Connecting the North: Economic and Social Implications of the Lelylijn

ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis [programme Economie en Bedrijfseconomie]

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Date final version: 30 Jul. 24

The views stated in this thesis are those of the author and not necessarily those of the supervisor, second assessor, Erasmus School of Economics or Erasmus University Rotterdam.

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Summary

This thesis investigates the potential socioeconomic impacts of the proposed Lelylijn railway project and accompanying proposed housing developments in the northern provinces of the Netherlands. Four potential development scenarios, proposed by a government workgroup, are assessed to see if these could be a solution to regional challenges. This is done with quantitative spatial modelling on commuting pattern data from Dutch workers. The study looks at the effects of improved transportation connectivity and new housing on the distribution of jobs and people, on housing price dynamics and on travel patterns. The thesis concludes that the Lelylijn railway, combined with large-scale housing developments, could stimulate the northern economy by redistributing jobs and could increase wages due to agglomeration effects. Furthermore, it could redistribute people, thereby reducing pressure on the Randstad while revitalizing the northern provinces. Furthermore, the shortcomings of the model used are discussed. The results are positive, but crude further areas for research are proposed, before a well-informed policy choice can be made.

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Introduction

For years there has been talk about building a new railroad to the northern provinces of The Netherlands, to better connect these people to the Randstad and other parts of the country. A first attempt, called the ‘Zuiderzeelijn’ from the twentieth century failed and was cancelled in 2007. A second attempt, with the rename ‘Lelylijn’ has been gaining a lot of traction in last few years. This railway would reduce the travel time between Groningen and Amsterdam significantly and connect mid-size cities in the north to the national railway network. With many national political parties supporting it, the previous government coalition ‘Rutte 4’ reserved money in 2021 (NOS, 2021) to build it. The new railway has even been included in the international railway network plans of the European Union (Rijksoverheid, 2022).

Furthermore, there is a big housing shortage in The Netherlands. The former minister of the interior Ollongren (2021) states that we need to build up to 900.000 houses until 2030 to solve the shortage. And there is not a lot of space in the west to build them. The north is relatively sparsely populated and has room to build many houses. According to the NOVEX program from her successor De Jonge (2022) the Lelylijn combined with large scale housing programs could contribute to solving this national problem while also benefitting the north. This NOVEX research has come up with four alternative implementation possibilities to be further researched (Stuurgroep Lelylijn, 2024b).

Social relevance

The government’s intention to build the Lelylijn and large amounts of housing has sparked public debate about the plan’s merits. With voices of people emphasizing the potential economic benefits, like businesses potentially relocating to the northern provinces leading to more job opportunities or preventing young high educated people from moving away by giving them the opportunity to commute to the bigger cities in het west of the country (Oosterhaven and Elhorst, 2024; Stuurgroep Lelylijn, 2024a).

Opposed are the people who think the negative consequences outweigh the positive. Some suggested that the Lelylijn will only benefit the towns and cities that get a train station, suggesting that the money would be better spent in a way that also benefits other people in the north (Van der Meer-Kooistra and Folmer, 2024). Politicians have argued that with new infrastructure population from the Randstad may relocate to the north making homes more expensive (Omrop Fryslân, 2024). Other have expressed their concern that the north will become just another Randstad and will lose qualities that make it unique right now, and that people might not want this (NRC, 2024). The National Advisor for the Physical Environment calls for more research on the effects of this on local communities and especially small towns and villages (Leeuwarder Courant, 2024). Some even argue that young people will still move away. And even worse: companies from the north may relocate the Randstad, leading to a decrease in jobs, because of the (effectively) smaller distance (Folmer and Van der Meer-Kooistra, 2024).

This large disagreement of opinions comes from valid concern and most of the time because nobody really knows what the effects are until the line is built. To be able to talk about the possible benefits and drawbacks it is therefore good to estimate, as good as we can, what these effects would be. To make it possible to fuel this debate based on facts. To that end I propose the following research question.

What would be the effects of the different scenarios from the NOVEX exploration for building the 'Lelylijn' on economic and social factors in the northern provinces of the Netherlands?

Academic relevance

There is still little (empirical) knowledge on the policies that government use to combat brain drain and population decline, and it needs to be studied more to improve interventions that can be taken by governments (Van Dijk et al., 2022).

A cost-benefit analysis for the Zuiderzeelijn (the initiative for a similar railway from the 90's that was not built) shows positive net present value and a job increase for the north

(Elhorst and Oosterhaven, 2006). However, such a study has not been done yet for the new Lelylijn, and the effect of the new house building programs has yet to be taken into consideration. There have been contributions by academics to the debate about the merits of the Lelylijn (see the references in the previous section; Van Dijk, 2023; Koster and van Dijk, 2022), but few academic studies have been undertaken in this direction.

To address this gap, this thesis presents analysis in the relatively new area of quantitative spatial models to study the research question. Though there is already a large body of research using these models, more is still needed to reconcile them with existing theories of spatial economics (Redding, 2010), to confirm them empirically and to expand our understanding of individual spatial choices (Redding and Rossi-Hansberg, 2017). With these quantitative models real world situations can be analysed instead of stylized model settings, use data from real world settings.

This thesis aims to contribute to the academic discourse on quantitative spatial modelling, the effect of infrastructure on economic growth, and the Lelylijn specifically. It will provide an economic analysis of the potential benefits associated with the Lelylijn and accompanying NOVEX program, and in doing so adds to both academic expertise and to the practical debate about government policy.

The structure of the remainder of this thesis is as follows. First the current planning alternatives of the Lelylijn and accompanying housing programs are explained, leading to the central research question to be split in three sub-questions. Next, I discuss the relevant existing literature about agglomeration effects, spatial economics and modal choices, that are necessary to answer these questions and some of the related empirical results. After that, the methodology, model and the data are specified. I show the maps and table with the modelling results and interpret these. Finally, the results are used to answer the main research question and the shortcomings of this research and ideas for future research are considered.

Lelylijn

The NOVEX development perspective (Stuurgroep Lelylijn, 2024a) identifies different challenges and chances for the north of The Netherlands to which the large housing building program and the Lelylijn could be a solution. Some of these clearly fall outside of the scope of an economics thesis like chances for futureproof agriculture or the raw materials transition. The challenges most relevant to the research question can roughly be grouped into the three categories.

The first is economic effects. According to Stuurgroep Lelylijn (2024a) the economy in the north is lacking behind the rest of the country. Measured in GDP per capita, the provinces of Fryslân and Drenthe had the lowest productivity of the Netherlands in 2022 (CBS, 2024b). Due to a lack of big cities, there are fewer agglomeration benefits (see Agglomeration theory below). So, with better interconnections, towns and cities in the north could 'borrow' each other's size. In this way more housing and better transportation connections could lead to economic growth and more jobs (Delfmann et al., 2014) and therefore more wealth. This observation gives way to the first sub-question:

How do the different NOVEX development alternatives affect the economic performance in the north, specifically: agglomeration effects and the attraction of more jobs?

As mentioned in the introduction, there is a housing shortage in the entire country. The report (Stuurgroep Lelylijn, 2024a) mentions some other challenges related to housing in the north specifically. First is the challenge to keep people there. Because of a lack of amenities and public services, and a lack of jobs, people are moving away to bigger cities (Van Dijk et al., 2022). A fast train connection to bring more jobs within commuting distance, combined with extra housing development could compel people to stay. And secondly, there are many rural areas in the north that are shrinking because the population is ageing (Delfmann et al., 20214; Van Dijk et al., 2022). The impulse given to the larger towns, when large amounts of housing and a train connection are built, could also raise the attractiveness for the surrounding villages and spillover effects could make these places more liveable and less likely to shrink. Therefore, to answer the main research question, we ask the following, second sub-question:

How do the different NOVEX development alternatives affect the attractiveness of living in the northern provinces and how will they affect the housing market?

The final category is transportation, the challenges identified in (Stuurgroep Lelylijn, 2024a) include compelling people to take public transport. Public transport, in the form of electric trains (and buses) is more sustainable and reduces congestion. Building the Lelylijn could help people to change their modal choice. Lastly, there is a large and growing degree of inequality in villages with bad transit, where people are at risk of getting left behind (Stuurgroep Lelylijn, 2024a, p. 76). Building new transport infrastructure could help mitigate this. The last sub-question, that will be answered before the main research question is then:

What is the effect of the different NOVEX development alternatives to commuting patterns?

When these three questions are answered it will be possible to give a characterisation of the full economic and social effects of building a Lelylijn combined with large housing development.

Literature

To research what the effects of the development of the Lelylijn and NOVEX locations will be, it is first necessary to understand why people and businesses are located where they are, what the driving forces are for people to move to cities and how cities and connectivity affect economic growth. Therefore, I will first discuss the available literature on these subjects. One of the effects mentioned by the NOVEX planners (Stuurgroep Lelylijn, 2024a), is 'borrowed size' or 'network effects'. These have to do with the fact that interconnected areas are more productive and will be fully explained below, but first it is necessary to introduce the field of spatial economics and the concept of agglomeration effects.

Spatial Economics

At the heart of the main research question and the subsequent sub-questions is the question of why people (and organizations) make location choices. How people choose where they live, where they work and how they travel, how firms choose the place where they set up shop, and how things like housing cost, wages, travel costs and the location choices of others influence each other. The part of economics that studies these choices is spatial economics or economic geography. To establish an understanding of these choices and their effect on a macro scale it is first necessary to talk about existing theories on the location choices and individuals and the spatial structure of the economy.

This thinking begins with Weber in the beginning of the twentieth century who models the location choices made by a single producer, with all prices as a given, who optimizes their location to minimize the transport costs of all inputs and the transport costs of the end-product to the market (Krugman, 1998). Alfred Marshall was the first to study agglomeration externality's, in other words to try to explain the observed phenomenon of firms locating close to each other (Krugman, 1993). According to McCann (2013), Marshall found that companies and people tend to locate close to each other, because it gives them certain advantages. He identified three different sources for these advantages. First the spill-over of knowledge between firms and workers, this can happen simply because of the close proximity of people. Second, because firms close to each other might use each other inputs, or the same inputs, more easily. And third, because of the proximity of good labour. These three things cause economies of scale that are external to individual firms but benefit the whole city or area (McCann, 2023).

The study of the location and size of cities as nodes in regions began with Walter Christaller (1933, as cited in McCann, 2013) and the central-place theory inspired by the observation of location patterns of cities in the south of Germany. According to Christaller there is an observable hierarchy in goods and services supplied by cities and their market area size. This hierarchy is matched by a hierarchy in city size. The goods and services that need the largest market area are supplied by only the largest cities with the largest hinterlands and these cities are located an equal distance apart, so their hinterlands don't overlap. The goods and services one level down in the hierarchy that don't need as big market area sizes are supplied by the largest cities, but also by cities one level lower in the city-hierarchy, these smaller cities are then placed equal spaces apart from each other, around and in between the largest cities. This continues until the lowest goods and cities in the hierarchy (McCann, 2013).

More recent are the new economic geography models developed by Krugman and Fajita (Krugman, 1998) that are based on general equilibria that result from the choices of rational individuals in a monopolistically competitive world (McCann, 2013). This type of model pioneered by Krugman (1991) based on international trade theories and was later further developed by Fujita and Krugman (1995) Its results somewhat confirm central-place theory, namely an equilibrium of large central cities situated far apart from each other that both capture similarly sized hinterland. For this contribution, Krugman was awarded with a Nobel prize for economics (Prize Committee of the Royal Swedish Academy of Sciences, 2008).

The models and theories named in the previous paragraphs are all purely theoretical and take place in a very stylized setting, and their results are difficult to translate to real world settings. Recent research has focussed on quantitative models that use data from real world settings (Redding and Rossi-Hansberg, 2017) and are able to make predictions on the effect of policy interventions like building new infrastructure and predict a new equilibrium after an external shock. These quantitative spatial economics have been build based on the foundations of the original New Economic Geography from Krugman and Fujita (Brakman et al., 2021), but unlike the original they are able to deal with many interconnected regions, whereas the original model by Krugman was constricted to a one-dimensional world i.e. assumed to take place in a world with X distinct locations laid out on circle, where workers or products can only be transported to an adjacent place clockwise or counterclockwise. An overview in Redding and Rossi-Hansberg (2017) show that this class of models can be used to research a range of real-world scenarios under many different assumptions and are highly customizable.

Agglomeration theory

The NOVEX document specifically mentions the possible agglomeration benefits as a chance for the Lelylijn to strengthen the northern economy. So, it is necessary to define what agglomeration effects are in order to be able to identify what causes them. Only then is it possible to give a hypothesis for the first two sub-questions.

As of 2021 the majority of the world's population lives in cities. And the world continues to urbanize, from the urban population making up 56% of the world in 2021 to and an estimated 68 per cent by 2050 (UN-Habitat, 2022). Which is notable because living in cities has some obvious disadvantages, like pollution and congestion. The question arises what it is that draws people to urbanize, this is called agglomeration effects and is subject to extensive academic research. A first explanation is that some places have 'natural advantages' over others that draw people to locate in one spot, think of natural harbours, fertile lands, being situated at the intersection of large rivers. Ellison and Glaeser (1999) estimate that at least 20 percent of the agglomeration effects can be explained based on a few observable natural advantages, and conjecture that the actual percentage could be as high as 50 per cent.

The existing literature divides the remaining causes of agglomeration effects of firms into three large categories: sharing, matching, and learning. It is concluded that the last, learning, has so far been least understood in the economic literature (Duranton & Puga, 2004; Puga, 2010).

Sharing

Sharing is perhaps the most intuitive cause of agglomeration advantage and can come in several ways. For example, investment in non-rivalrous facilities like infrastructure can be split among more users in an urban area and is therefore more efficient, because the more users, the lower the costs per user.

Sharing advantages also arise from sharing a pool of suppliers. This leads to economies of scale, with larger cities having a larger base of suppliers and therefore more efficient total production. Aside from the advantages of simply more suppliers, in larger cities workers and firms can specialize further and the advantages of more specialized and therefore more productive individual units is shared among all the firms in an agglomeration.

With larger agglomeration the sharing of a labour pool means demand for labour also becomes more consistent and therefore attracts more (skilled) workers, growing the labour pool itself and making it easier for firms to get consistent and high-quality labour.

Matching

A different cause for agglomeration advantages is matching. An example for this is the labour market. In a larger city with a larger labour pool and more firms, the chance increases of workers finding a job that suits their preferences and makes use of their skills. And similarly, the quality of the matches made increases when both firms and workers have more options to choose from. Higher quantity as well as higher quality of matches leads to more productive firms and workers. Of course, the same argument can be made for suppliers and buyers, end-producers and customers and producers or any other places where matching occurs.

Learning

Lastly there is the less well understood learning effects (Puga, 2010). In cities with many firms and workers close to each other, workers acquire new skills quicker and knowledge spills over between firms, either intentional or unintentional. Intentional, for example, because people set out to learn from the knowledge of others. Unintentional, for example, because of informal encounters between firms and workers, and the mobility of workers between firms. Another explanation of the learning effect is given by Jacobs (1969), according to whom the diversity and ‘inefficient’ duplication of work in larger cities leads to ‘added work’ which is the beginning of the natural creation of new industries, ideas and technologies.

Agglomeration disadvantages

Agglomeration has not only advantages, but there is also certain cost to large urban areas. With a larger city there is often more traffic congestion, more crime, noise, pollution and more that are an effect of having very many people living and working in the same shared space (Meijers et al., 2016). Smaller cities can mitigate these problems better

(Capello and Camagni, 2000), and make more pleasant places to live or work in because of it (Alonso, 1973).

Polycentricity

The NOVEX research says because the cities in the north are relatively small, the lagging behind of the formation of networks is handicap and are therefore losing out on agglomeration effects. Partly because of this it has a lower economic growth than the rest of the country (Stuurgroep Lelylijn, 2024, p. 46). The Netherlands has a long history of planning for smaller well-connected towns called 'groeikernen' to avoid the emergence of large metropolitan areas (Planbureau van de Leefomgeving [PBL], 2012). So, next we include an overview of the concepts related to agglomeration effects in networks in the theoretical framework used to answer the research question.

Borrowed size

The first economist to talk about the concept of borrowed size of smaller cities is William Alonso (1973). In a paper on, among other things, the desirability of limiting the population growth of cities, he argues that cities are not independent and that the economic and population size of one, also affects the other. He defines the concept of borrowed size as the effect that occurs when a smaller town or settlement has the qualities of a larger city, because it is close to one, while still keeping out some of the disadvantages that come with larger agglomerations. According to Alonso, the basis of the benefits of larger cities is the bigger potential of people meeting. Therefore, he suggests measuring borrowed size by 'population potential', the potential of people of a certain location to reach other populations. This way of thinking justifies the building of infrastructure to better connect smaller cities into the networks with larger metropolitan areas, this should raise the population potential of those smaller cities and give them more 'borrowed size'.

Agglomeration shadow

Within the framework of the 'new economic geography', previously discussed in To research what the effects of the development of the Lelylijn and NOVEX locations will be, it is first necessary to understand why people and businesses are located where they are, what the driving forces are for people to move to cities and how cities and connectivity affect economic growth. Therefore, I will first discuss the available literature on these subjects. One of the effects mentioned by the NOVEX planners (Stuurgroep Lelylijn, 2024a), is 'borrowed size' or 'network effects'. These have to do with the fact that interconnected areas are more productive and will be fully explained below, but first it is necessary to introduce the field of spatial economics and the concept of agglomeration effects.

Spatial Economics, Krugman (1993) coins the term agglomeration shadow. Krugman (1993) finds that in this model, over time once an equilibrium is reached, manufacturing and labour is concentrated in one or two major cities in a process where the smaller cities are 'eaten up' by the bigger ones. There is also the effect of agglomeration shadow, meaning that no two big cities are next to each other in an equilibrium situation. Even when in the starting situation there are two big cities close to each other, the bigger one tends to eat up the smaller one. There can be multiple large cities in an equilibrium, but never close to each other. When applied to the case of the Lelylijn, building a new railway would 'shorten' the distance between the smaller cities and Amsterdam. The conclusion would be that if this distance is reduced down to a certain threshold, then Amsterdam would dominate the smaller cities, both in terms of labour (inhabitants) and of their industries. But only if they are close enough to Amsterdam.

The next section will summarize some of the empirical findings of these contradictory effects of agglomeration shadow and agglomeration borrowed size.

Empirical findings

From empirical data from metropolitan areas in Europe from 2011 Meijers et al. (2016) find that network connectivity has a positive effect on the metropolitan functions used as a proxy for economic performance of cities, but generally not as much as local size, and not for every metropolitan function researched. And these network effects are bigger for larger cities than for smaller cities which benefit most from a bigger local size first.

The Greater Bay Area is major innovation centre for China and consist of several megacities surrounded by multiple smaller and medium size cities. Yang, Fan, Wang and Yu (2022), looking at innovation and knowledge network, found negative network externalities for the smaller and medium size cities in the network. This means that the smaller cities there experience an agglomeration shadow. Using a semi-natural experiment, namely the opening of high-speed railways, Jing and Haishan (2022) found that with the building of railways (which effectively brings places closer together) the smaller counties along the lines lost GDP per capita and population to the bigger cities. Which is the agglomeration shadow you would expect from the theory of New Economic Geography. Both these findings have to be taken with a grain of salt however, though they confirm the theory of laid out above and are therefore relevant, they are not directly applicable to the case of the north of The Netherlands, as even the small Chinese cities are bigger than even the biggest Dutch cities.

Going back to cities in Europe, especially Western Europe, Dijkstra, Garcilazo and McCann (2012) find that since 2000 the migration from rural to urban areas has stopped and even reversed a little. Furthermore Dijkstra et al. find that the large cities are not the most important drivers of economic growth anymore, and that this growth is mostly concentrated in de intermediate areas. And that Europe deviates from global trends in this regard. This does not necessarily mean that the large cities do not contribute to growth but may be an indication that smaller cities are able to borrow size in Europe. Ciccone (2002) estimates, based on data from France, Germany, Italy, Spain, and the UK, that the agglomeration effect of the concentration of labour is 4.5% (compared to 5% for the U.S.A.) and does differ significantly between different the European countries.

From these results you would expect the building of new railways like the Lelylijn to be mostly beneficial to the biggest city: Amsterdam and to the Dutch economy at large, but not so much for the intermediate small and medium cities. Henderson (2000), looking at the size of the largest cities per country, finds that The Netherlands is only one of a few countries to have such a small major city that it holds them back in terms of economic growth, because of missed agglomeration advantages. That is why letting Amsterdam benefit and grow might not be such a bad thing.

The economic literature presented here suggest that first that larger cities do better economically because agglomeration advantages outweigh agglomeration disadvantages. They would also suggest that when smaller cities are closer, i.e. better connected, to bigger cities, that they experience agglomeration shadow. In other words that the bigger cities profit more from this closeness. My hypothesis for the sub-question regarding the economic effects is therefore:

- The large increase of houses and people with them will increase the number of jobs in the cities where the new houses are located, at the expense of the other municipalities in the area
- The more concentrated in a smaller number of cities these programs are, the higher the local productivity, therefore the higher the wages are and the more people coming to work there.
- And the addition of the Lelylijn will benefit the large cities in the west, like Amsterdam, more than it will benefit the north.

The simple effects of supply and demand would predict that with the building of large amounts of housing, prices should go down with it. However, the findings of Krugman (1993) show that not only production suffers from agglomeration shadow, but the factor labour, in other words people, move to the bigger city as well. My hypothesis for the second sub-question therefore is that with the growing cities along the Lelylijn, agglomeration shadow over nearby municipalities should make these nearby places less desirable to live in. Finally, the rise in attractiveness of the cities along the Lelylijn originating from the extra housing and from higher wages will be partly cancelled out when these cities are connected to the Lelylijn. Because with better connections by rail they become closer to larger cities in the west, and this in turn will cause an agglomeration shadow from the western cities over the north.

Transport

Among the goals of the developers of the Lelylijn and accompanying urban development programmes is also the shift to a more environmentally sustainable transportation system, in other words, a shift from car use to public transportation. This begs the questions, what makes people choose a certain mode of transport, and can this be influenced by such things as urban planning and the building of new infrastructure.

Holz-Rau and Scheiner (2019) discuss how improvements to transport infrastructure has led to more travel in the past. But they scrutinize the potential for using this relation using planning and land-use policy to influence travel patterns in the future. They find that shifting from mainly transportation by automobiles to more sustainable modes of travel like walking, cycling and public transport is neither always possible, nor is it necessarily desirable. Not possible because first, the correlation between public transport orientated places and low car dependency may not be a causal relation, but simply an effect of self-selection. Secondly, the way land-use and transport habits influence each other is likely not constant over time, and therefore not suitable to be used for sustainability goals i.e. planning the cities of the future for the transportation patterns of today may have completely unpredictable outcome with different transportation patterns in the future. Lastly, it is not always possible to influence the causes transportation developments.

Also, it might not be desirable to inhibit the changing travel behaviour. The increasing transport demand and shift to car-dependent transportation is also caused by societal developments that are generally regarded as positive, like increased equality of men and women, higher education levels and higher income.

Holz-Rau and Scheiner (2019) suggest to also implement restrictive measures to achieve the goals of more sustainable travel, like higher fuels prices, parking restrictions et cetera. These are however less popular and not explored in this research.

The hypothesis that self-selection plays an important role in the fact that many residents of transit-oriented neighbourhoods use public transport is confirmed by Schwanen and Mokhtarian (2005) in a survey study among resident of urban and suburban San Francisco neighbourhoods by looking at peoples place of residence, their mode of choice and their preferred type of neighbourhood. Schwanen and Mokhtarian also show that urban residents who'd prefer to live in the suburbs will use private transport anyway, while suburban residents who would rather live in an urban neighbourhood will also use private transport, suggesting that the lack of public transport options in the suburbs play a role.

Ton et al. (2020) find that even in The Netherlands, a country known for their large bike infrastructure around train stations, a majority of the people still only use one mode of travel for commuting trips. Ton et al. also find that urban environment plays a role in the choice of mode, possible employer benefits play a bigger role.

A different way to discourage car travel is to discourage travel al together. Part of the NOVEX developments is to create new jobs in the poorer north, one could argue that locating those jobs near the places where people live could be a potential means to achieve to goal of reducing travel related externalities by reducing travel distances. Ding and Bagchi-Sen (2019) find that job availability and job proximity is a large determinant of commuting distance for the general population. However, this the effects are different between different sector and especially income levels. So, the applicability of this is probably limited. Also, Johansson, Klaesson and Olsson (2003) show based on commuting data that the sensitivity to time of commuters is not constant over travel time, it is less sensitive for shorter and longer travel times and more sensitive for medium travel times.

The economic literature presented here shows that it is difficult to discourage people from traveling by car. It suggests that the best way to discourage travel is to restrict travel altogether. And it suggests improved travel infrastructure might lead to more, not less commuting. Furthermore, it suggests that moving jobs closer might be a way to reduce commuting. Therefore, I propose the hypothesis that people in cities and towns that get a new railway station will commute more, and that municipalities where jobs are increased see a decrease in commuting trips and that these effects counteract each other in municipalities where both happen.

Methodology

In this study I will first use a quantitative spatial economic model as explained by Redding and Rossi-Hansberg (2017) and mentioned in the part To research what the effects of the development of the Lelylijn and NOVEX locations will be, it is first necessary to understand why people and businesses are located where they are, what the driving forces are for people to move to cities and how cities and connectivity affect economic growth. Therefore, I will first discuss the available literature on these subjects. One of the effects mentioned by the NOVEX planners (Stuurgroep Lelylijn, 2024a), is ‘borrowed size’ or ‘network effects’. These have to do with the fact that interconnected areas are more productive and will be fully explained below, but first it is necessary to introduce the field of spatial economics and the concept of agglomeration effects.

Spatial Economics earlier in this. This specific model was outlined in the Seminar Urban, Port and Transport Economics (Gerritse, 2023). Using topographical data for Dutch infrastructure (both rail and road), I will estimate commuting costs (travel time) between municipalities. I use Gerritse (2023) because it allows me to combine known commuter data between municipalities (CBS, 2024a) with commuting costs to quantify the parameters of the model and calculate policy counterfactuals for the proposed intervention outlined in (Stuurgroep Lelylijn, 2024a).

Model

In the model people consume two different goods: housing (h) and the sum of all other consumption (c), and they are assumed to have Cobb-Douglas utility. Using empirical data from households in the United States, Davis and Ortalo-Magné (2011) find that people spend approximately a constant part of their wages on rent and have Cobb-Douglas utility. The utility from consumption in this model is therefore $h^{\beta}c^{1-\beta}$ with a fraction β spend on housing. This leads to a utility function for people who live in o and work in d:

$$\mathrm{U_{od}} = \frac{1}{\mathrm{N_{od}^{1/\alpha}}} \mathrm{A_o} \frac{\mathrm{h^{\beta} c^{1-\beta}}}{\mathrm{d_{od}}} \tag{1}$$

Here, people experience a higher utility from living in more ‘attractive’ places (with more amenities), captured in the variable: A_o. And people experience a lower utility when a certain origin-destination pair is more crowded, captured in this formula by the variable N_{od}: the number of commuters between o and d. Finally, people have a lower utility when the travel costs are higher, manifested here in the variable d_{od}.

Furthermore, consumption is dependent on the wages, which in this model are a property of the location local labour market. Wages are spent on housing and ‘rest’, with housing prices being a property of the place where one lives and the ‘rest’ having a price of 1. This gives the equation:

$$w_d = r_o \cdot h + c \tag{2}$$

The labour market is modelled as follows. The wages are assumed to be equal to the marginal production in one municipality, which is $\mathrm{Q_d} = \mathrm{a_d} \frac{1}{1+\gamma} \mathrm{L_d^{\gamma}}$, with a_d being the exogeneous part of local productivity, L_d the total number of workers in a city and γ a number representing the size of agglomeration benefits. Consequently, the wages become $w_d = a_d L_d^{\gamma}$, which will be higher for higher L_d, e.g. in bigger cities. Just like one would expect with agglomeration benefits. The agglomeration shadow is then caused by changes in location choices by individuals, since a bigger city has higher wages, the benefit of higher income will outweigh the costs of commuting for people from nearby smaller places. Resulting in those people trading in their local job for one in the bigger city, decreasing the number of jobs in the smaller place.

These equations in an equilibrium lead to an indirect utility in the form of:

$$V_{od} = \hat{v} \frac{1}{N_{od}^{1/\alpha}} \frac{A_o}{r_o^{\beta}} \frac{w_d}{d_{od}} \tag{3}$$

Which can be rewritten as:

$$log(N_{od}) = -\alpha \, log(d_{od}) + \alpha \, log\left(\frac{A_o}{r_o^{\beta}}\right) + \alpha \, log(w_d) + c \tag{3}$$

With c being a constant term that capture the residual part of the indirect utility. When assumed that the country in the current condition is in equilibrium, the variables in this equation can be estimated using a fixed effects regression. For this a ‘pseudo-Poisson’ regression is used. ‘Pseudo’, among other things, because many of the flows have a value of 0, something ordinary Poisson regression cannot handle. Therefore, it is the standard practice to use a pseudo-Poisson fixed effects regression in international trade economics, spatial economics and everywhere else where gravity equations are estimated based on flows (Correia et al., 2020). The regression equation is similar to that of a gravity equation and looks like this:

$$\log\left(\mathrm{CommutingFlows}_{\mathrm{o,d}}\right) = -\beta \log\left(t_{o,d}\right) + \mathrm{FE_o} + \mathrm{FE_d} + c \tag{4}$$

To analyse the commuting data with this equation it is necessary to know the ‘generalized’ travel costs between every origin destination pair. For this study we want to separate the effect of travel times by train and by car. So, assuming the choice between public transport or cars depends on respective travel times and that some will always pick either one. As suggested by Gerritse (2023) the travel costs are modelled by the following equation:

$$\mathrm{t_{o,d}} = \left(\mathrm{t_{car,o,d}}\right)^{\delta_1}\left(\mathrm{t_{train,o,d}}\right)^{\delta_2} \tag{5}$$

To find an answer to the research question, the coefficients of the regression equation below are estimated using a Poisson pseudo-maximum likelihood regression on the observed commuter data of people in The Netherlands. Added is a covariate called 'within' as well, this is equal to 1 for equal origin and destination. This is because the calculation of travel times doesn't work well for same origin/destination pairs, as distances are calculated beginning and starting from a single, same point in the municipality (see Assumptions).

$$\log\left(\mathrm{Flows_{o,d}}\right) = \beta_1 \cdot \log\left(\mathrm{t_{car,o,d}}\right) + \beta_2 \cdot \log\left(\mathrm{t_{train,o,d}}\right) + \beta_3 \cdot within + \mathrm{FE_o} + \mathrm{FE_d} + \mathrm{c} \tag{6}$$

Using the fixed effects the parameters of the utility function in the current equilibrium are estimated. The parameter A_d is taken as fixed, because it captures exogeneous attractiveness of a certain city, the total amount of housing H_o is calculated, and the exogeneous part of local productivity a_d is estimated and assumed to be fixed.

Then we need to estimate the new parameters for the counter factual scenarios. The parameters H_o and travel costs $d_{o,d}$ between all origin destination pairs are modified, to reflect the changed housing supply and the changed transportation network. This means that there is no longer an equilibrium, the only other free variables (commuting intensities, wages and housing prices) need to be updated the find a new equilibrium. This is done in an iterative fashion. First using updated housing supply and updated travel costs, but old wages and housing prices, new commuting patterns are predicted, from this new location choices for living and working are derived, which in turn are used to derive wages and housing prices. The process then repeats this by using these new values to again re-estimate the commuting intensity. This is iterated until the values converge and a new is equilibrium is assumed to be found, or if after 100 iterations there is still no convergence.

After convergence, we end up with counter factual equilibria for each of the policy alternatives, including the distribution of people and jobs, wages and housing prices. Giving us the necessary data to answer the main research question and sub-questions.

Assumptions

The ‘economy’ in terms of jobs is endogenous in this model, it is the sum of all flows into a certain municipality. Contrary to the amount of housing, the number of jobs is not easily controlled by the government, but more a result of choices of individuals. The goal of this thesis is to research the effects of potential policy on the economy. Therefore, the effects of the policy (infrastructure and the location of housing) are taken as a given. And the changes in the location of jobs and commuting patterns are an outcome of the model.

The attractiveness of a place to live or to work are both split in an endogenous part in the form of land prices and wages respectively, and an exogenous part as amenities and local productivity respectively. For the calculated of a counter factual to be valid it is assumed that the exogenous part is constant, these can then be estimated from the real-world data (Redding and Rossi-Hansberg, 2017).

The model also assumes some general constants to be true, these are labelled α, β and γ. The first is the sensitiveness of people to changes in attractiveness of working of living somewhere. For low α people don’t care much where they live and spread more equally among the country, with high α people react very much and are eager to move places or switch jobs if the rent is lower or wages higher somewhere else. To estimate this parameter data on wages in every municipality would be needed. Then the estimated workplace fixed effects from the gravity model would be equal to $\alpha\, log(w_d)$ from equation (3). Because the wage data is not available. In the study of US commuters by Monte et al. (2018) an estimate of $\alpha = 3.30$ was found, Ahlfeldt et al. (2015) found an estimate of $\alpha = 6.83$ when studying data from Berlin from 1986 and 2008. These average to 5.507, so for the rest of this thesis the value of $\alpha = 5$ will be used.

The second, β, is the proportion of their income that people spend on housing. According to the CBS (2022c) this was 29 percent for the average Dutch person in 2021. Since the empirical estimate for the size of agglomeration effects of surrounding countries is 4.5%, it is reasonable to assume that the agglomeration effects of The Netherlands are about the same. Therefore, I take $\gamma = 0.045$.

The commuting data available is at the level of municipalities, therefore the travel times must also be calculated from the level of municipalities. In the case of this thesis, to keep things manageable, each trip is assumed to be started and ended from the geographical centre of the municipality. Moreover, from these centres the travel times are calculated as travelled along the digital representation of the respective transport networks, using the appropriate speeds. In the case of cars this using local road, provincial road and high-way networks, using 50, 100 and 120 km/h as the speed respectively. In the case of the train a combination is used. First the time it takes to walk at 5 km/h over the local road network from every municipality to every train station is calculated. Then the travel time between each train station pair over the rail network at 140 kilometres per hour (the max-imum speed of trains in the Netherlands). Finally, these two are combined to get the quickest way from each origin municipality to each destination. This is of course not very accurate, since the geographical centre is by no means where people actually live. And in the case of train also because it doesn't consider the various timetable for public transport.

Finally, the equilibria that are found are assumed to be unique.

Data

To estimate the parameter of the model outlined in the previous part, I use commuting intensity database "Werknemersbanen en reisafstand; woon- en werkregio" from the Dutch national statistics bureau (CBS, 2024a). The database contains an estimation of the absolute number of commuters between every two municipalities in The Netherlands and is updated every year. The CBS collects this data based on a trade register, tax and insurance information, and a yearly survey to Dutch firms. All of these are combined and adjusted for representativity.

From this database I use the commuting intensities from December 2022, and from this I discard the commuting data to and from the Wadden Islands. The only way people get to and from here is using a ferry, discarding the islands makes the rest of the analysis a lot easier because when calculating the travel frictions, I don't have to consider travel times by ferry. It is not likely that this will have a noticeable effect on the results as the number of people living and working on these islands is very small. Also, international commuting is not considered, as this is not tracked by CBS at the municipal level, so there is no data.

The second data source is the cadastral map of all infrastructure in The Netherlands called ‘Basisregistratie Topografie’ and published by Kadaster (2023). This dataset combines the layout data of all physical topographic items and spatial planning data. There are several sets with different levels of details, from these I use ‘TOP500NL’ which is detailed enough for the purposes of this research. The data from this set that I use are the geographical layout of the Dutch road and rail networks.

To support the analysis, I used several other supplemental data sets. To match the identification code of each municipality with their name I used the list of all municipalities on January 1 of 2022 from CBS (2022a). I used the data set ‘Wijk- en buurtkaart 2022’ (CBS, 2022b), which contains data on a range of characteristics of the municipalities, combined with geographical data. From this set I only used the geographical layout of the municipal borders. Finally, a data set ‘Stations 2022’, consolidating data from the NS (the Dutch national train company, which also owns all the train stations) API made by ‘Rijden de Treinen’ (2022). This data set contains all train stations on the Dutch rail network and their location in the period between January 2021 and September 2023.

Scenarios

The planning report (Stuurgroep Lelylijn, 2024a) proposes four different variants to develop the Lelylijn. All with different amounts of housing and distributed differently among the municipalities in the region. And they work with two reference scenarios: the first using estimates of existing development plans and the second with added houses. Both reference cases don’t include building a new railway.

First, I will shortly explain the idea behind each variant and then show in two tables the corresponding numbers. Table 1 shows these amounts, in both relative and absolute numbers.

The first variant concentrates extra new housing evenly among all towns except the largest two. The corresponding Lelylijn would be a sprinter train with a lot of stops connecting these smaller communities. This way it creates a collection of central places like in the theory of Walter Christaller (See Spatial Economics).

The second variant aims to save the open green space of the north. Extra new housing would be mainly concentrated in urban municipalities, along the Lelylijn, not the rural municipalities (Urk, Westerkwartier and De Fryske Marren) and would take no new green area. To prevent a negative impact on nature, the train would be a slower one that can still stop at all small towns as well.

The third variant aims to create an urban network. The Lelylijn connects the urban areas to create the agglomeration advantages in these places by giving them ‘borrowed size’, and by connecting them to the large economy of the Amsterdam region. This includes building a lot more housing concentrating it in the larger towns. The smallest villages (Urk, Noordoostpolder and De Fryske Marren) only benefit by being close to places with better jobs and amenities, but do not benefit directly from the development and do not grow.

The final variant to investigate focusses only on the biggest cities. The Lelylijn in this concept only stops in those cities and would be part of an international line from Amsterdam to Bremen and Hamburg in Germany that only stops in Groningen. In the scenario all the extra housing would be in the (domestic) endpoints of the railway: Leeuwarden and Groningen.

Table 1: Housing programs

Municipality	Currently	Reference	Variant 1	Variant 2	Variant 3	Variant 4
Leeuwarden	64 500	71 800	+ 0 (+0%)	+ 7 244 (+10.1%)	+ 6 684 (+9.3%)	+ 10 371 (+14.4%)
Groningen	138 500	170 500	+ 0 (+0%)	+ 17 202 (+10.1%)	+ 15 871 (+9.3%)	+ 24 629 (+14.4%)
Westerkwartier	26 900	29 100	+ 5 434 (+18.7%)	+ 0 (+0%)	+ 2 709 (+9.3%)	+ 0 (+0%)

Smallingerland	25 200	25 000	+ 4 669	+ 2 522	+ 2 327	+ 0
			(+18.7%)	(+10.1%)	(+9.3%)	(+0%)
Heerenveen	23 300	25 300	+ 4 726	+ 2 553	+ 2 355	+ 0
			(+18.7%)	(+10.1%)	(+9.3%)	(+0%)
De Fryske Marren	22 400	22 800	+ 4 258	+ 0	+ 0	+ 0
			(+18.7%)	(+0%)	(+0%)	(+0%)
Noordoostpolder	19 900	24 300	+ 4 538	+ 0	+ 0	+ 0
			(+18.7%)	(+0%)	(+0%)	(+0%)
Urk	6 600	6 600	+ 1 232	± 0	± 0	+ 0
			(+18.7%)	(+0%)	(+0%)	(+0%)
Lelystad	35 800	54 300	+ 10 143	+5 479	+ 5 054	+ 0
			(+18.7%)	(+10.1%)	(+9.3%)	(+0%)
Totaal	363 100	430 000	+ 35 000	+ 35 000	+ 35 000	+ 35 000

Table 1 shows the housing numbers from the scenarios worked out in absolute and relative numbers. To emphasize the effects of all the variants, I use a stylized version of the numbers given by the report (Stuurgroep Lelylijn, 2024a). First of all, in the suggested building programmes the number of new houses is not equal for every scenario. Since we are interested in the differences in effects that comes from different distributions of new houses rather than from different amounts, the number of new houses is equalized to be 35.000 new homes. Because of this choice, the second reference variant, whose only differences is more houses, becomes irrelevant, and it is not used in this study. Furthermore, the differences between variants are exaggerated to make the difference in results more pronounced.

This is in part because the report doesn't mention all numbers, but mostly the differences between the scenarios are exaggerated to make the differences in results more pronounced. This is done by giving each municipality an equal (in percentages) increase in size. The differences between scenarios are then which of the municipalities get extra housing. So for example, in scenario 1 every municipality grows with the same percentage except for Leeuwarden and Groningen. This way it is easier to compare the ideas behind the scenarios and the effect of their implementation.

Table 2 shows the differences between the variants of the Lelylijn that go with each scenario. These are taken directly from the NOVEX report.

Table 2: Overview of the different Lelylijn variants

			Part of Lelylijn?			
Station	Municipality	New?	Var. 1	Var. 2	Var. 3	Var. 4
Leeuwarden	Leeuwarden	No	X	X	X	X
Groningen	Groningen	No	X	X	X	X
Leek	Westerkwartier	Yes	X	X	X	
Drachten	Smallingerland	Yes	X	X	X	X
Heerenveen-Noord	Heerenveen	Yes	X	X		
Heerenveen	Heerenveen	No			X	X
Joure	Fryske Marren	Yes	X	X		
Lemmer	Fryske Marren	Yes	X	X		
Emmeloord	Noordoostpolder	Yes	X	X		X
Urk-Emmeloord	Noordoostpolder	Yes			X	
Urk	Urk	Yes	X			
Lelystad	Lelystad	No	X	X	X	X

Remarks: An 'X' marks that the station would be a station along the new railway in that variant; when it is 'New?' that means that the station does not yet exist (as part of a different railway).

Results

The first result, shown in Table 3, is the fixed effects regression on the commuter data. As explained in Methodology, this is necessary to estimate the parameters in the model. In column (1) are the results of a fixed effects regression with only the travel time by train as a covariate. Column (2) is the same but with only the travel time by car. Column (3) has both, and column (4) includes the 'within' term as well, which is a dummy for when the origin and destination are the same municipality. The unit of all the travel times is seconds and commuter flows are in absolute numbers. The fixed effects are also estimated, but not displayed, all 115,600 of them would not fit in a table.

The effects of all covariates in all four columns are statistically significant with a p-value below 0.01, so moving on, we can use the fourth model with all covariates. Because the regression is a log-log regression, the value of the covariates can be interpreted as follows: For example, in column (4), when the travel time by train between a certain origin destination pair is raised by one percent, the number of commuters goes down by 1.305 percent on average.

From the results it becomes clear that commuters in The Netherlands in 2022 are more sensitive to time by car, than time spent in the train. A decrease in drive time would result in an increase of commuter by more than 2.5 time more than a similar decrease in train time. This could be simply the result of more people taking their cars to work than a train, but more data would be needed to confirm that.

This means that if the goal is to encourage people to commute between two municipalities for example to let them live in the north and work in the west of the country, the commuting flows would rise more with a similar decrease in travel time by car. In other words, it might be better to improve road infrastructure instead of rail infrastructure. Also, if we don't consider that people might move or change jobs because of infrastructure, improving rail infrastructure would only increase commuting flows (assumably by rail) and not decrease them, if the goal is to reduce commutes by car, it might be wiser to slow down car infrastructure instead, which would considerably reduce commuting flows (assumably the ones by car).

The R^2 is up to 0.92 which means that the fit of the model is good, and the covariates and fixed effects explains almost 92 percent of the variation of the log commuter flow.

Table 3: Regression results

	Log commuter flow			
Variable	(1)	(2)	(3)	(4)
Log travel time train	-6.516217***		-3.348614***	-1.305113***
	(0.1645141)		(0.1677733)	(0.1078274)
Log travel time car		-1.349101***	-.7369453***	-3.166474***
		(0.0096156)	(0.0255768)	(0.0560542)
Within				-8.003403***
				(0.2037397)
Constant	58.58988***	15.70089***	38.41106***	40.62619***
	(1.290153)	(0.067199)	(1.184295)	(0.7014669)
Observations	115,600	115,600	115,600	115,600
Pseudo R^2	0.8105	0.8110	0.8553	0.9164

*Remarks: Standard error in parenthesis; * p<0.10, ** p<0.05, *** p<0.01.*

The intermediate result, the coefficients of the explanatory variables and fixed effects, are then used to calculate the exogenous parts of the attractiveness of living and working in every municipality. These are used to calculate the counter factual scenarios, giving the following results.

Economy

We want to test the hypothesis that the building of houses increases jobs in those municipalities, at the expense of municipalities in the vicinity, and that this job growth is bigger when it is more concentrated. Further, we hypothesized that the building of the Lelylijn will benefit the west more than the northern cities.

Table 4: Absolute job growth in the Lelylijn municipalities

	Job growth			
Municipality	(1)	(2)	(3)	(4)
Groningen	1011	6260	6404	8945
Leeuwarden	513	2962	2762	3872
Smallingerland	1849	1096	1090	247
Heerenveen	2250	1137	1067	227
Westerkwartier	1427	122	820	141
De Fryske Marren	1526	100	93	21
Noordoostpolder	2294	-13	-18	-40
Urk	1208	-20	-21	-24
Lelystad	3201	1626	1491	-54
Total:	15278	13270	13688	13334

Remarks: This table shows the change of jobs in absolute numbers, compared to the reference case, not compared to the current number of jobs!

First looking at the absolute jobs growth in all scenarios it becomes clear that all scenarios increase the number of jobs. In the municipalities where no new housing is projected, the increase in jobs is negligible, so the job growth probably comes mostly from the building of houses. This is also to be expected from the model: In the model jobs first follow people, with the 'centripetal forces' of agglomeration effects as Krugman (1991) calls it, pulling people to bigger cities and 'centrifugal forces' of travel costs pushing them back.

In Table 4 we can also see that in scenario (1) the overall growth of jobs is the biggest, while the new housing is the most spread-out of all scenarios. This result is exactly the opposite of the hypothesis. And can be explained by the fact that the higher wages coming from agglomeration benefits do not outweigh higher commuting costs for Dutch people. In other words, we can conclude that in the Dutch situation commuting costs win from agglomeration effects.

Table 5: Relative job growth in the Lelylijn municipalities

	Job growth (%)			
Municipality	(1)	(2)	(3)	(4)
Leeuwarden	0,63%	3,92%	4,01%	5,60%
Groningen	0,68%	3,91%	3,65%	5,11%
Smallingerland	5,96%	3,54%	3,51%	0,80%
Heerenveen	6,92%	3,50%	3,28%	0,70%
Westerkwartier	7,63%	0,65%	4,39%	0,75%
De Fryske Marren	9,42%	0,61%	0,58%	0,13%
Noordoostpolder	10,82%	-0,06%	-0,08%	-0,19%
Urk	12,20%	-0,21%	-0,22%	-0,24%
Lelystad	10,10%	5,13%	4,70%	-0,17%

Remarks: This table shows the relative change of jobs, compared to the reference case, not compared to the current number of jobs!

Furthermore, when looking at Figure 1 which shows the relative increase (green) or decrease (orange/yellow) of jobs in the whole country, several things become clear. First, the job market doesn't change noticeably in the municipalities outside of the Lelylijn area in any of the scenarios, with all other places seeing a similar decrease. There is a difference between scenario (1) and the rest, with the rest of the country losing more jobs in the first scenario. This can probably be contributed to the fact that the job change is relative, the first scenario has a bigger overall increase in jobs in the north, therefore a relatively bigger decrease in the rest (because the total amount of people going to work does not change). This is because we are using a general equilibrium model that can only tell something about distribution of people or jobs and cannot consider population growth or decline.

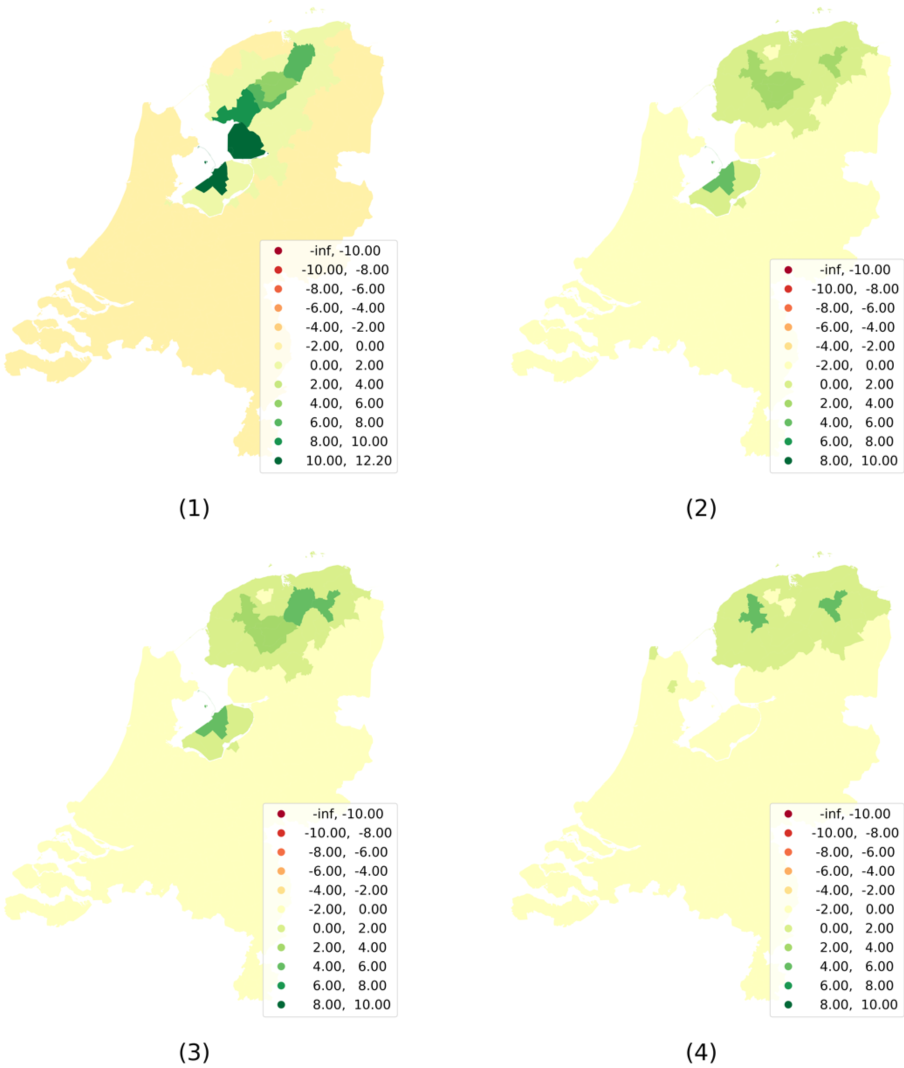

Figure 1: Estimated job growth (%) in all the scenarios

In Figure 1 we can also see the effect of the NOVEX development on surrounding municipalities. First of all, both the Lelylijn and the new housing seem to have little effect on cities in the west of The Netherlands, the change in jobs is mostly constrained to the places directly affected and those surrounding them. So, the hypothesis that the Lelylijn would mostly benefit the Randstad must be rejected.

Moreover, according to Figure 1 the places next to the Lelylijn municipalities don't seem to suffer from agglomeration shadow, on the contrary, these places benefit from an increase in jobs as well. This indicates that the borrowed size effect from Alonso (1973) is bigger than the Kruger's agglomeration shadow (1991) in this instance (and for this model).

Finally, there seems to be a limit to the maximum size of the area that profits from this growth. The benefits as shown by the maps generally don't go further than the province. Building housing in Lelystad for example benefits the whole of Flevoland, but doesn't go much further, the development in Leeuwarden in scenario (4) is good for Fryslân and two municipalities in North Holland, but not more. This can perhaps be explained by the fact that people aren't willing to commute more than that. Wages being higher in the west to begin with, combined with lower commuting cost could, within the framework of the model, persuade people to start commuting. This was also the hypothesis: After the Lelylijn was built, more people would commute to the west. The fact that this does not show in the results would suggest there is a limit to distance people are willing to commute and therefore a limit to the size of an area that can function as one city, at least without even quicker transport options.

Housing

The hypothesis for the second sub-question was that the cities with growing housing stock get more people, but that it should make surrounding municipalities less desirable to live in. And that the rise in attractiveness of the growing cities will be partly cancelled out when these cities are better connected, and therefore closer, by rail to larger cities in the west.

When looking at the population changes in Table 6, it shows that the population of the Lelylijn municipalities has grown in all the scenarios where there was housing built in that municipality and shrunk or stayed the same size when there wasn't anything built. Which is in line with the hypothesis.

Table 6: Relative change in population in all the scenarios

	Population Change (%)			
Municipality	(1)	(2)	(3)	(4)
Groningen	-0,22%	6,53%	6,06%	9,40%
Leeuwarden	-0,12%	6,11%	5,66%	8,73%
Smallingerland	10,39%	5,73%	5,28%	0,00%
Heerenveen	11,36%	6,12%	5,66%	-0,14%
Westerkwartier	11,23%	-0,11%	5,65%	-0,08%
De Fryske Marren	11,09%	-0,09%	-0,11%	-0,15%
Noordoostpolder	13,17%	-0,20%	-0,22%	-0,25%
Urk	11,69%	-0,22%	-0,22%	-0,23%
Lelystad	13,49%	7,30%	6,71%	-0,26%

Remarks: This table shows the relative population change, compared to the reference case, not compared to the current population!

Figure 2 shows the changes in population in percentages in the entire country in all the four different Lelylijn scenarios in comparison to the reference scenario. This confirms mostly the building programs, with the Lelylijn municipalities getting more inhabitants. But not exclusively, all the scenarios (including references) show some surrounding places growing as well. This exactly opposite of the hypothesis that making one city bigger should make the agglomeration shadow bigger, instead surrounding towns seem to profit from their growing neighbours. Again, the forces of borrowed size must be bigger than those of the agglomeration shadow, just like the results on jobs above.

Furthermore, there seems to be only an effect on 'one end' of the new railway in , the places which it connects to the northern cities i.e. Amsterdam, Rotterdam, Zwolle et cetera, show no change, other than the relative decline in population of the whole country (which is a consequence of the model as the total population is assumed to be constant). This contradicts the hypothesis that larger cities in the west will attract more people from the north. This might be because of the same effect as with the jobs, commuting from a place like Drachten (Smallingerland) to Amsterdam is just too far and no-one will start doing it.

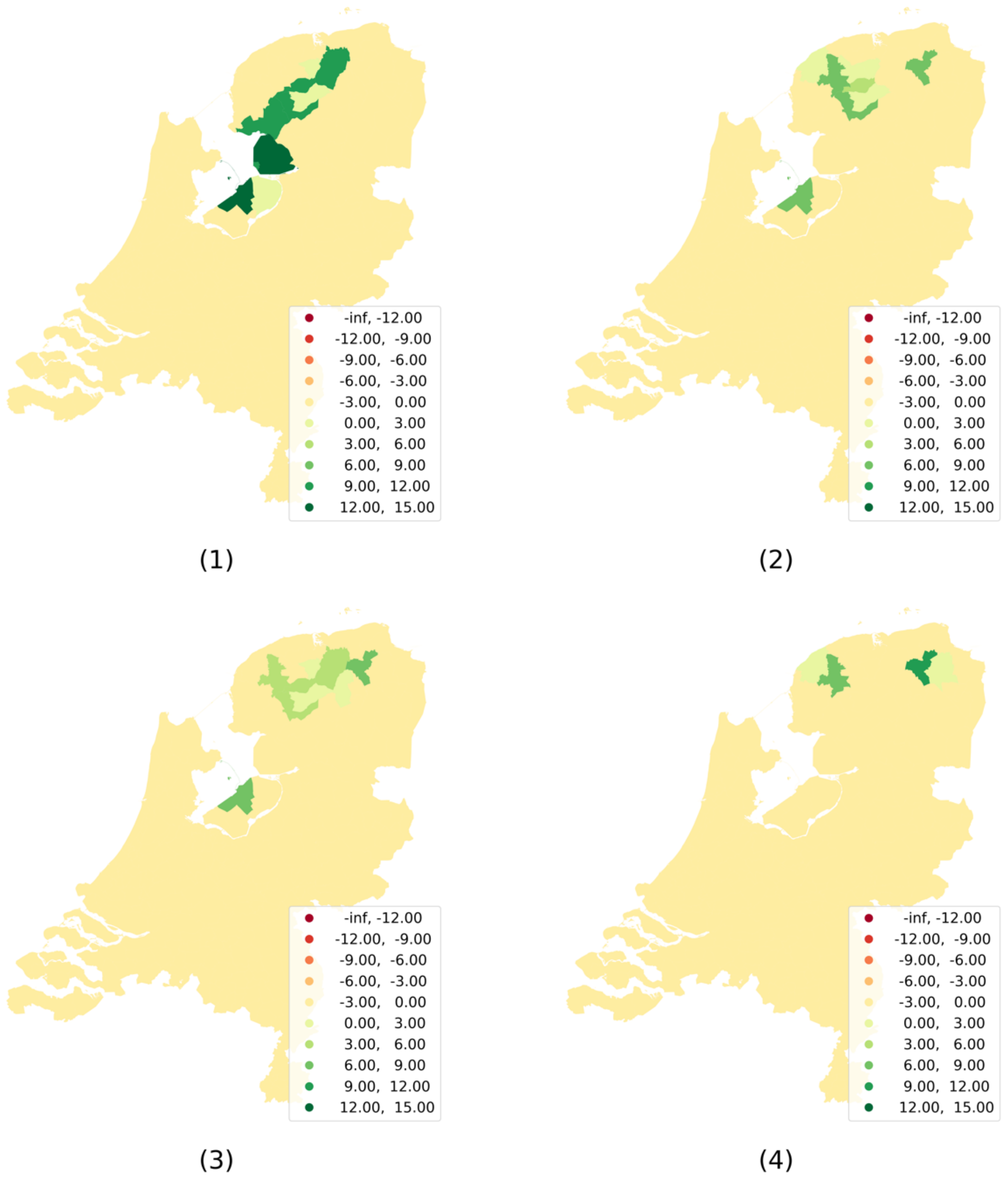

Figure 2: The estimated relative population changes in all the scenarios

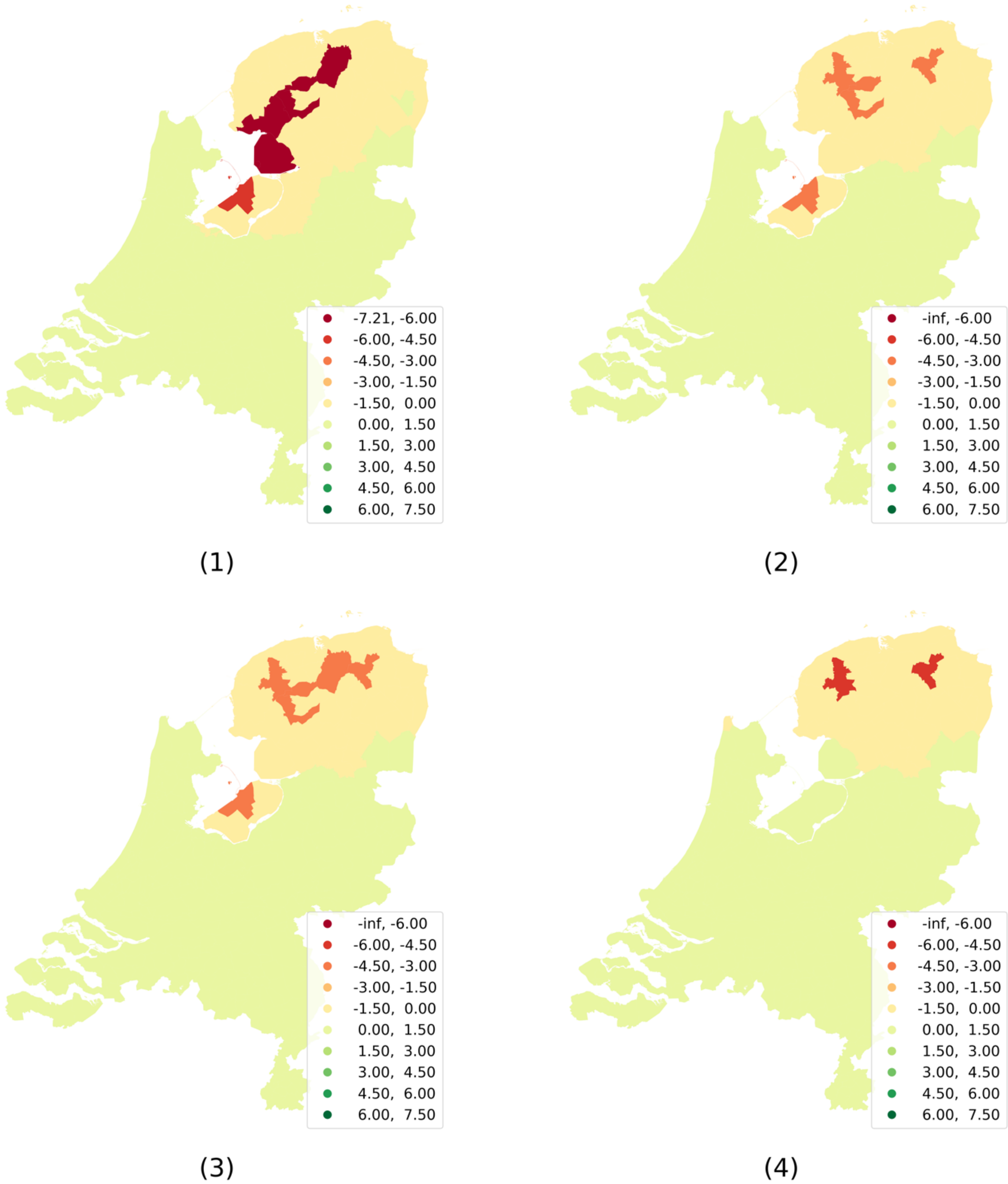

Figure 3: The estimated relative housing price changes in all the scenarios

Lastly, the housing prices react exactly as expected, as can be seen in Figure 3. They are falling more when more houses are built, and housing prices are falling in surrounding places, with prices going up in the rest of the country. This last effect is a consequence of the assumptions in the model, namely that Dutch people spend a fixed amount of their income on housing, and as income approximately the same (or rising slightly in the case of more agglomeration effects) the total consumption should also stay approximately the same. Which means that falling prices in one place must mean rising prices somewhere else.

From this we can conclude that the worries of some politicians (see Introduction) that better train connections would cause unaffordable houses for the local population, are unfounded and unnecessary, at least when the building of the Lelylijn is combined with the extra housing.

Table 7: Relative changes in cost of housing

	Housing price change (%)			
Municipality	(1)	(2)	(3)	(4)
Groningen	-0,05%	-3,71%	-3,48%	-5,17%
Leeuwarden	-0,06%	-3,89%	-3,63%	-5,40%
Smallingerland	-7,12%	-4,08%	-3,79%	-0,06%
Heerenveen	-6,80%	-3,85%	-3,59%	-0,07%
Westerkwartier	-6,69%	-0,14%	-3,63%	-0,18%
De Fryske Marren	-7,05%	-0,08%	-0,08%	-0,04%
Noordoostpolder	-6,65%	-0,01%	-0,01%	0,00%
Urk	-7,21%	0,00%	0,00%	0,01%
Lelystad	-5,94%	-3,37%	-3,12%	0,01%

Remarks: This table shows the relative change in housing prices, compared to the reference case, not compared to the current prices!

Transportation

Figure 4 shows the weighted average of the transport friction of all residents of a certain municipality. Because the model does not allow us to discern people who travel by car with people who take the train it is not possible to precisely characterize the changed travel behaviour, but the model used gives a proxy: the transport friction. This is the variable $t_{o,d}$ from equation (5) from the Methodology. It gives a generalized travel costs i.e. the generalized travel time between every origin destination pair. Assuming that the preferences estimated with the fixed effects regression don't change, the new generalized travel time can be calculated for the situation in which a Lelylijn is built. We also know the new commuting flows for every scenario, so we can use these to calculate the weighted average of generalize travel time for the residents of each municipality. Figure 4 show the relative change of this weighted average for each scenario compared to the reference scenario. The values in the figure can therefore be interpreted as the average commuting time.

The hypothesis for the final research question is that with better transport connections the number of commutes increases, that with more local jobs, commutes decrease, and in municipalities with both these effects counteract each other. It becomes clear from Figure 4 that with the building of the Lelylijn commuting increases dramatically among residents of the places that get a new station, or places close to new stations, confirming the first part of the hypothesis. Unlike with jobs and population from the previous result, the changes here don't coincide with the building of houses. In all scenarios the municipalities of Smallingerland and Noordoostpolder see the biggest increase in commuting. This is explained by the fact that these are two municipalities that currently have no train stations. The figure shows a decrease of commuting for the rest of the country, but being somewhere between one and zero percent, this is a negligible effect, especially compared to the increases elsewhere.

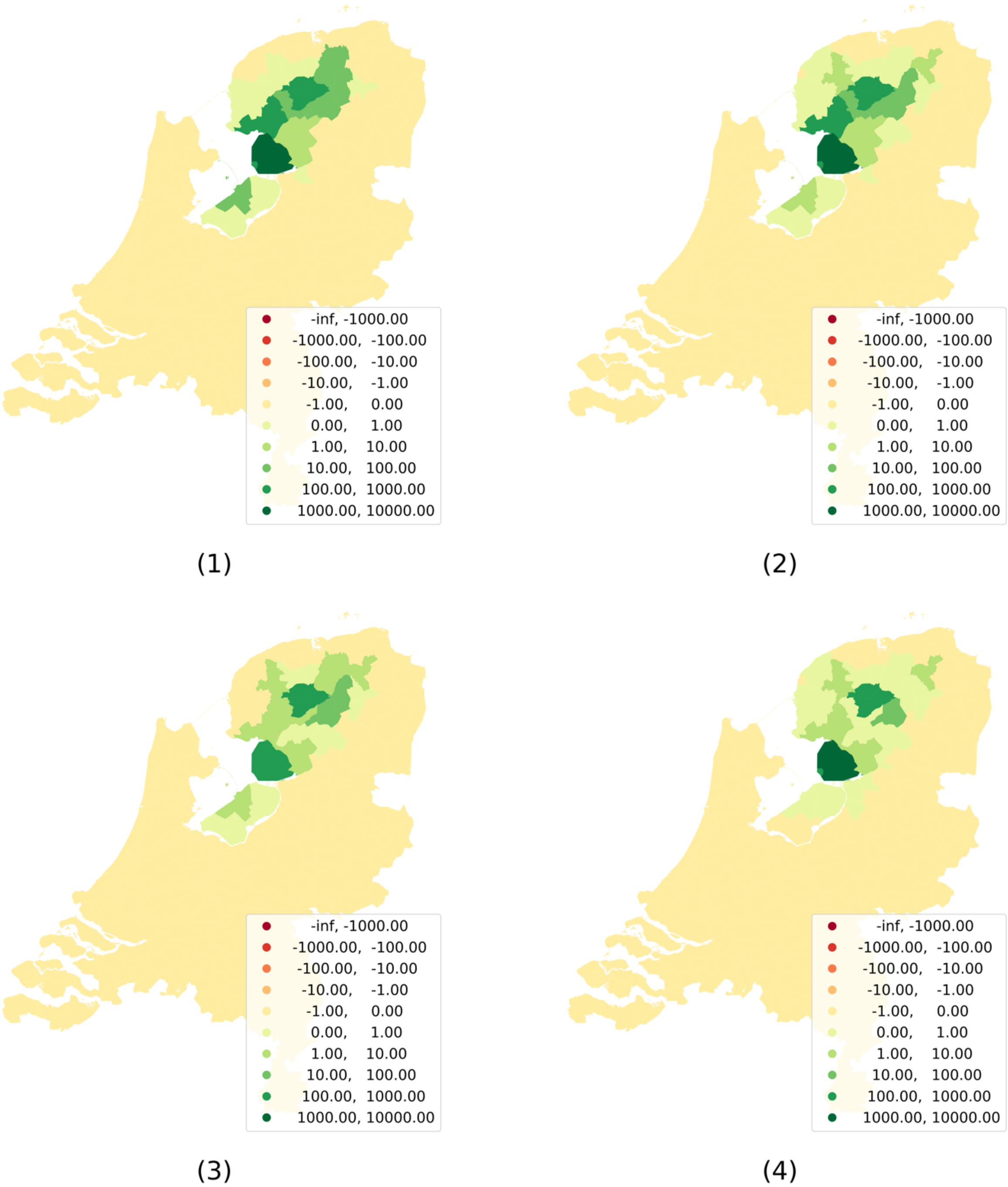

Figure 4: Relative change (%) of average transport friction in all scenarios

Also, for all scenarios it is clear that when housing is built in a certain place and as a consequence the number of local jobs increases as well, commuting there increases. This is in contradiction to the hypothesis. This can be explained by the fact that although the number of jobs will increase with the number of people, the increase in people is in most cases still even higher. And the difference between these two variables must mean that some of the new habitants must commute, increase average commutes.

The last part of the hypothesis, namely that effects counteract each other in municipalities with growing employment and new railway stations clearly not the case. This must be due to the fact that, as said in the previous paragraphs, the increase in local jobs does not decrease commuting.

The overall effect of all development scenarios seems to be a dramatic increase in commuting, which is also contrary to the policy aims of the government.

Discussion

Looking at the economic effects, the results show that spreading out new development leads to the biggest increase in jobs. Meaning that the effect of commuting costs is likely stronger than the agglomeration advantages in the north of The Netherlands. In other words, jobs in the north would still not be concentrated enough so that the resulting wage increase from agglomeration benefits is high enough for people to accept the cost of commuting. The results also show that any economic effects are mostly restricted to the area where the development is happening. The job market in rest of the country neither benefits nor hurts from the Lelylijn or the increase in houses, whereas it considerably benefits the north. Finally, there seems to be no noticeable effect of agglomeration shadow in this case, the whole of the north reaps from the positive changes of all development alternatives.

The second part of the results looked at the effect on housing. The results shows that the population will grow where housing gets built and otherwise shrink or stay the same size. This population growth spills over to adjacent municipalities as well, meaning that there doesn’t seem to be much agglomeration shadow. Furthermore, just as with the job market, the rest of the country experiences almost no effects from any of the development alternatives.

Housing prices go down in all scenarios and more so when more houses are built in a certain city, and this effect spills over to surrounding places as well.

The final part of the results shows the effects on commuting patterns. The model makes it difficult to study these effects, but a few conclusions can be made. The building of the Lelylijn leads to a large increase in commuting, especially in places that didn't have access to a train station before. These changes have very little to do with where houses are built, suggesting that the effect is indeed from the new infrastructure and not from the housing development. However, the building of new housing in cities and towns does seem to lower the commuting flows, contrary to the prediction. Overall, commuting increases in every scenario.

It has to be kept in mind that every prediction made in this report is only an educated guess, its resemblance to any real-world outcome depends heavily on the assumptions in the model, the validity of the data and interpretation. There is no way to accurately give a statistical significance to the predicted outcomes (that I know of). Empirical studies have shown that these types of models that are based on commuting data can be biased (Donovan et al., 2023).

There are some inaccurate assumptions used in this report (a by no means exhaustive list). First of all, there is empirical evidence that commuting intensities reacts to travel times in a different way than assumed in this model, with the coefficient being different for long and short trips than for intermediate length trips (Johanson et al., 2003). The way travel times were estimated in this research is also inaccurate. Assuming trips start from the geographical centre of a municipality is a crude solution. Also, when calculating the travel times for trips on a train, no regard was paid to train schedules or the fact that there are other forms of public transit.

Furthermore, in the general equilibrium model it is assumed that the total population is constant, it does not consider population growth. Since the realisation of this project is likely to take some years, if not decades, it is unrealistic to assume the population levels will be the same as they are now. And there are many more simplification and assumptions.

Conclusion

This thesis has tried to give an answer to the following research question:

What would be the effects of the different scenarios from the NOVEX exploration for building the 'Lelylijn' on economic and social factors in the northern provinces of the Netherlands?

I have shown that in all scenarios the effects are overwhelmingly positive for the northern provinces of the Netherlands. Job opportunities increase, housing prices go down, and the fears of some that it would be other regions of the country that would benefit from this development at the expense of the northern provinces, or the fears of rising prices have been shown to be unfounded. Furthermore, I have shown that is not only a select few places that benefit from the proposed development, but that the advantages are spread among the whole north to an extent.

The results of all different scenarios are similar and to say which one would be preferable over the others would be impossible at this point. And it is also not the point of this research or the scenarios. The model, however, has given some useful insights, although crude results. Different scenarios lead to different distributions of jobs and people. And any choice includes a number of political trade-offs. To be able to better analyse the effects on for example changes in modal split, more academic research needs to go into better quantitative spatial models.

Finally, to make a policy recommendation more research needs to be done on the costs of building this infrastructure, in a full social cost-benefit analysis. Also, this project does not exist in a vacuum, there are other plans and realities that are affected by and have an effect on the decision to build one of these development alternatives. Any final decision needs to take this interaction into account. But based on the results from this research, it seems like building the Lelylijn and the proposed housing development program would be good idea. Moreover, one of the goals of this government project is to facilitate a shift in mode from cars to trains and the results from this research show that the opposite would be achieved. Therefore, the recommendation of Holz-Rau and Scheiner (2019) of making car infrastructure less attractive should be researched in combination with investments in new railways.

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