by enhancing connectivity, reducing costs, and fostering the conditions necessary for innovation and productivity, when looking at these process through the lens of economic geographical theory.

### 2.1.2 Empirical evidence

The role of infrastructure in economic development can also be found in practice. In Germany, Ahlfeldt & Feddersen (2018) found that when the German HSR line which runs from Cologne to Frankfurt was opened, the time needed to travel between these two cities dropped by over 55%. Similar to how the Lelylijn would be built, stops in smaller towns in between Cologne and Frankfurt are also located along this HSR line. Besides this, the average GDP per capita in Montabaur increased by 10% compared to neighboring municipalities six years after it opened. This outcome is the result of increased market accessibility and labor force pooling (Ahlfeldt & Feddersen, 2018). Adjacent districts saw improvements in their economies as well, but as distance from the stations increased, the effect dropped. (Ahlfeldt & Feddersen, 2018). The results of the study therefore indicate that improved transportation connections can benefit core regions at the expense of peripheral areas (Ahlfeldt & Feddersen, 2018).

As (Chen & Vickerman, 2017) describes as well, a correlation between transport infrastructure and economic performance can be identified. In Kent, UK, the High Speed 1 (HS1) railway was opened in 2009. In remote communities like Dover and Canterbury in Southwest England, the largest positive effect on travel time was noted, with new passengers making use of the railway line due to shortened travel time. Nonetheless, the unemployment rate did not decline, despite the significant increases in accessibility and passenger development; rather, it continued to be greater in Dover, Ashford, and Canterbury than in Dartford. Dartford, exhibiting a higher

proximity to economic centres and a larger labor market, this can point to unequal distributions of improved labor market access as well (Chen & Vickerman, 2017).

In the Italian context, however, it has been observed that the introduction of the high-speed rail (HSR) line predominantly benefited smaller, more peripheral areas. Di Matteo and Cardinale (2023) highlighted that these regions experienced significant economic and social advantages from the enhanced connectivity provided by the HSR. The HSR line reduced travel times to larger cities, making peripheral areas more attractive for commuters. Local economies experienced a positive effect as well, as local businesses were able to reach broader markets. This case shows the potential for railway infrastructure to enhance regional development, particularly in areas that are at a greater risk of being overlooked.

This is in line with (Jin et al., 2020), as they describe how the construction of high-speed railway lines in China are associated with economic growth. Unfortunately, the growth was mainly found in large cities and less so in other cores.

In another study, ten countries (Azerbaijan, Albania, Belarus, Bulgaria, China, Georgia, Mexico, Moldova, Serbia, and Turkey) were included in a study to analyze the economic effects of infrastructure investments on the national economy. In most cases, a positive relationship between the investment and economic growth was established. Important to note however is that in this case, not only railway infrastructure was taken into account (Ibrahimov et al., 2023). Government expenditure, on in this case infrastructural development, appears to indeed stimulate economic growth in a number of different ways. As (Aschauer, 1988) has described, a distinguishment is need to be made regarding different types of government spending. The study argues that public investment, particularly in infrastructure has a significantly larger impact on output than public consumption or military investment. Public investment is found to also complement private capital, increasing the productivity of private investments, and thus having a positive effect on the overall economy (Aschauer, 1988).

Furthermore, according to Heuermann and Schmieder (2019), the presence of road or rail infrastructure, including high-speed rail, has a positive impact on the quantity of interregional trade, resulting in economic advantages for peripheral regions.

Despite potential positive effects on well-being and economic growth, it is observed that the introduction of light rail systems tends to increase rents in areas with better accessibility, leading to the displacement of lower-skilled workers to more isolated neighborhoods. Consequently, this phenomenon results in a reduction in overall metropolitan employment equilibrium (Tyndall, 2021). The patterns observed resemble the impact of High-Speed Rail (HSR) services on land prices, with the trade price of land use showing a slight increase within a 5 km radius of the transportation hub in a smaller city, as noted by Rungskunroch et al. (2020).



## 2.2 Large-scale labor market effects

### 2.2.1 Labor market accessibility and infrastructure

Besides the economic impact of railway projects, there is currently a discourse defining economic impact in terms of general well-being of the population (Diener & Seligman, 2004). The level of accessibility to job opportunities, amenities and services within one's residential area significantly influences overall well-being, as noted by Leitmann (1999). In particular, inhabitants of low-density or rural regions often face obstacles in accessing essential spatial services, particularly in terms of public transportation availability (de Jong et al., 2011). This also relates to the accessibility of the labor market. In a study conducted in the US, it was found that in metropolitan areas with robust rail transport systems already in place, further investments in rail infrastructure were associated with positive employment outcomes. However, in automobile-centric areas, the impact of railway infrastructure on employment tends to be insignificant (Sobieralski, 2021). A larger dependency on cars for commuting compared to other regions in the Netherlands can also be observed in the province of Fryslân (Kennisinstituut voor Mobiliteitsbeleid, 2022). Sobieralski suggests that such areas may benefit more from investments in highway infrastructure. However, car dependency can potentially decrease should the threshold to make use of public transport be lowered by the construction by the Lelylijn for example. Similarly, Heuermann & Schmieder (2019) examined the impact of high-speed rail expansion in Germany on worker mobility and commuting decisions. They found that reductions in travel time between regions lead to an increase in the number of commuters, with workers choosing to change jobs to smaller cities while still residing in larger ones. This modal shift toward rail transportation enhances labor market accessibility and promotes economic integration between regions. Johansson et al. (2020) highlight the role of railway investments in improving accessibility to jobs and expanding labor markets. They argue that by linking regions and increasing the size of labor markets, railway infrastructure enhances the matching between individuals and jobs, leading to increased

productivity. Furthermore, Wang et al. (2023) focus on the impact of high-speed rail (HSR) on the labor market in South China. Their study reveals that HSR significantly enhances labor quantity by reducing travel time, transportation costs, and promoting labor mobility across regions. Although HSR has an insignificant effect on labor quality, its opening improved regional accessibility, attracted investment, and created more job opportunities, thereby increasing overall labor quantity and contributing to regional development.

### 2.2.2 Invariants in travel behavior

Important to note however, is that certain invariants in travel behavior exist, despite changes in travel time due to expanded infrastructural networks. Invariants in travel behavior refer to consistent patterns or characteristics observed across different individuals, groups, or contexts in how people make travel-related decisions and choices. These invariants relate to fundamental aspects of human behavior and preferences in transportation, which remain relatively stable over time and across various circumstances.

A common phenomenon relates to general laws of constant travel time, explaining how the preferred commuting time for the average person remains constant over time and space (Marchetti, 1994). Studies have shown that individuals tend to allocate a relatively consistent amount of time to travel each day, known as the travel time budget. This invariant suggests that people are willing to spend a certain portion of their time on travel activities, regardless of changes in transportation options or accessibility. With improved connectivity and faster railway connections, commuters will generally still prefer the same travel time. Similar to Marchetti, a concept often used in Dutch concept is known as the BREVER wet (Wet Behoud REistijd en VERplaatsingen or Law of constant travel time and movement). This concept describes how due to the invariants in commuting time in combination with continuous technological developments allowing people to travel further in the same amount of time, the distance travelled by persons increases, rather than the overall travel time decreasing (Hupkes, 1977). Through faster connections however, the distance radius in which the commuter can potentially operate does increase, which can lead to a larger job offer potential. Adding to that,

recent developments following the COVID-19 pandemic however, also appear to have an impact on travel time preferences since remote work has since the lock-down period remained present in many places of work (Reiffer et al., 2023). In companies and sectors where working from home a number of hours per week is possible, one might increase the preferred travel distance from one's home to the place of work, as the distance travelled is only to be covered once or twice a week. As working remotely is not an option for many, particularly low-income sectors, this development does not apply to the entirety of the labor force. Of interest therefore is to investigate the accessibility effects on the local labor market for various labor market sectors associated with both a lower and higher educated workforce.

## 2.3 Regional labor market effects

In this section, the critical role of context in shaping accessibility dynamics and labor market impacts is explained. Contextual factors that influence individuals' access to job opportunities and their ability to benefit from railway projects are explored.

### 2.3.1 Education level

Contextual factors such as education level play an important role in the access to employment opportunities. When examining the role of education level in job accessibility, it's crucial to consider how different sectors of the economy interact with spatial dynamics and how they benefit from increased connectivity. A concept related to this is how knowledge-intensive industries, which rely heavily on innovation and the exchange of ideas, would benefit more from improved knowledge transfers facilitated by better connectivity. These industries thrive on collaboration and access to a skilled workforce and are therefore likely to benefit from improved job accessibility across a broader geographic area (Isaksen & Onsager, 2010). Similarly, sectors with higher productivity, meaning more income per hour worked is generated, are more likely to experience positive externalities across a larger area. These sectors often require specialized knowledge and skills, making access to a larger, more diverse labor pool helpful (Döring & Schnellenbach, 2006). The diffusion of knowledge and the pooling of specialized labor across regions can lead to increased productivity and innovation, benefiting the broader economy. This effect can also benefit sectors of the economy typically associated with lower productivity, or with a workforce with typically lower education levels. However it follows from the theory mentioned above that the impact of increased accessibility on the different types of industries might differ. It is possible therefore that not all labor market sectors (and therefore people of different education levels) are affected or benefit equally from large infrastructural investment, such as in the case of the Lelylijn. By acknowledging that the benefits of job accessibility and connectivity vary depending on the type of sector and whether it is reliant on high-skilled labor or productivity levels, potential inequalities can be identified.

This understanding emphasizes the importance of considering sectoral differences when evaluating the potential impacts of projects like the Lelylijn.

### 2.3.2 Residential context

Besides education level, the place of residence play a role in the context of labor market accessibility. In cities, larger populations and economic agglomeration effects may exacerbate inequalities, making it challenging for individuals, especially from rural areas, to access employment opportunities. This is dependent on the access to transportation possibilities an individual might have. However, for residents of more rural areas or smaller urban cores, commuting distances are often found to be larger than for residents of larger cities (Kures & Deller, 2023). Depending on the public transportation network, access to the labor market can be more difficult for low-skilled workers when they reside outside of urban centers (Haddad & Barufi, 2017). This is in line with (Stanef, 2014) in which is described how the composition of the labor market differs across urban and rural areas, where a higher level of employment in industry and services can be identified in urban areas compared to more rural ones.

Important to consider as well is the possibility of better accessibility increasing competition between cores along the railway, rather than increasing opportunities overall (Chen & Vickerman, 2017). As shown in Italian context however, mainly smaller more peripheral areas benefited from the introduction of a HSR line (Di Matteo & Cardinale, 2023).

Again in the case of exploring the local level effects, the context is of importance. In the specific instance of this case study, the study area consisting of larger and smaller cores in the province of Fryslân, can be described as an area with large car-dependency, as mentioned before (Kennisinstituut voor Mobiliteitsbeleid, 2022). Railway infrastructure may therefore potentially have a reduced impact and lower effectiveness in creating employment within regions dominated by automobile-centric environments (Sobieralski, 2021). Since the place of residence plays an important role in commuting behavior and modal choices (Ko et al., 2019), this factor is taken into account in the study through gravity model analysis, as elaborated on in section 3.

## 2.4 Conceptual Model

The conceptual model (see figure 2) serves as a visual representation of the theory which was highlighted above, guiding this thesis. Within the theoretical framework the impact of large-scale infrastructure investments on labor market accessibility was discussed. The conceptual model therefore shows this relationship, as well as the impact thereof on the access to the labor market on the local level. The model explicitly incorporates educational levels as a factor, reflecting the assumption that workers with different qualifications will be affected differently by changes in accessibility. This aspect of the model is grounded in the theory that higher educational levels typically correlate with greater mobility, as explained earlier. Consequently, the model suggests that the impact of the Lelylijn on labor market access may not be the same across all education levels, but rather, it might be more pronounced for those with higher qualifications, who are more likely to work in industries that benefit from increased connectivity. The influence of the different labor market sectors on this relationship is also visible in the model, as the type of industry might affect how this relationship works exactly (Döring & Schnellenbach, 2006). As explained further in section 3, assumptions are made regarding the labor market sectors and the corresponding educational levels, in order to investigate how the workforce of different educational levels are affected by the changes in accessibility. This relationship is also shown in the conceptual model below. The model also implies that labor market accessibility is not static but is influenced by infrastructural developments such as the Lelylijn. As accessibility improves, the spatial reach of labor markets expands, potentially altering the dynamics of local economies. This dynamic aspect of the model aligns with the broader theoretical framework that links infrastructure improvements to economic growth through mechanisms such as labor market pooling, knowledge spillovers, and reduced transport costs.

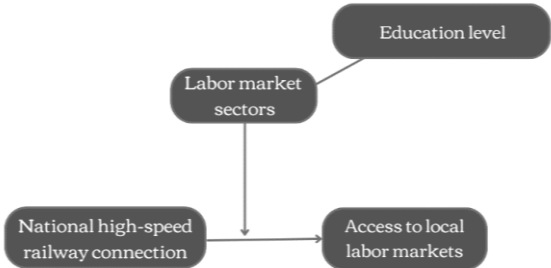


Figure 2: Conceptual model (source: author)

## 3. Methodology

### 3.1 Research Design

The research design for this thesis aims to systematically address the main research question: "How does the construction of national scale railway connections impact accessibility to local labor markets?" This overarching question is explored through three sub-questions. The study is focused on combining a literature review and a quantitative analysis, to provide a comprehensive understanding of the impacts of the Lelylijn. The first sub-question 'How can accessibility be conceptualized from a theoretical perspective?' is addressed through a literature review. By reviewing existing theories and empirical studies, the research identifies key factors that influence accessibility and investigates how these factors interact in the context of transportation infrastructure. The review is used as a framework for understanding the empirical data and interpreting the results in a broader theoretical context. The second sub-question, namely 'What are the existing patterns of labor market accessibility for individuals with varying levels of education residing in the province of Fryslân prior to the implementation of the Lelylijn?', and the third sub-question 'How does the introduction of the Lelylijn alter labor market accessibility for individuals with varying levels of education residing in the province of Fryslân?' are both answered through gravity model analysis. This analysis is based on identifying the differences in accessibility scores calculated with current and future travel times, for six urban cores and four labor market sectors in the province of Fryslân. This approach is elaborated upon in section 3.3.

### 3.2 Case study approach and selection

A single in-depth case study of the Lelylijn was chosen to address the larger research question. The Lelylijn, being in an early project phase, offers a unique opportunity to analyze potential impacts before significant investments and construction occur. This allows for proactive policy recommendations and planning adjustments. Additionally, focusing on this single case provides a detailed understanding of the specific regional and local context, which is essential for assessing local impacts and making relevant policy suggestions. By concentrating on the early-stage Lelylijn case, the study aims to anticipate potential challenges and opportunities for future planning and ensuring that the benefits of high-speed rail are distributed equitably across the Northern Netherlands. This approach makes it possible therefore to assess relationships between transportation infrastructure and labor market accessibility, possibly also with relevance to similar projects in other contexts.

Besides the early stage of the project, the proximity of the local context for the researcher in combination with an internship at the municipality of Leeuwarden also played a role. As a result it was of interest to focus on the Frisian province specifically. Besides this, the bundling route (Bundelingsalternatief), which is often considered as the route with the highest realization potential, includes multiple stops along the way throughout the province. This indicates that local consequences must be considered, as having several regional stops suggests that accessibility improvements have a potential impact on the local labor market. This makes the project an interesting case to answer questions considering local labor market outcomes for national-scale railway projects.



## 3.3 Data collection and analysis

### 3.3.1 Gravity modelling

The gravity model in accessibility analysis is based on the concept that the interaction between two locations is directly proportional to the attractiveness of the destination (Joseph & Kuby, 2011). This can among others, be expressed in the number of jobs or services. In this analysis, the employment capacity of different labor market sectors for each of the urban cores that are taken into account, are used. The second aspect of the model is the concept that the interaction between two places is inversely proportional to the cost of travel, which can be expressed in distance, travel time or monetary costs (Joseph & Kuby, 2011). In this analysis the cost is expressed in minutes of travel time. This concept is related to Newton's law of gravity, where the gravitational force between two objects is proportional to their masses and inversely proportional to the square of the distance between them. This model is used to base the calculation of an accessibility score on. The accessibility score for a given origin city is calculated as the sum of the employment capacities of all other cities, weighted by the inverse of their travel cost raised to the power of the decay parameter, as shown in the formula below. A higher accessibility score for a city means that it has better access to jobs considering the travel times to other cities. This could mean that there is either a large number of jobs within commuting distance or shorter travel times to those jobs. This model can therefore be used to estimate the effect on accessibility to labor market sectors with both the current railway infrastructure and with the Lelylijn added to the network. The accessibility score for a city is calculated by getting the sum of the accessibility score from a city to each of the other cores taken into account in the analysis. For each city, the employment capacity is then divided by the travel time raised to the power of the decay parameter.

$$A_i = \sum_j \frac{E_j}{(t_{ij})^\beta}$$

Figure 3: Accessibility model formula

$A_i$  is the accessibility score for origin city  $i$ .

$E_j$  is the employment capacity (number of jobs) in destination city  $j$ .

$t_{ij}$  is the travel time between city  $i$  and city  $j$ .

$\beta$  is the decay parameter.

The decay parameter controls how quickly the influence of a destination decreases with increasing travel time. A higher beta means that people are less willing to travel longer distances, so closer destinations contribute much more to the accessibility score than distant ones. The quality of the distance decay parameters that are computed for the spatial interaction analysis impacts to a large extent the quality and the outcome of most analyses pertaining to flows of people to and from jobs, services, or similar activities (Östh et al., 2016). This means that estimates of accessibility to amenities, including in this case employment opportunities, may differ greatly depending on factors like spatial clustering or relative proximity to the subject of the study as well as variations in the way the friction of distance is modeled in the evaluations. In order to estimate the parameter accurately, it was estimated for different education levels and was based on a linear regression model applied to the data. This is in line with related literature as often differences in education level differ the willingness to commute as well as the distance often observed to be commuted (Poudel & Singleton, 2022). Therefore, the expectation is that with increasing distance, the interaction decreases faster when considering lower education levels and related job opportunities (Besser et al., 2008). A higher parameter is therefore usually expected in the lower education level estimate, whereas a lower parameter is expected for higher education level and related jobs (Cheng & Bertolini, 2013). The decay parameter was derived by making use of the CBS dataset containing information

about commuting behavior in the Netherlands (CBS, 2024). From this dataset, the data from the Northern Netherlands was selected in order to reflect actual travel behavior of the population to be studied, since the data is necessary to make inferences about the accessibility between the selected cores in the province of Fryslân. As mentioned before, with this data it was possible to distinguish between education levels. The minutes as well as kilometers travelled each day are taken into account in the estimation for the parameters. These variables were log-transformed and a linear regression was fitted to the log-transformed data. The decay parameter was separately estimated for low and high education levels by selecting the data based on education levels and applying the above regression model to each group. Therefore, the decay parameter that best described how the kilometres and time travelled decreased with increasing distance for the different education levels.

<b>Education level</b>	<b>Estimated parameter</b>
<b>Lower</b>	0.923
<b>Higher</b>	0.773

Table 1: Estimated decay parameters

### 3.3.2 Secondary data selection

In this analysis, secondary data was used to assess the impact of the Lelylijn railway project on labor market accessibility in the Northern Netherlands. The primary dataset used in this study is the LISA (Landelijk Informatiesysteem van Arbeidsplaatsen) dataset, which contains detailed information on over 1.8 million company establishments across the Netherlands. This dataset provides data points for each establishment, including the establishment name, address, activity code (SBI 2008), number of full-time and part-time employees (disaggregated by gender), phone number, municipality code, and BAG (Basisregistratie Adressen en Gebouwen) data, which includes XY coordinates. From this dataset, specific variables were selected for analysis based on their relevance to the research objectives, as shown in the figure below.

<b>Variable name</b>	<b>Translation</b>	<b>Data</b>
Vestigingsadres	Establishment address	Precise location of establishments
Activiteitencode (SBI)	Activity code	Categorizations of establishments by sector
Personeel	Number of employees	Employees within establishments, indicating size
Basisregistratie Adressen en Gebouwen	Basic Registration of Addresses and Buildings	Coordinates of establishments allowing for spatial analysis

Table 2: Selected variables within the LISA dataset

These variables are included in the analysis as they provide the necessary spatial and categorical information to assess how the Lelylijn project could alter labor market accessibility. The activity code allows for sector-specific analysis. The SBI codes relating to the specific sectors in the study area, are then used to make inferences on the education level of the sector-specific labor force. For the analysis to say something about the differences in accessibility changes for people with different education levels, four sectors that are typically associated with either lower or higher education levels are selected from the LISA dataset. The two sectors that are commonly associated with a high number of employees with lower education levels are Wellness and other services and Sale and repair of motor vehicles, motorcycles and trailers (UWV, 2017). The two sectors that are more commonly associated with a high number of employees with higher education are Legal services, accounting, tax consultancy, administration and Holding companies (not financial) (CBS, 2022). The sectors were chosen based on the education level of the workforce as well as the prevalence of the companies in the six cores that were included in the analysis, to ensure that a sufficient number of cases, which is also sufficiently comparable across sectors, is present in the data and to avoid bias. The cases in these sectors were selected from the LISA dataset in R and loaded into ArcGIS in order to perform a selection of the jobs based on the geographical boundaries of the six cores, for each sector.

### 3.3.3 Core selection and unimodal focus

In order to perform this analysis, six centers within the province of Fryslân as both places of employment and population were selected for accessibility analysis. Urban cores such as the six centers that are selected in the analysis, often represent the main centers of economic activity within a region, where jobs, services, and population density are concentrated. By focusing on these cores, the analysis can capture the most significant interactions and flows of people and goods, which are the primary drivers of regional economic dynamics (Joseph & Kuby, 2011). Gravity models traditionally rely on aggregate measures of mass, such as population size or employment capacity. Urban cores provide a natural aggregation of these measures, reflecting the economic and social interactions that are most relevant to the study (Piovani et al., 2018). Focusing on the accessibility between cores has a practical advantage as well. From a policy-making perspective, the focus often lies on urban cores because these areas are the primary targets for infrastructure development and economic policy. This type of analysis therefore can therefore inform targeted interventions in areas that are most likely (or not likely) to benefit from the potentially improved accessibility.

For the analysis, six urban cores within the province of Fryslân were selected: Leeuwarden, Drachten, Heerenveen, Sneek, Lemmer and Joure. These places were selected based on certain criteria. The centers were selected partly based on their size and significance within the region, ensuring that the analysis would capture the primary hubs of employment and population within Fryslân. The first four cores were chosen based on this criterium as they are organized in a network structure, called the Fries Stedelijk Netwerk (or F4) consisting of the four largest urban cores in the province (Gemeente Leeuwarden, 2024). By focusing on these key urban centers, the study is aimed at assessing the impact of changes in accessibility on the most relevant areas of economic activity. Secondly, the cores were selected due to their existing connection to the current railway infrastructure network. This connection is crucial because the accessibility analysis hinges on understanding how enhancements or changes to transportation infrastructure, such as the potential integration into the Lelylijn network, would impact these areas. By choosing centers already linked to the railway, the analysis can better

model the potential shifts in accessibility brought about by the new infrastructure. Lemmer and Joure are of smaller size and are not part of this network, however they are part of the potential railway in the form of the Lelylijn sprinter, which does decrease travel times towards the other cores. Therefore they are taken into account for the analysis as the economic interaction has the potential to change as a result of better connectivity.

The argument could be made that besides Joure and Lemmer, more cores within the province could be considered for the interaction analysis, as even though they would not be connected to the Lelylijn directly, travel times to other places can still change significantly. However, compared to larger urban cores, smaller and more rural communities often have less public transportation alternatives. Because there is a lack of convenient or frequent public transportation in some locations, inhabitants may rely more heavily on their cars (Kennisinstituut voor Mobiliteitsbeleid, 2022). The car could be required to be used to even access a train station. For this analysis however, the focus lies on unimodal travel. Excluding multi-modal travel from the analysis is a deliberate choice based on several key considerations. Research suggests that once people opt to use a car for part of their journey, they tend to continue using it for the entire trip, rather than switching to another mode of transport (Schneider et al., 2020). This is particularly relevant for the projected route of the Lelylijn, which runs along existing motorways. Since these routes can already be efficiently covered by car, incorporating multi-modal travel would introduce unnecessary complexity into the model. Including multi-modal options would also require additional assumptions, such as transfer times between modes and variations in travel speeds across different modes (Oostendorp et al., 2019). By focusing solely on single-mode travel, the analysis allows for a more accurate assessment of the effects of the Lelylijn on regional accessibility. This approach ensures that the results are based on realistic travel patterns, without the added uncertainty that multi-modal assumptions would introduce.

### 3.3.4 The bundling route

As mentioned before, the current plan involves a number of different routes that could potentially be realized (Gezamenlijke Analyse Deltaplan Voor Noordelijk Nederland (Deel B) Eindrapport, 2022). Each of the routes have their own (technical, spatial and socio-economic) challenges and benefits (Gezamenlijke Analyse Deltaplan Voor Noordelijk Nederland (Deel B) Eindrapport, 2022). Currently, three different routes are still considered, namely the *Bundelingsalternatief* (bundling route), a route with a more southern orientation (*Zuidelijk alternatief*) via Emmeloord and Assen, and the *Afsluitdijk* route. The *Bundelingsalternatief* route proposes a railway line that follows the existing A6, A7, and A32 highways. This route therefore connects to the existing transportation corridors in order to minimize negative external effects of construction and usage the railway line. Starting from Lelystad, the track would run parallel to the A6 through Flevoland, and the A7 towards Heerenveen and finally align with the A32 to reach Groningen. The second potential alternative, the *Zuidelijk alternatief* route is a route with a more southern orientation that would include stops at Emmeloord and Assen. This route would start in Lelystad, pass through Emmeloord in the Noordoostpolder, and then continue northwards towards Assen before reaching Groningen. The third option, the *Afsluitdijk alternative*, involves a route across the Afsluitdijk, the major causeway that connects the provinces of North Holland and Fryslân, as part of the railway route. This route would begin in Lelystad, follow the Afsluitdijk to connect North Holland with Fryslân, and then continue through Leeuwarden to Groningen. The most often described option for the Lelylijn, is the *Bundelingsalternatief* (bundling route) that connects Groningen to Lelystad with a number of stops along the way, including a route from Heerenveen to Leeuwarden, as shown in the figure above.

In order to make the analysis possible the choice was made therefore, to focus on the bundling route (*bundelingsalternatief*). For this route, there is both a proposed intercity route (starting in Groningen, through Drachten, Heerenveen, Emmeloord and Lelystad, as shown in figure 4) as well as a sprinter route (besides the aforementioned stations, containing also stops at Joure

and Lemmer). In order to make inferences about changes in accessibility for a larger part of the province, the sprinter route was selected for further analysis.



Figure 4: Visualization of the bundling route



### 3.3.5 Current and future travel times

The travel time between the stops on the sprinter route for the Lelylijn are based on the calculations made by the project organization, and shown in table 4 below (Studio Bereikbaar, 2024).

<b>Station A</b>	<b>Station B</b>	<b>Current travel time</b>	<b>Lelylijn travel time</b>
Drachten	Leeuwarden	42	25
Drachten	Heerenveen	27	8
Drachten	Sneek	65	27
Heerenveen	Leeuwarden	17	17
Leeuwarden	Sneek	19	19
Heerenveen	Sneek	46	31
Lemmer	Drachten	63	15
Lemmer	Heerenveen	26	7
Lemmer	Sneek	44	32
Lemmer	Leeuwarden	48	30
Joure	Leeuwarden	47	21
Joure	Heerenveen	18	3
Joure	Drachten	60	11
Joure	Lemmer	24	4
Joure	Sneek	32	32

Table 3: Current public transport travel times and public transport times after Lelylijn construction

For the sprinter travel times, assumptions are made regarding the travel times to and between the Leek, Joure and Lemmer stops based on the distance between the locations of the proposed stops and the intended speed of 200 km/h for the Lelylijn, as well as on the travel times between other stops along the sprinter route which were already calculated by the project organization. Travel times were then compared with current travel times provided by travel planning tool 9292. Current and new travel times are shown in table 3.

### 3.3.6 Ethical considerations

This thesis primarily employs secondary data for its analysis. As a result, ethical considerations typically associated with primary data collection are of smaller importance. The primary dataset used, namely the LISA dataset offers both anonymized information and publicly available data, ensuring the privacy of individuals and organizations. For the LISA dataset, although not open source, a selection was performed to include only relevant information such as establishment addresses, activity codes, number of employees, and XY coordinates. Adding to this, the dataset does not contain sensitive information such as company names or personal details, ensuring confidentiality and compliance with data protection regulations. By utilizing these datasets, the research avoids potential ethical issues related to privacy and consent, which are common in studies involving primary data collection. The analysis focuses on aggregated data, thereby eliminating risks of identifying individuals or specific businesses.

This research was conducted in conjunction with an internship, during which the researcher attended various meetings related to the research topic and engaged with stakeholders. While this experience provided valuable practical insights and contextual understanding, it also posed potential risks of researcher bias. The close interaction with project stakeholders and exposure to their perspectives might inadvertently influence the researcher's analysis and interpretations. To mitigate this risk, reliable and transparent data sources were used, such as the LISA dataset in order to minimize the influence of subjective interpretations.

## 4. Findings

As previously described, the quantitative analysis that is performed for this study is aimed at assessing accessibility changes in the labor market of Fryslân after the introduction of the Lelylijn. This was done in order to answer the research questions ‘What are the existing patterns of labor market accessibility for individuals with varying levels of education residing in the province of Fryslân prior to the implementation of the Lelylijn?’ as well as ‘How does the introduction of the Lelylijn alter labor market accessibility for individuals with varying levels of education residing in the province of Fryslân?’. The analysis led to the results in the form of accessibility scores for each of the cores that were taken into account in the analysis, both in the current situation as well as in the situation where the Lelylijn has been constructed. Below, table 5, 6 and 7 show the results.

### 4.1 Sectoral composition

Looking at the distribution of jobs across different sectors, Leeuwarden is the dominant hub for wellness and other services, hosting more than twice the number of jobs compared to Drachten, the second-largest center in this sector. This concentration suggests that Leeuwarden benefits from robust infrastructure and connectivity, attracting businesses that require accessibility and a large customer base. Drachten also maintains a significant presence, indicating a strong local demand and supportive economic environment. Smaller cores like Sneek, Heerenveen, Joure, and Lemmer have fewer jobs, reflecting their more limited economic activity in this sector. The sale and repair sector is nearly equally distributed between Drachten and Leeuwarden, with each hosting around 190 jobs. This balance indicates that both urban cores are well-equipped to support automotive businesses, likely due to their size and connectivity. Heerenveen follows with a moderate number of jobs, while Sneek, Joure, and Lemmer have fewer positions, suggesting limited automotive activity. The strong presence in Drachten and Leeuwarden highlights the importance of these cores as key economic centers capable of sustaining diverse industries. Leeuwarden leads in professional services, with 219

jobs, significantly outpacing other urban cores. This dominance highlights Leeuwarden’s role as the primary administrative and corporate hub in Fryslân, likely supported by existing infrastructure and a concentration of high-skilled labor. Heerenveen and Drachten also show substantial numbers. In contrast, smaller cores like Sneek, Joure, and Lemmer have fewer jobs, indicating a more limited presence of high-skilled sectors in these areas. Leeuwarden dominates the holding companies sector with 522 jobs, far surpassing all other urban cores. This indicates a significant concentration of corporate headquarters and administrative functions in Leeuwarden. Drachten, Heerenveen, and Sneek also have notable numbers of holding companies, though substantially lower than Leeuwarden. Joure and Lemmer have the fewest jobs in this sector, reflecting their smaller size and limited corporate presence.

Across all four sectors, Leeuwarden consistently exhibits the highest number of jobs, affirming its status as the central economic hub of Fryslân. Drachten follows as a significant center, particularly in the wellness services and automotive sectors. Heerenveen and Sneek serve as important secondary hubs with a diverse economic base, while Joure and Lemmer remain smaller cores with more limited economic activities. The concentration of jobs in Leeuwarden and Drachten across multiple sectors highlights the critical role these urban cores play in regional economic activity.

	<b>Drachten</b>	<b>Leeuwarden</b>	<b>Heerenveen</b>	<b>Sneek</b>	<b>Lemmer</b>	<b>Joure</b>
<b>96: Wellness and other services</b>	189	412	138	153	65	68
<b>45: Sale and repair of motor vehicles, motorcycles and trailers</b>	190	194	115	74	34	46
<b>69: Legal services, accounting, tax consultancy, administration</b>	109	219	121	93	32	41

<b>70: Holding companies (not financial)</b>	197	522	244	235	72	80
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Table 4: Job quantity per sector in each of the cores

## 4.2 Accessibility outcomes per core

From table 5 through 7, the results indicate that the Lelylijn has a positive impact on job accessibility across all six urban cores, as reflected in the increase in accessibility scores across all labor market sectors. However, the magnitude of these increases varies significantly between the cores. This shows the varying impact of the new infrastructure. The most notable increases in accessibility are observed in Lemmer and Joure, with accessibility scores increasing substantially across all sectors. This is expected given that these towns are currently not served by the existing railway network, meaning that the introduction of the Lelylijn offers a new, direct mode of transportation that significantly reduces travel times to other urban cores. The reduction in travel times enhances interaction and connectivity, leading to substantial improvements in accessibility. For instance, Lemmer sees a notable increase in accessibility for Holding companies (non-financial), from 166.0 to 250.6, and for Legal services, from 75.1 to 177.0, which is more than a doubling in the latter sector.

More moderate increases are found in Drachten, Heerenveen and Sneek. These cores also experience significant improvements in accessibility, but to a lesser extent compared to Lemmer and Joure. For example, in Heerenveen, the accessibility score for Holding companies increases from 368.3 to 423.2, showing a significant but not transformational change.

The smallest increase in accessibility is observed in Leeuwarden. While there is still an improvement, the change is relatively modest compared to the other cores. The high concentration of jobs in Leeuwarden means that, even before the Lelylijn, the city already had strong internal job accessibility. The increase in jobs accessible via the new railway line might be less pronounced in percentage terms because Leeuwarden already provides a robust local job market. Therefore, while the travel times to other cores are reduced, the relative impact on

accessibility scores is dampened because the city is already well-served in terms of job opportunities. For example, the accessibility score for Legal services in Leeuwarden increases from 259.1 to 265.2, a modest gain compared to the increases seen in other cores like Lemmer or Joure.

Across the various sectors, the increase in accessibility scores is more pronounced for sectors typically associated with higher education levels. For example, the Legal services and Holding companies sectors see some of the largest absolute increases in accessibility, particularly in Lemmer and Joure, where infrastructure improvements have the most significant impact. This suggests that these sectors, which often require higher educational qualifications, may disproportionately benefit from the new Lelylijn in terms of enhanced access to job opportunities. On the other hand, sectors like Wellness and other services and Sale and repair of motor vehicles see smaller increases, particularly in already well-connected cores like Leeuwarden and Heerenveen.

In summary, based on this analysis, the introduction of the Lelylijn will likely lead to a more integrated regional labor market, with the most significant gains in accessibility observed in areas that are currently under-served by existing railway infrastructure. While all cores benefit, the impact is uneven, with newly connected towns like Lemmer and Joure experiencing the largest increases. This has important implications for regional development and the potential for economic growth, particularly in higher-educated sectors that stand to gain the most from improved connectivity.

	<b>96: Wellness and other services</b>	<b>45: Sale and repair of motor vehicles, motorcycles and trailers</b>	<b>69: Legal services, accounting, tax consultancy, administration</b>	<b>70: Holding companies (not financial)</b>
<b>Drachten</b>	216.6	206.0	145.5	279.1
<b>Leeuwarden</b>	443.0	216.4	259.1	607.3
<b>Heerenveen</b>	192.1	146.7	176.4	368.3
<b>Sneek</b>	195.5	99.0	141.1	341.0
<b>Lemmer</b>	97.7	55.2	75.1	166.0
<b>Joure</b>	105.2	69.8	88.5	184.8
<b>Sum</b>	1,250.1	793.1	885.7	1,946.5

Table 5: Current accessibility scores for the four investigated labor market sectors

	<b>96: Wellness and other services</b>	<b>45: Sale and repair of motor vehicles, motorcycles and trailers</b>	<b>69: Legal services, accounting, tax consultancy, administration</b>	<b>70: Holding companies (not financial)</b>
<b>Drachten</b>	250.3	227.7	178.2	449.9
<b>Leeuwarden</b>	449.8	222.0	265.2	619.0
<b>Heerenveen</b>	231.0	177.4	204.6	423.2
<b>Sneek</b>	202.0	105.1	147.5	352.9
<b>Lemmer</b>	143.1	90.2	177.0	250.6
<b>Joure</b>	175.2	122.5	149.6	310.7
<b>Sum</b>	1,451.4	944.9	1,122.0	2,406.4

Table 6: Accessibility scores for the four investigated labor market sectors after Lelylijn introduction

### Relative change

	<b>96: Wellness and other services</b>	<b>45: Sale and repair of motor vehicles, motorcycles and trailers</b>	<b>69: Legal services, accounting, tax consultancy, administration</b>	<b>70: Holding companies (not financial)</b>	<b>Sum</b>
<b>Drachten</b>	15.6	10.5	22.5	61.2	109.8
<b>Leeuwarden</b>	1.5	2.6	2.4	1.9	8.4
<b>Heerenveen</b>	20.3	20.9	16.0	14.9	72.1
<b>Sneek</b>	3.3	6.1	4.5	3.5	17.5
<b>Lemmer</b>	46.5	63.3	135.6	51.0	296.3
<b>Joure</b>	66.5	75.4	69.0	68.1	279.0
<b>Sum</b>	153.6	179.0	249.9	200.7	85.5

Table 7: Relative changes in accessibility scores across labor market sectors

### 4.3 Accessibility outcomes per sector

The analysis of accessibility score changes across different labor market sectors reveals significant disparities, particularly when these sectors are viewed through the lens of education level. The sectors of Legal services, accounting, tax consultancy, and administration and Non-financial holding companies experience the most substantial increases in accessibility, with gains of 27% and 24%, respectively. These sectors are typically associated with a higher-educated workforce, which suggests that the introduction of the Lelylijn will likely have a more pronounced positive impact on individuals with higher educational qualifications. In contrast, sectors more commonly linked to lower education levels, such as Wellness and other services and Sale and repair of motor vehicles, motorcycles, and trailers, see smaller increases in accessibility, at 16% and 19%, respectively. This difference points to a potential inequality in the benefits conferred by the new railway line. As accessibility improves more significantly for sectors that require higher education, the Lelylijn may enhance job opportunities more for higher-educated individuals than for those with lower educational qualifications. This variation in accessibility score increases highlights the differential impact of infrastructure improvements on various segments of the labor market. Legal and administrative sectors, which often require advanced degrees and specialized skills, stand to gain the most, potentially leading to greater economic opportunities for professionals in these fields. In contrast, sectors with a lower educational threshold may not experience the same level of benefit, which could reinforce existing socio-economic disparities. Additionally, the findings imply that the sectors with higher educational requirements may experience enhanced externalities due to improved connectivity. For instance, knowledge-intensive sectors are more likely to benefit from the ease of knowledge transfer and collaboration across regions, which is facilitated by improved transport infrastructure. This could lead to increased innovation and productivity in these sectors, further widening the gap between higher and lower-educated segments of the workforce. However, besides the differences in accessibility increase for the different labor market sectors, all sectors do see an increase in accessibility, pointing out that the introduction



of the Lelylijn does contribute to enhancing accessibility to local labor markets for all sectors that were investigated.

## 5. Discussion

The analysis shows that the Lelylijn can significantly enhance accessibility across the province of Fryslân, with the most substantial benefits observed in areas currently lacking railway connections. This outcome aligns with findings in transport geography, which suggest that cities directly connected by new infrastructure tend to experience the most significant increases in accessibility. For instance, following the introduction of the high-speed rail line between Cologne and Frankfurt, the average GDP per capita in the region was 10% greater than in neighboring municipalities six years later (Ahlfeldt & Feddersen, 2018), meaning the Lelylijn could potentially boost regional economic performance as well, especially in sectors that thrive on enhanced connectivity. However, the analysis also showed that these improvements in accessibility are larger in sectors associated with higher education levels. This suggests that while the Lelylijn has the potential to drive regional economic development, it may also risk increasing inequalities between different labor market sectors. The literature indicates that large infrastructure projects can indeed result in such disparities (Sobieralski, 2021). The relevance of these differences in accessibility improvements across sectors therefore requires further investigation, since for sectors associated with higher education, such as Legal services or Non-financial holding companies, the interaction between different job locations within the sector may be more crucial than for sectors typically associated with lower education levels. In the sectors typically associated with higher education levels, where collaboration and proximity to other firms or institutions can drive economic productivity, even moderate increases in accessibility can positively impact sector performance and job creation (Chakraborty et al., 2013). This does not indicate however that the lower increase in accessibility for sectors associated with lower education levels is without consequence. As (Overman et al., 2010) have described, when regions experience productivity growth, which often translates into wage growth, they become more attractive to workers. This increased desirability drives in-migration as people move to take advantage of the higher wages and job opportunities (McCann, 2013). However, as more people migrate to these regions, the demand for housing increases, driving up the cost of housing. Over time, the rising cost of housing can

act as a deterrent to further migration, particularly for lower-income individuals or those in lower-wage jobs (Overman et al., 2010). This dynamic has significant implications for regional prosperity. If the increase in house prices is driven by better infrastructure and connectivity, but the economic benefits of these improvements are concentrated at the top of the wage pyramid, a broader prosperity issue arises. High housing costs disproportionately affect lower-income individuals, especially if their wages do not increase alongside those of higher-wage workers. For people with lower education levels or those in lower-wage jobs, the combination of low or stagnant wages and rising housing costs can make it increasingly difficult to live in or move to more prosperous regions or cities. This process can therefore increase inequalities, as the benefits of economic growth and improved infrastructure are not evenly distributed. In order to overcome such potential inequalities, practical solutions may include introducing policies that promote affordable housing in areas likely to experience an increase in housing prices due to improved accessibility. This could include rent controls and affordable or social housing quotas for new developments (Power, 2012). Furthermore, (partly) subsidizing travel costs for lower-income workers, could help them take advantage of improved accessibility without disproportionately affecting their cost of living (Guzman & Hessel, 2022).

Besides sectoral differences, the investigated cores showed differences in accessibility changes as well. While Leeuwarden might not exhibit the most significant relative growth in accessibility, it remains the best-connected and largest city within the region, including jobs within its municipality. This suggests that despite the smaller percentage increase in accessibility, Leeuwarden still acts as a central core in the regional economy. However, the results indicate that smaller cores like Lemmer and Joure experience greater relative increases in accessibility. As (Del Bo et al., 2010) have also found, it is therefore possible that the introduction of the railway line can strengthen the process of regional convergence. Although this has not been extensively tested on such a small regional scale before, there is some indication that the improved connectivity could help bridge the economic disparities between different parts of the province and enhance regional economic development.

In the larger academic debate on infrastructural investment in relation to labor market outcomes, the results do comply with existing ideas on economic benefits due to railway development (Aschauer, 1988). The study adds to the existing body of research by providing insights into how local labor markets within a region are affected due to the introduction of a large-scale railway project. As follows from the analysis, the local labor market impacts can be described as finding increased labor market accessibility for urban cores within the region, however with differences found across labor market sectors. These findings however do require further research.

Future research could examine the long-term effects of the Lelylijn on labor market dynamics, particularly in terms of how changes in accessibility influence migration patterns, the creation of new job opportunities, and further economic development in different labor market sectors. Another aspect future research could focus on relates to incorporating more sophisticated modelling techniques to better understand these dynamics, as well as making use of longitudinal data once the Lelylijn would be constructed in order to assess the long-term impacts of the Lelylijn. Additionally, qualitative studies could provide deeper insights into how different communities perceive and adapt to these changes.

## 6. Reflection and limitations

This study was aimed at investigating how the introduction of the Lelylijn would affect labor market accessibility in Fryslân, particularly in relation to inequalities, expressed in varying levels of education. The results indicate that the introduction of the Lelylijn significantly improves overall labor market accessibility across the province, with the most substantial improvements observed in areas currently lacking railway infrastructure, with the improvements in accessibility being most evident in the labor market sectors typically associated with a higher educated workforce, leading to potential disadvantages. However, the results of the analysis do require further research as there is a number of limitations to the study and the type of analysis that was performed. One limitation of this study is that the analysis was performed using accessibility scores which were derived using a gravity model. This approach may not fully capture the complex dynamics of labor market interactions (Joseph & Kuby, 2011).

Furthermore, the analysis does not account for potential changes in population distribution and future employment opportunities following the construction of the Lelylijn, which could influence the outcomes. The analysis was performed based on the data that is currently available, while the Lelylijn will likely not be constructed earlier than twenty years into the future, which is why the results provide an indication of potential labor market effects, yet cannot provide absolute certainty of economic developments in the future.

Another key limitation of this study is the reliance on labor market sectors as a proxy for education levels, due to the lack of availability of a dataset with detailed employee data containing education levels. The approach may involve inaccurate estimates. Despite the efforts to select labor market sectors typically associated with either high or low education levels, it does assume a direct correlation between sector employment and education level, which may not capture relevant variations.

Not only does the lack of a detailed employment dataset influence the results of the analysis, the lack of reliable travel behaviour data also plays a role. With relevant data such as the preferred modes of transportation, commuting distances, and the travel patterns between the

cores that were taken into account for the analysis, it would have been possible to more precisely estimate the true changes in accessibility

Another limitation relates to how labor choice is generally understood to be made. Due to the assumptions within this gravity model, attractiveness of a job opportunity largely depends on the proximity and accessibility of said job. However, job choice is not solely dependent on the location of the company as well as the residential location of the worker. Other factors, such as housing and related costs may play a role (Krusell et al., 2010). However, in order to gain a more complete insight on how the labor market dynamics in the Fryslân province may alter as a result of the Lelylijn construction, future research is needed.

Another limitation to the study is related to potential challenges in incorporating smaller, more remote urban and rural cores into such analyses. In order to fully understand accessibility and labor market dynamics in the region, it can be of interest for future research to incorporate this in new studies. In conclusion, despite aforementioned limitations, this study does provide evidence that the Lelylijn will alter labor market accessibility in Fryslân, particularly benefiting higher-educated sectors.

## 7. Conclusion

The primary objective of this thesis was to answer the main research question: ‘How does the construction of national scale railway connections impact accessibility to local labor markets?’. The first sub-question focused on how relative accessibility can be conceptualized from a theoretical perspective. The theoretical framework was based on economic concepts as New Economic Geography (NEG) which include the notion of reducing transport costs to enhance economic integration and labor market pooling, which can drive regional productivity and economic growth. Furthermore, empirical research shows that improved transportation connections can benefit core regions at the expense of peripheral areas (Ahlfeldt & Feddersen, 2018). As (Chen & Vickerman, 2017) describes as well, a correlation between transport infrastructure and economic performance can be identified. Based on empirical and theoretical evidence, the conceptual model was developed and used for exploring the answers to the sub-questions as well.

The second sub-question investigated the existing patterns of labor market accessibility for individuals with different education levels in Fryslân prior to the Lelylijn. The analysis revealed significant disparities in accessibility, with the larger urban cores as Leeuwarden and Heerenveen generally having better access to a broader range of job opportunities, while smaller towns like Lemmer and Joure had much lower accessibility, particularly for higher-educated sectors.

The third sub-question examined how the introduction of the Lelylijn would alter labor market accessibility with the introduction of the Lelylijn. The findings suggest that the Lelylijn would lead to substantial improvements in accessibility across the province, particularly for areas currently lacking railway connections. However, the benefits are not uniformly distributed. Sectors associated with higher education levels, are expected to see the most significant increases in accessibility. In contrast, sectors with lower educational requirements, like Wellness services and Sale and repair of motor vehicles, are projected to experience smaller

gains. This indicates that the Lelylijn may disproportionately benefit higher-educated individuals, potentially increasing existing inequalities in access to job opportunities.

In conclusion, the Lelylijn does lead to substantial improvements in accessibility to labor markets within the province for all investigated sectors and urban cores overall, showing potential for economic convergence.



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