A Socio-Spatial Impact Assessment of Public Transport Service Reductions and Reorganizations in the Northern Netherlands

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Summary

The Netherlands, especially the northern provinces of Drenthe, Friesland, and Groningen, has recently experienced a reduction in public transport availability and reliability due to neoliberal policies such as privatization, austerity, and cost-cutting. This study seeks to examine the recent reductions in transportation services in the three aforementioned provinces and understand and analyze their impacts. The study utilized a mixed methods approach to conduct a socio-spatial impact assessment, using primary data from questionnaires regarding travel behavior and social attitudes, and secondary data from databases regarding regional bus service frequency and land values of different land uses. Analysis of the secondary data finds no correlation between changes in bus service frequency and total land values of the municipalities in the study area, showing that there was no spatial impact. However, the analysis of the primary data shows that bus service reductions have had a social impact, in terms of changes in behavior of those who used public transport services which were reduced in frequency. Multiple respondents reported changes in social habits, work and education schedules, and the shops they patronized, demonstrating a limited socio-spatial impact. A majority of those sampled were students, leading the research to highlight the social impact of public transport reductions on students. Future research should aim to include more respondents and data sources covering a broader population and area.

1. Introduction & Background

With the advent of neoliberal-style governance in Europe more broadly, and in the Netherlands specifically, infrastructure systems throughout the continent and the country have continuously undergone reorganization and, occasionally, reductions (Peters, 2012). One of the sectors in the Netherlands which has experienced the most visible changes as a result of these policies of privatization and network reorganization is public transport (Veeneman & van de Velde, 2014). Accordingly, the geographic spread of places in the Netherlands with better public transport connectivity than automobile connectivity has *decreased* in recent years (NOS, 2023). The regions with the most prominent decrease in public transport connectivity are rural areas (NOS, 2022). The provinces which have experienced the largest reductions in bus service in terms of areas served and frequency are Groningen and Drenthe, with reductions among the public transport operators, QBuzz and Arriva (NOS, 2023). These reductions have significant implications for the population of the northern Netherlands, the most prominent being the limitation of the ability of residents to easily reach grocery stores, hospitals, and schools by public transport (NOS, 2023). In other words, reductions in public transport services have a direct impact on the geographic distribution of accessibility and, therefore, a socio-spatial impact, theoretically. A socio-spatial impact is characterized by a combination of social impact and spatial impact. Social impact can be measured in terms of social attitudes and behavioral changes in the travel patterns of those affected (Esteves et al., 2012), and the spatial impact can be assessed using data concerning the use and valuation of land (Schreurs et al., 2023). No such assessment has yet to be conducted (neither in English nor other languages) on the

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socio-spatial impact of public transport service reductions (and reorganizations) in the north of the Netherlands, demonstrating the relevance of the research. Social impact assessments of public transport reductions have previously been conducted in other regions, but they have not focused on socio-spatial impact, instead electing to solely analyze demographic or health data (James et al., 2014; Kar et al., 2022).

Drawing on the background, this study sought to answer the following research questions and sub-questions:

What is the socio-spatial impact of the reductions in public transport services in the north of the Netherlands (Groningen, Friesland, Drenthe), particularly as it relates to accessibility?
- How do changes in public transport services affect the valuation of land (of different land use categories) in the municipalities experiencing changes?
- What are the attitudes of individuals and the behavioral changes individuals make in response to reductions and reorganizations in public transport services in their municipalities?

1.2 Structure
Firstly, the theoretical framework of the research will be explained and graphically depicted in a conceptual model in order to clarify the approach of the research. This section will also aid in justifying the methods which are at the core of the research. Secondly, the methodology will be clearly explicated to ensure the methods used to collect and analyze the primary and secondary data are understood. An adequate understanding is necessary to clearly present the results of the data collection and analysis in the results section. The results will be further discussed in relation to the theoretical framework in the discussion section. Finally, the most significant results will be summarized in the conclusion along with a reflection of the limitations of the research and potential future directions for the research.

2. Theoretical framework
The most important theoretical concepts in this research are: accessibility, social impact assessment, and spatial impact assessment. In this study, in line with the definitions in previous academic research, accessibility refers to the ability of traveling with ease to places of importance, such as residences, commercial sites, and workplaces, especially among individuals using public transport (Geurs & Van Wee, 2004). According to Geurs and Van Wee, the components of the theory and measurements of accessibility include *land use*, *transport*, *time*, and *people* (2004), all of which are accounted for in the research undertaken.

Social impact assessment is defined as the methods of measuring and understanding the effects of infrastructure projects on a population, which can be conducted using a variety of methods, including using demographic data (Esteves et al., 2012), health and economic indicators (James et al., 2014), and social attitudes (Kar et al., 2022). Social attitudes and behavioral changes in response to public transport reductions, including location choices, were

emphasized in the data collection and analysis of social impact. Here location choices refers to the choices of people regarding their place of residence, of employment and education, and the shops they frequent (Zondag & Pieters, 2005). All of these choices can be made in relation to accessibility provided by areal public transport services (Zondag & Pieters, 2005). These topics of research link to the elements of accessibility (*people*, *time*, and *transport*), because changes in public transport services affect the travel time of passengers. In response to lengthened journey times, people express certain attitudes towards these changes, especially because of the travel-behavioral changes and location choices they may have to make in response to these changes. Thus, capturing all of these aspects is crucial in a social impact assessment of public transport reductions and an assessment of their overall impact on accessibility (Esteves et al., 2012; Kar et al., 2022). In order to adequately provide information regarding the social impact, the research focused on the variables of attitudes and behavioral changes, including those related to location choices. Accordingly, the research sub-question concerned with social impact can be posed: *What are the attitudes of individuals and the behavioral changes individuals make in response to reductions and reorganizations in public transport services in their municipalities?*

Considering the geographically varying impact of changes in public transport on the accessibility of certain locations, spatial impact assessment is also a crucial concept. Spatial impact refers to the impact of changes in public transport on various aspects and measures of the built environment such as land value, land use, and building density (Bocarejo et al., 2013). The concept of spatial impact directly implicates the aforementioned concepts in the accessibility framework: *land use* and *transport*, as accessibility of different uses of land and the transport systems which construct that accessibility is the focus of accessibility analyses. Since the research area covers a large area, with communities varying in terms of urban-rural typology, spatial impact will be researched using the land values of different land use categories as a measure of the effect of public transport services on the built environment. Formulated as a research sub-question, the aim and the methods of the research can be articulated as: *How do changes in public transport services affect the valuation of land, of different land use categories, in the municipalities experiencing changes?*

Importantly, land value also relates to location choices, a measure of social impact, which affects land value in aggregate, as location choices affect the demand for land and land uses of varying types (Srour et al., 2002; Zondag & Pieters, 2005). Given this link between the social and spatial impact assessments of changes in accessibility, the two types of impact assessments can be synthesized and reconciled to form an accessibility-focused socio-spatial impact assessment. Thus the primary research question of the study is: *What is the socio-spatial impact of the reductions in public transport services in the north of the Netherlands (Groningen, Friesland, Drenthe), particularly as it relates to accessibility?*
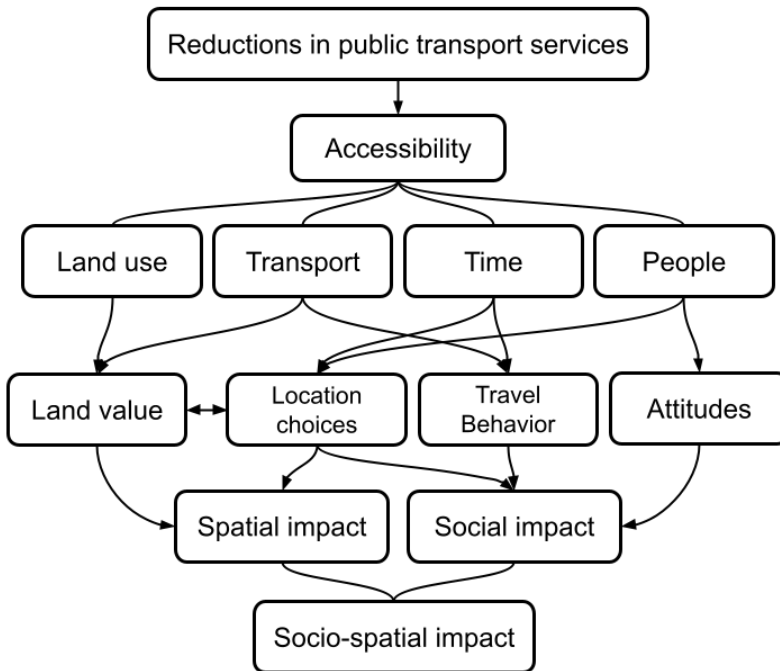
3. Conceptual Model

Figure 1: Conceptual Model of Research

As can be observed in Figure 1, the research approach is a socio-spatial impact assessment, with an analytical framework of accessibility. Starting from the top, the public transport reductions are the central focus in this study. The changes in public transport impact the accessibility of the areas served by public transport, and thus, affect all of the factors of accessibility (*transport*, *land use*, *time*, *people*). The effects of changing accessibility include the effects on *people* who use public transport and effects on their travel *time* using public transport. These effects can be researched by examining the *attitudes*, *travel behavior*, and *location choices* of people affected by changes in accessibility, all of which produce a measurable *social impact*. The effects of changes in accessibility can also include changes in the demand for property of differing *land use* categories, since the connectivity provided by (public) *transport* is altered. The changes in demand for different land uses results in varying *land values*, which is also reflected by changes in the aforementioned *location choices*, both factors contributing to a measurable *spatial impact*. Combining the social and spatial impact informs the choice to utilize research methods that can best be described as a *socio-spatial impact* assessment.

4. Methodology

A mixed methods approach was employed to collect and analyze data relevant to the research question and sub-questions. Considering the divergent nature of the research necessary to assess the socio-spatial impact, specifically as it relates to accessibility, the research

addresses each specific sub-question as a means of providing an answer to the primary research question.

In order to answer the first research sub-question the collection and analysis of secondary data consisting of public transport frequency and land values of different land use categories in the region being studied was conducted. This analysis involved spatial-temporal data consisting of bus stop locations and the bus service frequencies of the lines at each bus stop from two different years, 2013 and 2020, in the municipalities in the north of the Netherlands (Figure 2). This data was sourced from public transport open data website openOV, from which the files "trajecten.csv.gz" and "2013-trajecten.csv.gz" were downloaded (OpenOV, 2021). This analysis also involved data consisting of land values of municipalities in the Netherlands, the dataset for which was downloaded from the national Dutch statistical bureau's (CBS) website, under the name "Waarde onroerende zaken van woningen en niet-woningen 1997-2020" (CBS, 2020). This data specifically consisted of the total land values of all the properties in each municipality in the Netherlands, the total value of all residential and non-residential properties in each municipality, and the average value of residential properties in all of the municipalities in the Netherlands, broken down by each year from 1997 to 2020.
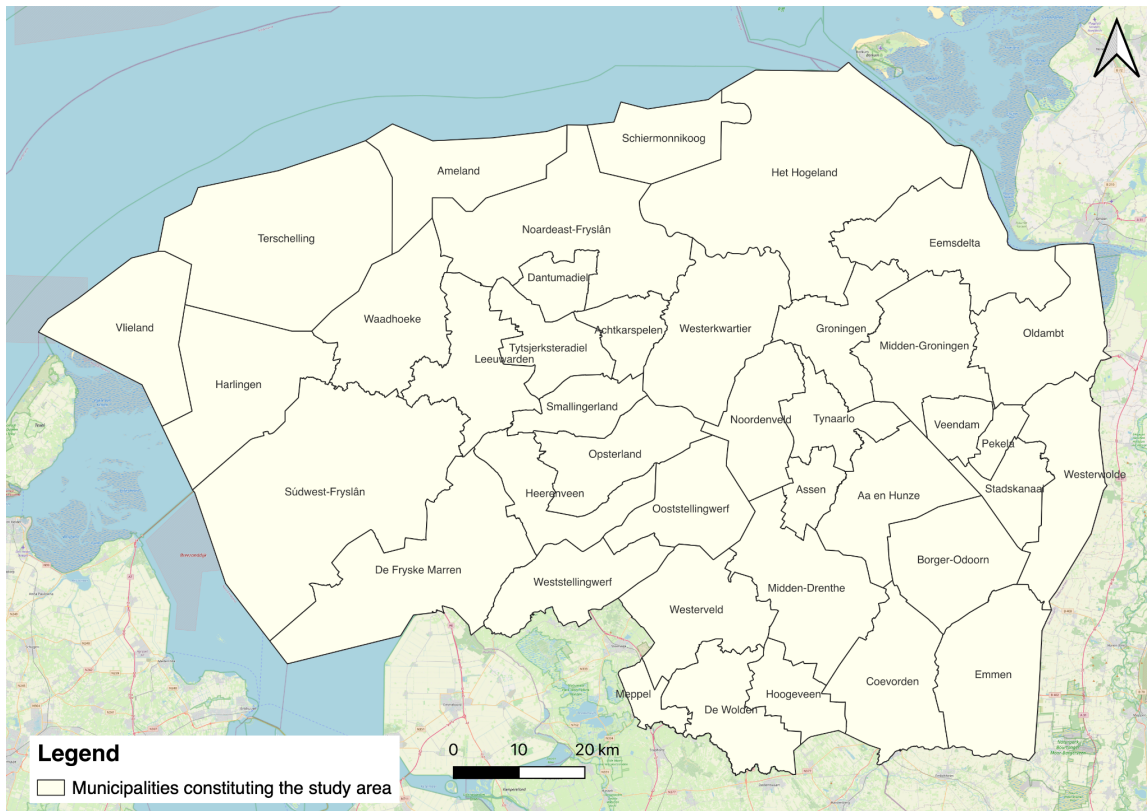

Figure 2: Municipalities being studied. Data sourced from Kadaster (2023).

In order to properly compare the data, QGIS was used to reformat the data and tabulate the relevant data points for each municipality using a Kadaster dataset with municipal

boundaries sourced from the Dutch government's open data hub website PDOK. The file downloaded with this data was 'Administratieve Eenheden (INSPIRE geharmoniseerd)' (Kadaster, 2023). In QGIS, the aforementioned bus stop locations were compiled into each corresponding municipality, with the weekly bus service frequency for 2013 and 2020 tallied up in each municipality. Then, in the dataset with frequency totals, the changes from 2013 to 2020 in frequency totals were calculated to produce the critical statistic regarding changes in the bus frequency in each municipality. The changes from 2013 to 2020 in land values of each municipality were calculated separately in Microsoft Excel. The original data with changes in the total land value of all properties, residential properties, and non-residential properties was already formatted to reflect the relevant data at the municipal level. The data was subsequently compiled into the dataset along with the changes in bus service frequencies, which produced the dataset with changes in all types of data represented as positive and negative proportions. The changes in municipal-level bus service frequency and municipal-level land values were subseuqently analyzed using a simple linear regression analysis, with changes in bus service frequency on the x-axis and changes in property value on the y-axis.

In order to answer the second sub-question (*What are the attitudes of individuals towards reductions and reorganizations in public transport services in their municipalities, particularly as it relates to their decisions of where to reside?*) and to contribute to an understanding of the research problem laid out in the main question, specifically regarding the social impact, an online questionnaire was developed to record the behavioral changes among individuals affected by public transport service reductions. This questionnaire, found in the appendix, includes questions about different aspects of the personal impact of public transport service reductions, inquiring about the behavior and attitudes in response to the reductions of those aware or affected by the reductions. The questionnaire asked its respondents to specify if they still rely on public transport in this case, or if they have had to rely on other modes of transport. The questionnaire also asked respondents to share their level of satisfaction with their modal switch because of public transport reductions. Finally, the questionnaire inquired about how the changes in public transport services have affected their regular routines and the effect of the reductions on decisions about mobility and where to live. This section included questions asking respondents to specify the weight, on a 1-10 scale, the importance of living near frequent public transport service. These questions in particular helped provide data on the location choices of those affected by reductions in public transport services. The questionnaire also asked respondents for demographic information, such as age, gender, employment or student status, and income. This was necessary to ensure conclusions regarding the data did not generalize for all populations, and necessary to acknowledge limitations of the research, but also helped identify the social group which provided most of the responses: students. This also helped inform the discussion of the results, focusing on the perspective of students regarding social impact.

The sampling methods employed to recruit participants involved non-probabilistic sampling methods, namely convenience and snowball methods. The convenience sampling

method was employed by contacting students who attend the Rijksuniversiteit Groningen. Snowball sampling was employed by asking the students participating in the questionnaire to distribute the questionnaire among their peers. In total, the goal of the questionnaire was around 70 responses, using 90% confidence intervals and 10% margins of error, and accounting for the combined population of the three provinces that the research was conducted in. A higher than average sampling bias should be acknowledged because of the sampling methods employed to distribute the questionnaire and collect responses. The limited reach of the research effort meant distribution was not widespread with limited responses. As a result of the limited means of distribution, the main demographic group which responded to the survey were younger people, students, and those with lower incomes, ostensibly living in proximity to their campus. Students, however, also provide an important perspective on issues around public transport. Their reliance on the service because of lower than average incomes and inner city living makes them uniquely vulnerable to issues related to public transport reductions (De Angelis et al., 2021; Sun et al., 2018).

Regarding ethical considerations, the collection and analysis of the qualitative data is the only category of data being collected which may have presented ethical issues. One ethical concern which should be acknowledged is the positionality of the author of this study, who has only been a resident of the regions of focus for a short time (three years), limiting perspective on specific regional issues in this realm. This is important because the respondents might have included residents of rural areas of the region, which have a history of being negatively stereotyped (Rijnks & Strijker, 2013). However, the likelihood of the data and analysis being influenced by these stereotypes is low, considering that the qualitative data is asking respondents to share opinions in response to public transport reductions, rather than asking more specific questions about the urban-rural typology of their region of residence. In order to ensure accuracy of the data and minimize potential (aforementioned) biases, the collection and analysis of this qualitative data was conducted in a consensual and confidential manner. There were no inquiries into personal information from the questionnaires, maintaining the respondents' anonymity. Data collected from the questionnaires was stored in a secure online student account, and was deleted after the analysis of the data was complete and the research report was written.

In the research, it was hypothesized (H1) that the reductions and reorganization of public transport services have a measurable socio-spatial impact in the study area, especially in the aforementioned categories of behavioral changes, social attitudes, and land values. Regarding changes in the use and valuation of land, it was expected that municipalities which experience a reduction in public transport service experience a decrease in land values, in all land use categories. Specifically, the R-squared of the linear regression analysis comparing the change in bus service frequency and property values will equal 1, and the associated correlation coefficients will equal 1 or -1. This was premised on the results of prior research which have demonstrated the reverse trend: that land values, of all land use categories, increase with an increase in public transport service (Du & Mulley, 2006). Regarding social

attitudes and changes in behavior, it is expected that residents will express feelings associated with disenablement and being neglected and make travel behavior changes, as has been illustrated in prior research into the social impact of public transport service reductions (Kar et al., 2022; Neudorf, 2021).

The null hypothesis (H0) for this research posited that there is no evidence for any measurable socio-spatial impact of the public transport reductions and that there was no evidence shown for any discernible correlation between public transport reduction and changes in land value of various land use categories. The null hypothesis stated that the respondents to the surveys had no reaction to the changes in public transport service and made no changes to their travel behavior and location choices.

5. Results

5.1 Primary Data

The results from the questionnaire show that the data collected is skewed regarding the demographics of the respondents. The relatively low average age (95.65% under 30) corresponds with the high proportion of respondents who were students (62.96%) (Figure 3). Just over half of the respondents identified as female (56.52%), and of the 33.33% of respondents who are employed, a majority (61.11%) made under 20,000 Euros per year in pre-tax income, and no respondents stated that they made over 60,000 Euros per year in pre-tax income (Figure 4).
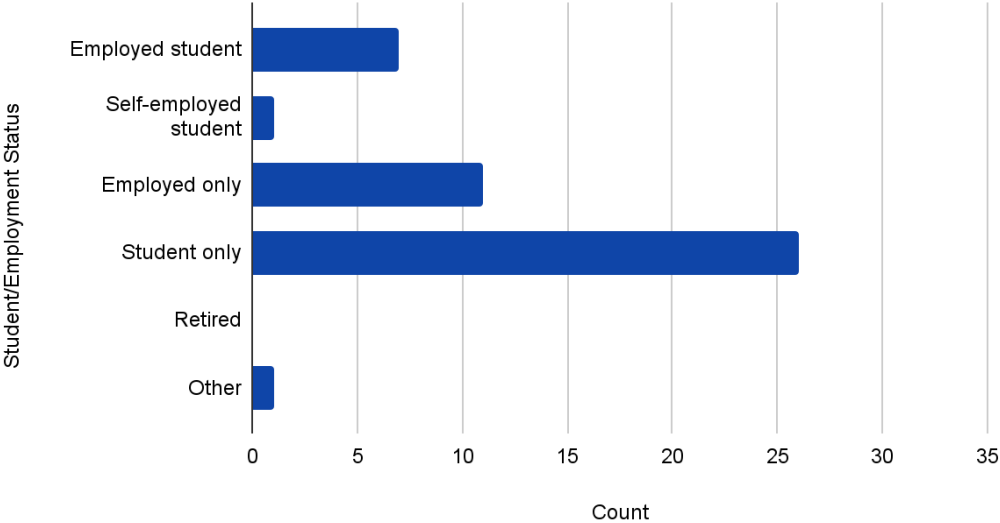

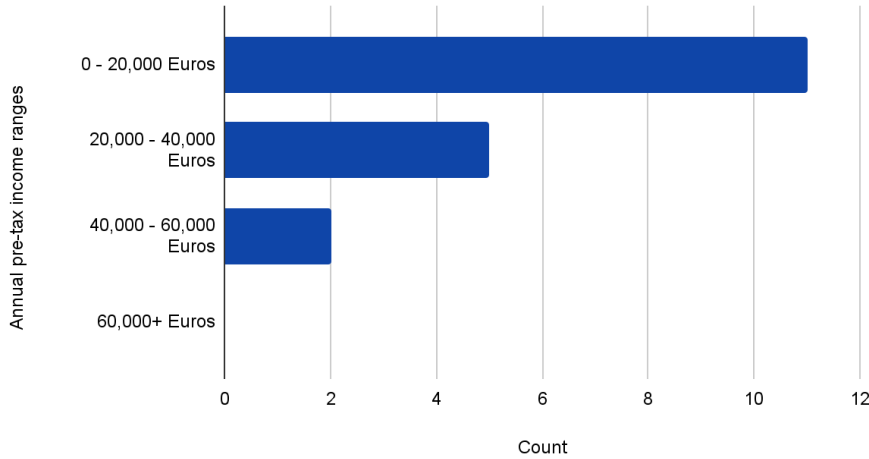
Figure 3: Student/Employment status breakdown

Figure 4: Wage breakdown of questionnaire respondents

Regarding travel behavior, the largest proportion of respondents commuted to work or school by public transport (41.03%), with a smaller proportion of those who cycle (38.46%) and a smaller but still significant proportion of drivers (12.82%) (Figure 5). However, 44% of respondents cycled to shops, while only two stated that they use public transport to travel to shops (5.56%).
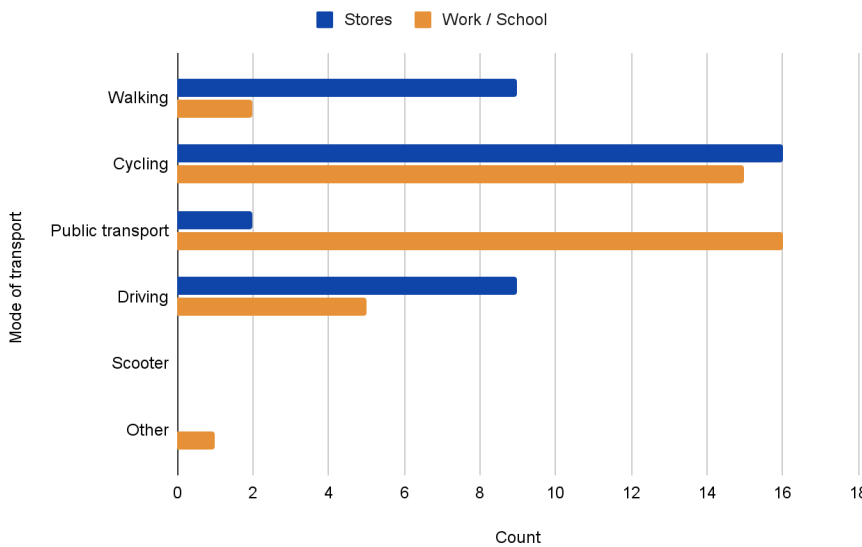

Figure 5: Modes of transport used by respondents for commuting to work/school and traveling to shops

Regarding attitudes towards public transport and the importance of it in choices around where to live, work or study, 48.48% of respondents weighed the importance of working and studying nearby frequent public transport at 8, on a Likert scale from 1 to 10 (Figure 6). Another 21.21% of respondents weighed the importance of working and studying nearby frequent public

transport at 7, and only 12.12% of respondents weighed it at 6 or under (Figure 6). Similarly, a plurality (38.46%) of respondents weighed the importance of living nearby frequent public transport at 7, and only 15.4% of respondents weighed the importance below 7 (Figure 7). When asked to elaborate on the personal importance of living and working nearby public transport many of the respondents' comments centered around the potential but infrequent need for public transport's convenience. These comments included quotes such as "I like to be mobile, however I am not a frequent user of public transport" and "I think it's important so that it gives me more options to travel and more flexibility to my schedule. For example if I want to go out of the city I can bike to the nearest train station, park my bike and take the train" and quotes describing how it enables respondents to carry large loads: "it allows me to travel even with some heavier luggage because I don't have a car", but also, reflecting the lower scores: "I hardly used public transport to begin with and at the moment I don't use it at all".
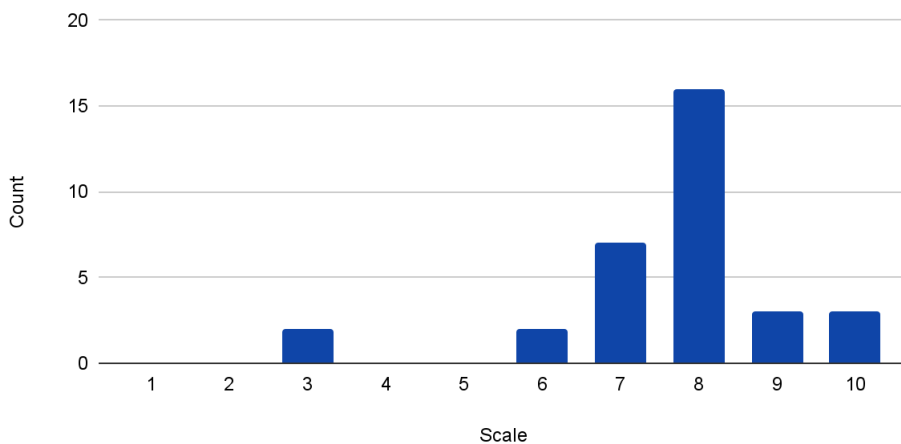

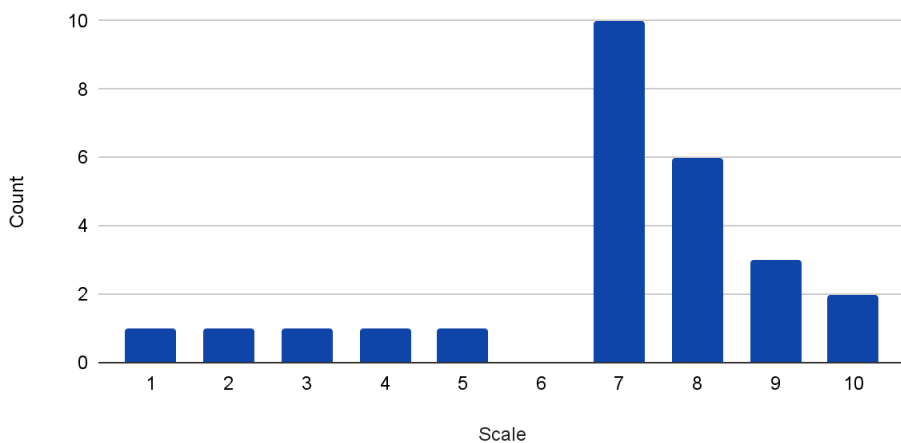Figure 6: Importance of working/studying nearby frequent and reliable public transport

Figure 7: Importance of living nearby frequent and reliable public transport
        Regarding the core of the research for which the questionnaire was designed to

capture, a majority (56.25%) of respondents stated that they were aware of reductions in public transport services in their vicinity. All of the services respondents were aware of being reduced were Qbuzz or Arriva buses, except for one respondent who said it was Arriva's train services. A majority of the respondents who were aware of the reductions in service reported that they were dissatisfied or highly dissatisfied with the reductions (Figure 8). When asked to elaborate, respondents' comments mentioned a new lack of accessibility and inconvenience:

"Less accessibility to other parts of the city"

"For moments I can't use [my boyfriend's] car it would be a pain in the ass to travel as a 5 minute walk to the nearest bus stop changed into a 15-20 minute walk"

However, one response mentioned a new, convenient side effect:

"Because the bus line 10 used to go across the Grote Markt in Groningen but now it takes a different route due to the construction in the Grote Markt. It takes longer to go to the train station but it doesn't take too long and its convenient that the bus stops in front of my house"
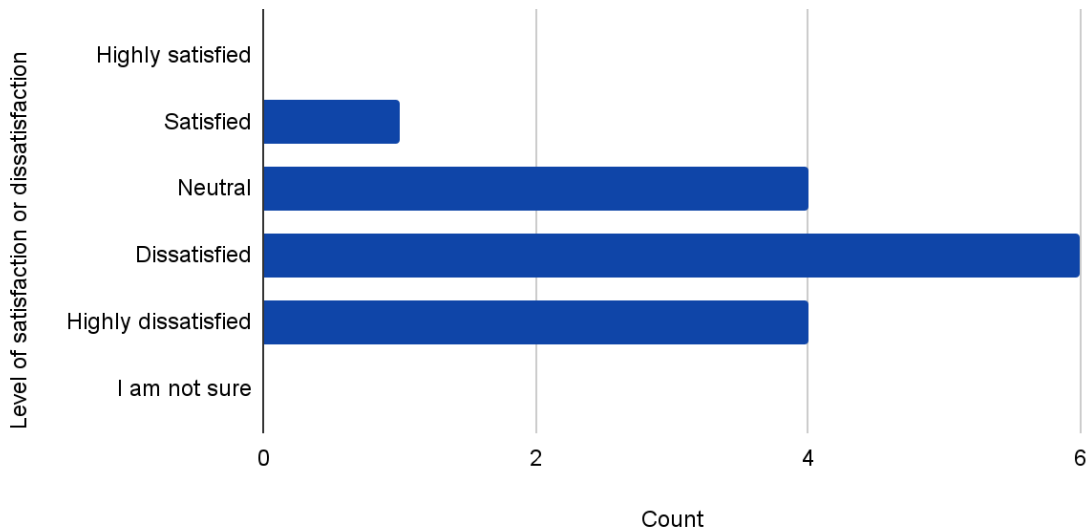

Figure 8: Level of satisfaction or dissatisfaction with changes in public transport services

A majority (67%) of respondents who were aware of the changes in public transport stated that they were affected, and all of those who said they were affected said their journey time was now longer. Of the small portion of respondents who were able to answer if they changed public transport, the modal choice was mixed, with one respondent switching to walking, one

to cycling, three to driving, and three remaining public transport commuters (Figure 9). Of the respondents who reported a switch or not switching, half said they were neutral to the modal switch, and one said they were unsure, with a minority reporting feeling satisfaction or dissatisfaction with the switch. The comments regarding the respondents' satisfaction and dissatisfaction with their modal switch or lack thereof were mixed, mentioning the positive and negative aspects of their modal switches:

"Driving makes you independent from public transport but it can be tiring and parking is not always convenient"

"Inconvenient but I like walking"

"Because it doesn't take too long. Still a few minutes later"

"They give me a new opportunity"

Most respondents said that they had not made any changes to their work, school, residence or other choices around location as a result of changes in public transport, but of those who did, two said they changed their hours of working, two attended school for less time each day, two visited friends or family less frequently, and four shopped at different locations (Figure 10).
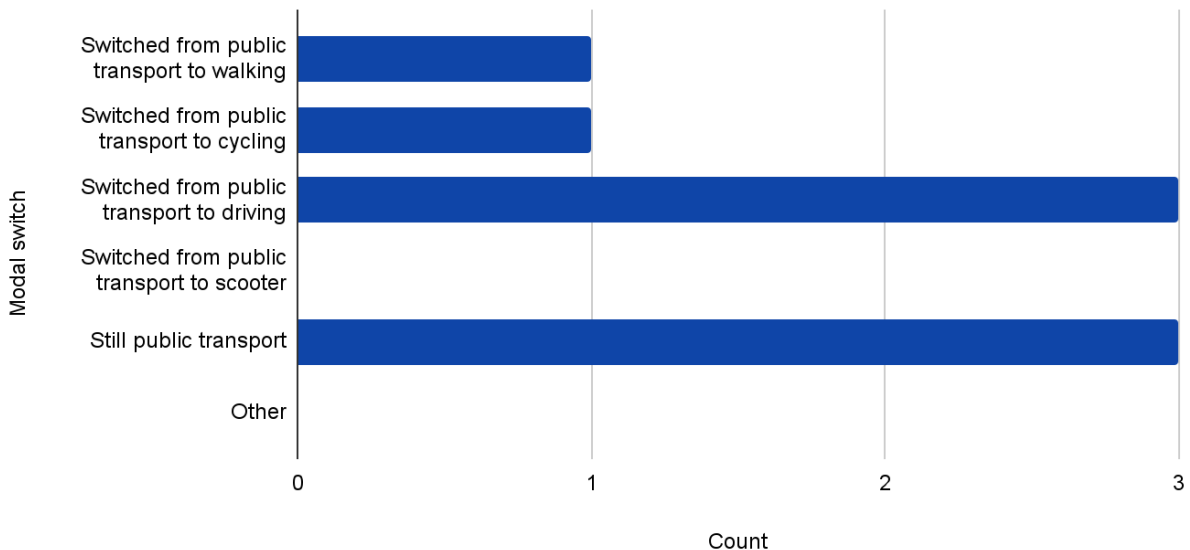

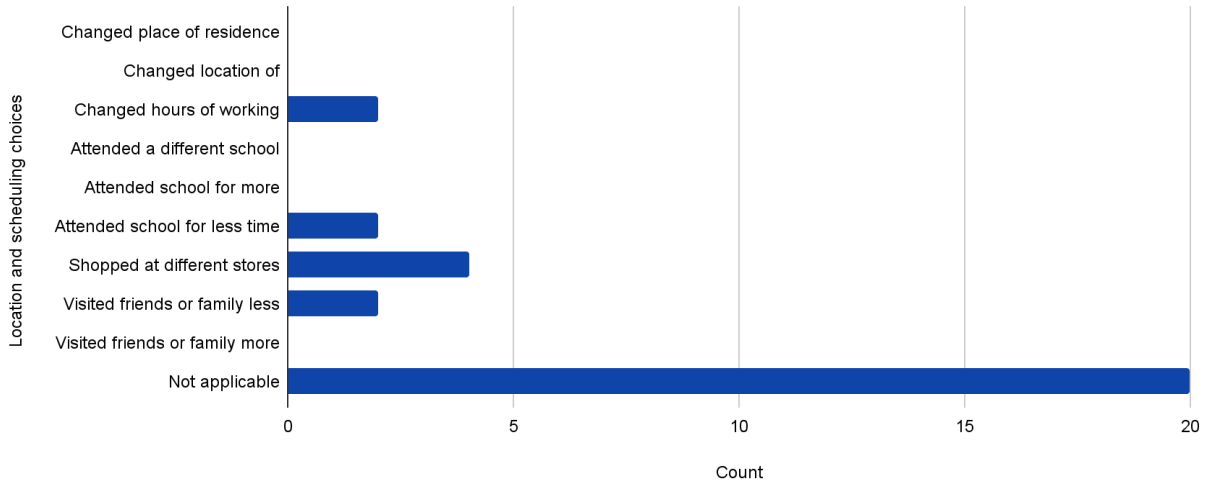Figure 9: Modal switches made by respondents

Figure 10: Location choices because of changes in public transport

5.2 Secondary Data

The results from the secondary data analysis show that there were increases in bus service frequency in 90.63% of the municipalities in the region being studied and the remaining municipalities experiencing a decrease (Figure 11). Most municipalities experienced an increase in total property value and total residential property value, while most experienced a decrease in non-residential property value (Figure 12; Figure 13; Figure 14). Regarding the core of the analysis, the results demonstrate there is no correlation between the change in land values of all land use categories and the change in bus service frequency (Figure 15 & Figure 16). The R-squared values of the three different analyses were either close to or equalled zero, and the associated correlation coefficients were -0.039 for the analysis between changes in bus service and in total property values, 0.018 for the analysis with residential property values, and -0.243 for the analysis with non-residential property values (Figure 15 & Figure 16). These results demonstrate that there is no correlation, and therefore the analysis undertaken and the results produced failed to reject the null hypothesis in the case of the research sub-question: How *do changes in public transport services affect the valuation of land, of different land use categories, in the municipalities experiencing changes?*
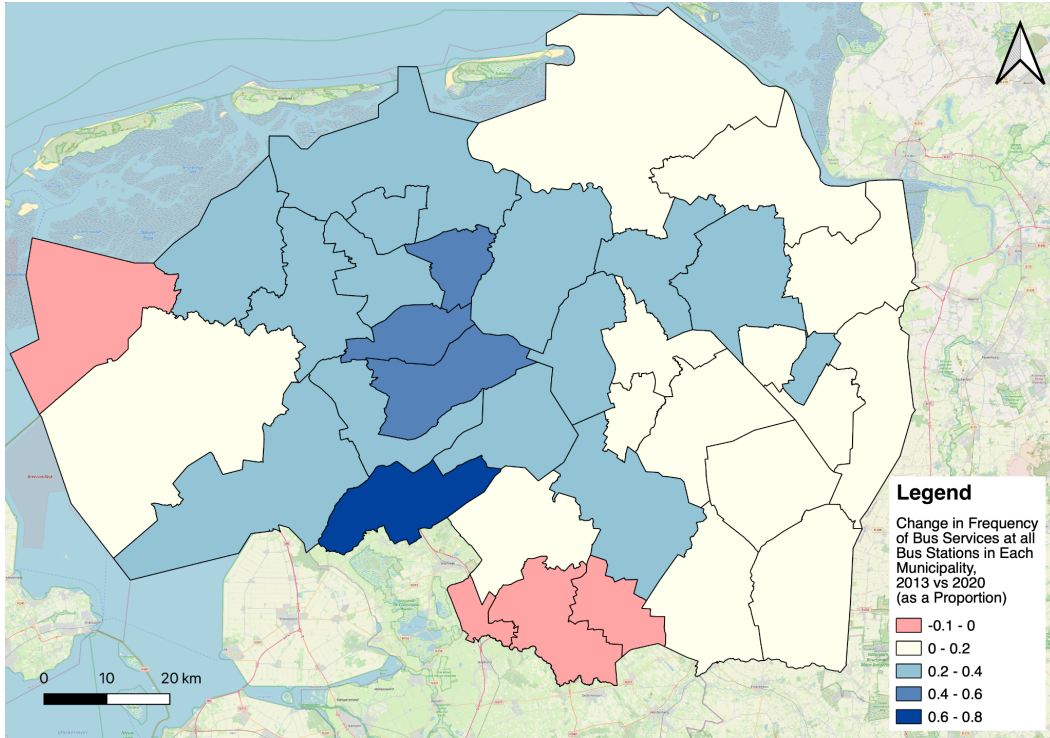
Figure 11: Change in frequency of Bus Services at all Bus Stations in Each Municipality, 2013 vs 2020. Data sourced from OpenOV (2021).
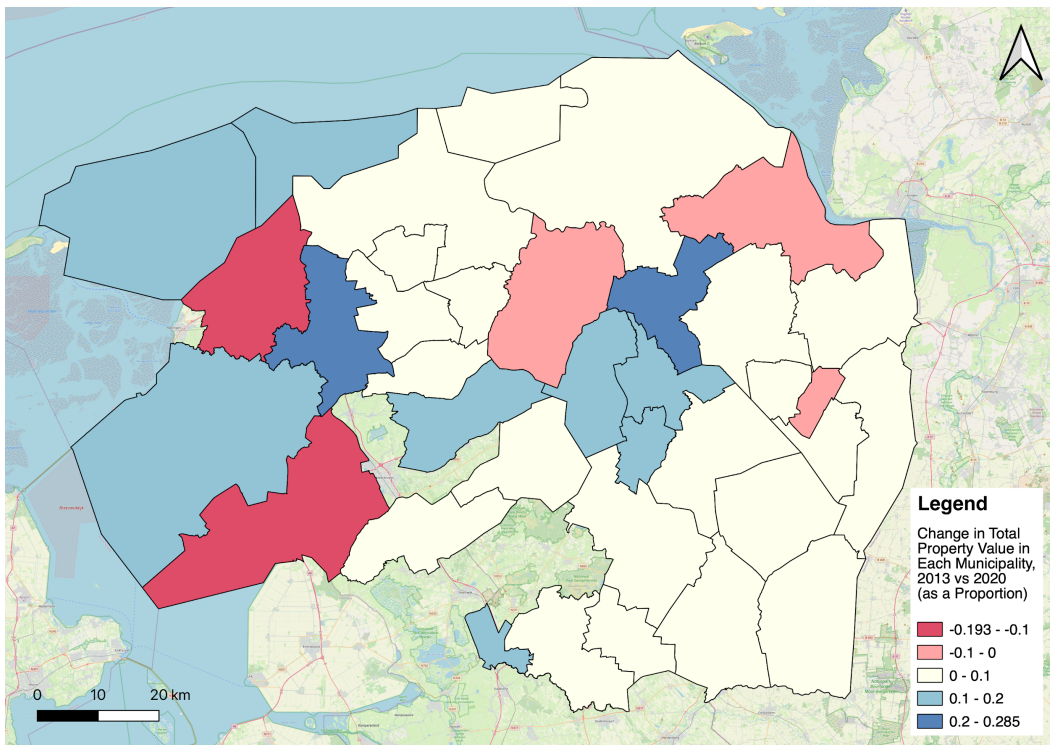

Figure 12: Change in Total Property Value in Each Municipality, 2013 vs 2020. Data sourced from CBS (2020).
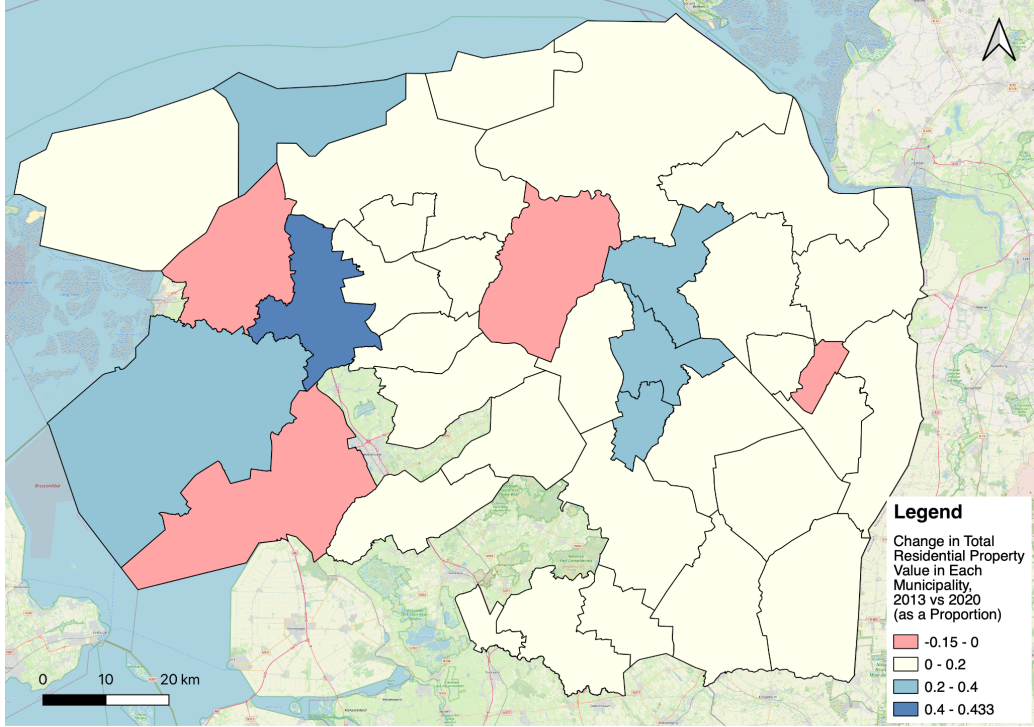
Figure 13: Change in Total Residential Property Value in Each Municipality, 2013 vs 2020.
Data sourced from CBS (2020)
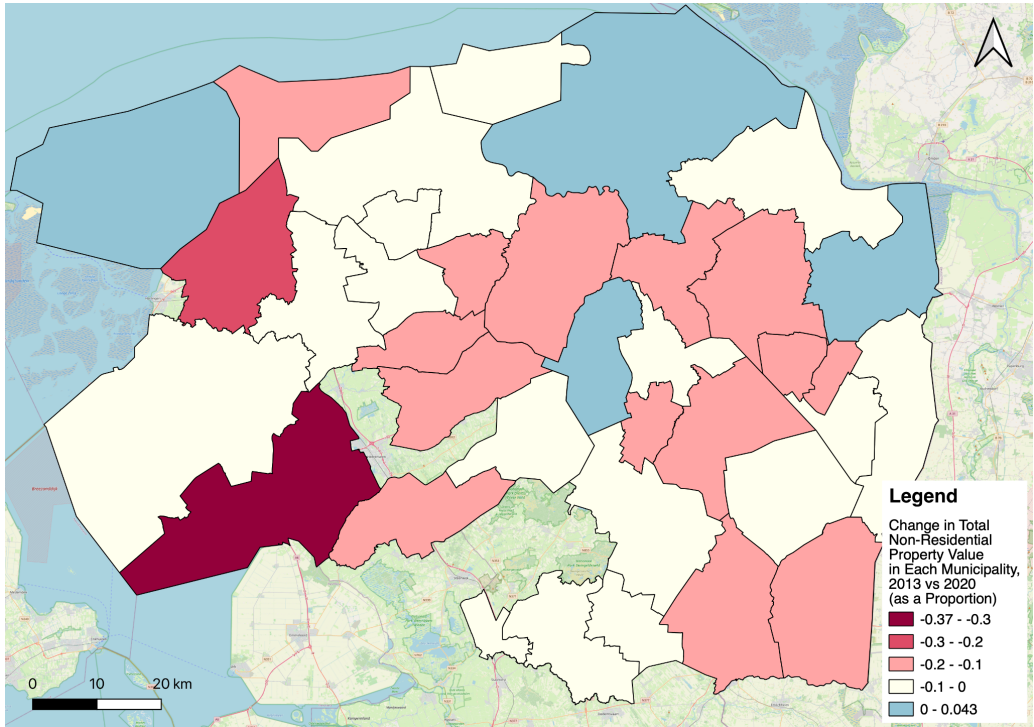
Figure 14: Change in Total Non-residential Property Value in Each Municipality, 2013 vs 2020. Data sourced from CBS (2020).

Figure 15: Change in bus service frequency vs change in total property value, 2013 vs 2020. Data sourced from CBS (2020) and OpenOV (2021).
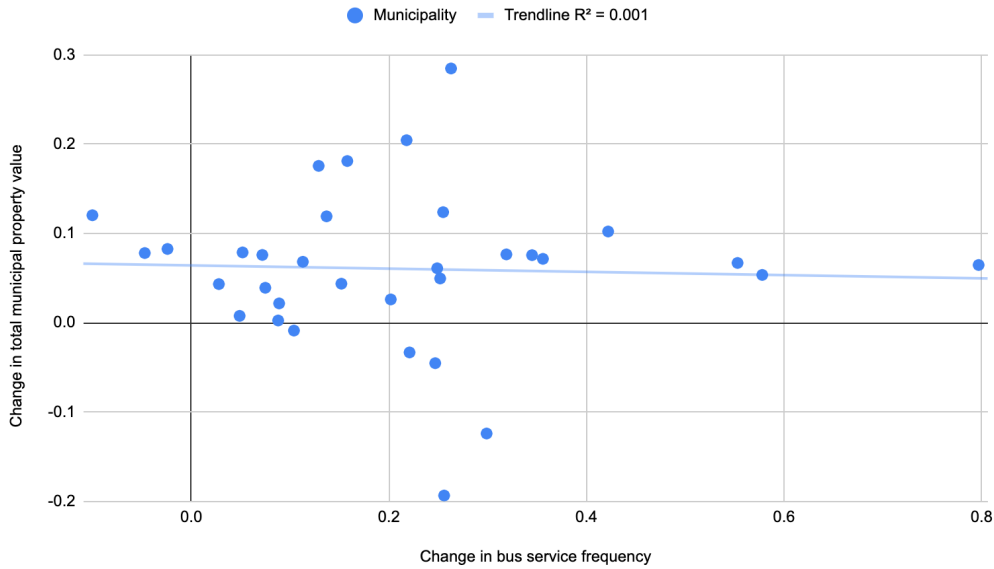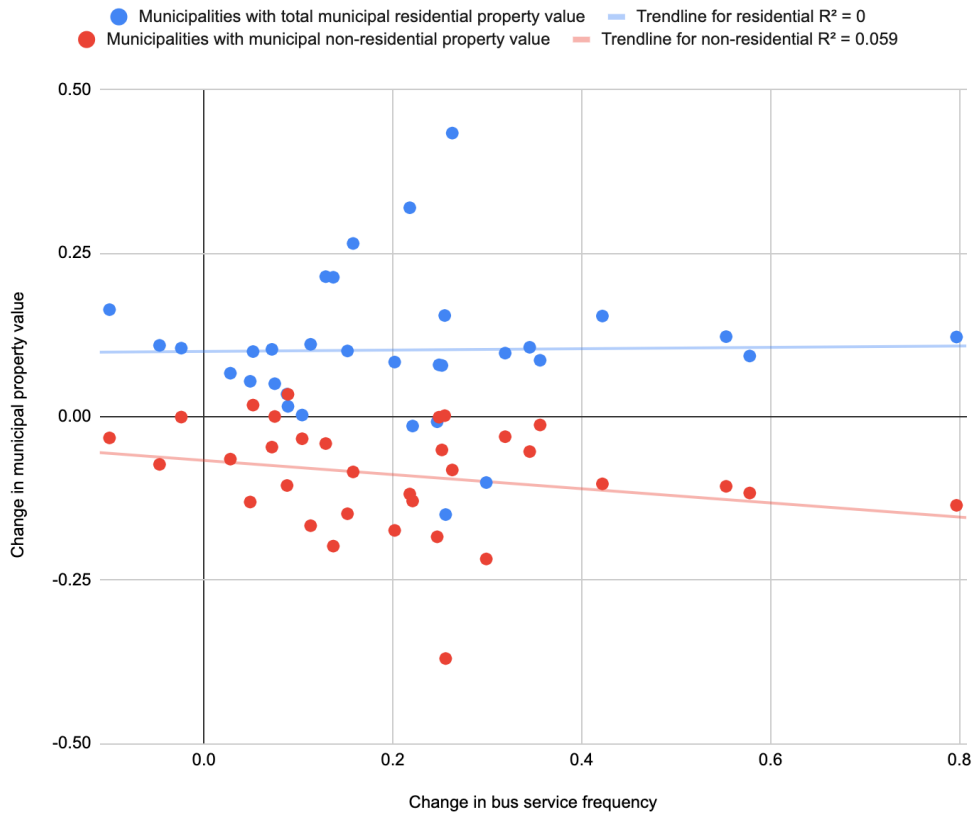

Figure 16: Change in bus service frequency vs changes in total municipal residential and non-residential property values, 2013 vs 2020. Data sourced from CBS (2020) and OpenOV (2021).

6. Discussion

When analyzed through the lens of a socio-spatial impact assessment, the primary data results demonstrate that a social impact of the reductions on the respondents was recorded, but was divergent in its effects according to the various measures of social impact. When examining the results from the primary data regarding those who relied on public transport which was reduced in frequency, it was recorded that they all experienced an increase in travel times. A majority of respondents who experienced this change (five respondents out of the eight) switched from public transport to other modes including driving, cycling, and walking. Additionally, in the whole group, four respondents changed the shops which they patronized, an important signifier that those who experienced inconvenience from public transport did experience an impact. Similarly, two reported altering their work schedule, two their study schedule, and two the amount of time they socialized with friends and family.

A change in travel behavior and decisions to change which shops one patronizes, work schedule, or school schedule all represent a significant impact. A change in the shops one frequents, which four respondents stated they made, is especially disruptive and the ostensible change in accessibility leading to this change in consumer behavior is a key component of social impact that has been measured in prior research (Kar et al., 2022). Changes in accessibility of different shops can alter the access one has to more nutritious food, essential medicine, and other goods and services (Kar et al., 2022). This can have effects on physical health (Neudorf, 2021), but also on mental health, since the longer travel times which respondents stated they experienced and the resultant logistical and locational alterations respondents had to make can both cause stress (Neudorf, 2021). Alterations causing stress also includes changes in working and school hours. This stress is further magnified for students, who made up a majority of the respondents to the questionnaire, as they are disproportionately dependent on public transport due to factors such as income (De Angelis et al., 2021; Sun et al., 2018). This stress can affect modal choice, as reductions in frequency reduce the propensity of students to use public transport (De Angelis et al., 2021; Daniels & Mulley, 2012).

Another contributing factor in stress related to changes in travel behavior that was observed among two respondents in the survey is the increasing inaccesibility of friends and family. As previous research has discussed, inaccessibility of friends and family can have dramatic effects on personal relationships (Neudorf, 2021). A decrease in visits as a result of increased inaccessibility can strain existing relationships, and hinder socialization in general, and cause issues with ensuring care for vulnerable relatives and friends (Neudorf, 2021). A related effect of reductions in public transport with respect to personal relationships is the potential for dependence of people on their friends, family, or partners to provide a means of transport, as illustrated by the aforementioned quote:

> "My boyfriend has a car currently, which is the reason I don't need to take public transport anymore."

This dependence can strain the relationship if it becomes more difficult for one of the members of a relationship to travel, or leave one depending on the other for transportation (Neudorf, 2021). Along with the previously explored changes in behavior, significant effects such as these constitute a social impact.

Along with behavioral changes and location choices, the attitudes of respondents are also included in the socio-spatial impact assessment. In general, a majority, 66.67% of the respondents who were aware of public transport service reductions were either dissatisfied or highly dissatisfied with the reductions (Figure 9). When asked to elaborate on their feelings, respondents stated that they were unhappy with the reductions because they provided "less opportunities for travel" and compromised the "accessibility to other parts of the city". One respondent explained their dissatisfaction as resulting from their dependence on the buses for commuting to school. Generally, the respondents expressed negative attitudes towards the reductions in public transport service, and explained their feelings using reasons around accessibility (of important locations), similar to prior research (Neudorf, 2021). Interestingly, among the four respondents who reported changing their mode of transport as a result of public transport service reductions, only one reported being dissatisfied with their modal choice, three reporting feeling neutral and one feeling unsure. When asked to elaborate, the respondents who felt neutral weighed the convenience, cost, and travel time of different modes together. One respondent stated that "driving makes you independent from public transport but it can be tiring and parking is not always convenient" and another stated that their switch was "inconvenient but [they] like walking" and that their change "[gave them] a new opportunity". In conclusion, even those most affected held neutral, somewhat optimistic attitudes towards the effects of changes in public transport on their own daily life, in contrast to prior research on emotional responses to effects of public transport service reductions.

When analyzed through the lens of a socio-spatial impact assessment, the results from the secondary data analysis show that the changes in public transport service have had no spatial impact in the time period in which this impact was studied. This runs mostly counter to the conclusions reached by prior research, and which informed the theoretical framework, which established that increased public transport services, especially more frequent bus service, increases land values of all properties, especially non-residential commercial ones (Bocarejo et al., 2013). Crucially, it was observed that neither bus service nor property values, except for non-residential values, decreased in the vast majority of the municipalities studied, during the seven year period between 2013 and 2020. However, the methods employed for the research still accounted for this potential outcome in the hypothesis (H1). The hypothesized but ultimately unobserved correlation between bus service frequency and property values was premised on the positive correlation between increases in public transport service and land values of different land use categories observed in prior research. However, the analysis found no correlation, in either direction, between changes in bus service frequency and changes in property values, demonstrating that the trend from previous research was not observed in the reverse direction.

Considering the reasons for the lack of a correlation, there are a number of trends which the secondary data analysis could not address which might have been confounding variables. A number of the municipalities included in the secondary data analysis have recently been experiencing population decline (Ministry of the Interior and Kingdom Relations, n.d.), which likely contributed to the majority of them experiencing reductions in non-residential land value. While this trend materialized despite an increase in bus service, the change in population affects aggregate demand for the properties located in the municipalities studied, which may have introduced confusion to the analysis. Another trend unrelated to public transport which may have affected the integrity of the analysis is the national trend of rising home prices in the Netherlands (CBS, 2023). Rising residential land values, observed in most of the municipalities studied, may have been part of the same trend which most of the Netherlands has been experiencing. The methods of analysis, however, compared changes in total land values of municipalities between different municipalities, meaning any discernible relationship would have resulted from relative increases or decreases within the study region.

These trends in land values in the study area are somewhat inconsistent with the results regarding location and modal choices and location importance. While none of the respondents reported any moving of residence location, which would have implicating changes in residential real estate values, a small number did report changes in the shops they patronized. The lack of a correlation between changes in bus service frequency and non-residential property values, however, means no link can be established between the results of the primary data and secondary data in this regard. Instead, data on the respondents' modal choice when traveling to shops might better explain the lack of a correlation, as only 5.56% of respondents used public transport to travel to shops (Figure 5). Respondents' preferences for where they would like to study and work relative to public transport service reinforces this explanation. In general, respondents weighed the importance of working/studying in the vicinity of frequent and reliable public transport slightly lower than the importance of living near frequent and reliable public transport (Figures 7 & 8). Along with the lack of residential mobility as a result of public transport reductions and the small number of respondents who made other location choices based on the changes, the result of the assessment of socio-spatial impact is that the impact was limited.

Notably, a majority of respondents to the questionnaire reported that they were aware of reductions in reductions in public transport services in their vicinity, yet the secondary data analysis shows that there was an increase in the seven years in almost all of the municipalities the respondents could have originated from. More recent or more route-specific reductions in public transport service, likely the subject of the respondents' reports may have contributed to the majority of respondents who were aware of reductions but the minority of respondents who reported being impacted.

7. Conclusion

The research undertaken in this study demonstrates that, within the region of the Netherlands which were studied, the socio-spatial impact of reductions in public transport was limited. Most of the respondents to the questionnaire, intended to answer the first sub-question, said that they did not experience any changes in public transport with which they were dissatisfied, even a majority of those who exclusively relied on public transport and experienced longer commute times as a result of these changes. Likewise, the secondary data analysis conducted in service of answering the second sub-question produced results which showed that there was no correlation between changes in bus service frequency and land values of different land uses in the municipalities studied.

A number of limitations may have hindered the ability of the research to rigorously analyze the situation in the region and assess the socio-spatial impact. Due to the limited ability of the researcher to gather a large sample, the sample for the questionnaire was insufficiently representative. This manifested in the results, as the sample size was smaller than what was necessary for inferential statistics, as estimated by a power analysis, and a majority of the respondents were students, a plurality of whom cycled to their classes. Additionally, while it was not requested of the respondents to specify where they lived, it was likelier that the questionnaire was mainly answered by residents of the city of Groningen, rather than residents of rural areas which have experienced higher reductions in public transport in recent years (NOS, 2023). This was also a result of the sampling methods.

Regarding the secondary data, the data used and the method of analysis of the data significantly limited its analytical power and precision. Firstly, the simple categorization of residential and non-residential land was simplistic and might have obscured trends which could have been significant if they were occurring in land dedicated towards commercial, industrial, or agricultural uses. Secondly, the data was at least three years old, limiting its relevance and potentially unable to capture the trends in the Netherlands which have been discussed in prior research. However, more recent data may have included the economic impact of COVID-19, which had a major effect on land values. Finally, both the bus service and property value data was tabulated on the municipal level, which may have diluted the numerical influence of any larger changes in bus service and property values.

These limitations can inform routes for future research, which could be conducted using data on a smaller scale, a different time scale, or for a different or wider area. More detailed and recent data consisting of the locations of residential properties, the locations of workplaces and educational institutions, and essential services such as doctor's offices could help to examine more local, spatial effects of changes in accessibility. Additionally, other indicators such as changes in walkability and density could be used to measure the effect on the built environment. Furthermore, a more expansive questionnaire distributed to more municipalities could capture the trends recorded in secondary data and either interrogate or corroborate those trends. The secondary data and analyses could even be combined to produce more accurate and comprehensive results.

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Appendix I: Questionnaire

Questionnaire

Conditional statements, ex. "if yes to 5c" will not appear on the questionnaire, they are guides for the workflow on Qualtrics.

By clicking the button below, you acknowledge:
Your participation in the study is voluntary.
You are 18 years of age or older.
You are a resident in the Provinces of Groningen, Friesland, or Drenthe.
You are aware that you may choose to terminate your participation at any time for any reason.
 a. I consent, begin the study
 b. I do not consent, I do not wish to participate

Question 1. What is your age range?
 a. 18-30
 b. 31-40
 c. 41-50
 d. 51-66
 e. 67+

Question 2. What is your gender?
 a. Male
 b. Female
 c. Prefer not to say
 d. Other

Question 3. What is your employment status? Select all that apply.
 a. Employed
 b. Self-Employed

    c. Unemployed
    d. Student
    e. Retired
    f. Other

Question 3a. If a, b, or f, what is your annual income after tax (bruto)? Leave it at zero for prefer not so say.
    a. Slider scale between 0-100,000+ Euros

Question 4. Which mode of transportation do you primarily use to travel to stores (if there are multiple modes, pick the one which makes up the largest share)?
    a. Walking
    b. Cycling
    c. Taking public transport (including bus, train, or Hub Taxi)
    d. Driving
    e. Scooter
    f. Other

Question 4a. If a, b, d, or f to 2a, which mode of transportation do you primarily use to commute to work/school (if there are multiple modes, pick the one which makes the largest share)?
    a. Walking
    b. Cycling
    c. Taking public transport (including bus, train, or Hub Taxi)
    d. Driving
    e. Scooter
    f. Other

Question 5a. Are you aware of any public transport services (bus or train) which have been reduced in frequency or eliminated entirely in your vicinity?
    a. Yes
    b. No

Question 5b. If yes to 5a, what was the mode of transport of the services and which companies provided these services?

Question 5c. If yes to 5a, what is your level of satisfaction or dissatisfaction with this change in public transport services?
    a. Highly satisfied
    b. Satisfied

    c. Neutral

    d. Dissatisfied

    e. Highly dissatisfied

    f. I am not sure

Question 5d. If yes to 5a, expand on why you felt this level of satisfaction or dissatisfaction.

Question 5e. If yes to 5a, how do these changes in service make you feel?

Question 6a. If yes to 5a, did you use public transport services (bus or train) which have been reduced in frequency or eliminated entirely in your vicinity to make regular journeys, before and/or after they experienced these changes?

    a. Yes

    b. No

Question 6b. If yes to 6a, how did the changes in service affect your journey time of your regular journeys? My journeys are now

    a. Longer

    b. Shorter

    c. Around the same time

Question 6c. If yes to 6a, did you change your mode of transportation? Select all that apply

    a. Switched from taking public transport to walking

    b. Switched from taking public transport to cycling

    c. Switched from taking public transport to driving a car

    d. Switched from taking public transport to riding on a scooter

    e. I still take public transport

    f. Other

Question 6d. If a, b, c, d, or f to 6c, what is your level of satisfaction or dissatisfaction with your change in the mode of transportation you primarily make regular journeys with?

    a. Highly satisfied

    b. Satisfied

    c. Neutral

    d. Dissatisfied

    e. Highly dissatisfied

    f. I am not sure

Question 6e. If a, b, c, or d to 6c, expand on why you felt this level of satisfaction or dissatisfaction.

Question 6f. If a, b, c, or d to 6c, how else did the changes in the mode of transport you use to make regular journeys make you feel?

Question 7. If yes to 5a, did you make different choices around locations because of changes in public transport service? Select all that apply.
    a. Changed place of residence
    b. Changed location of employment
    c. Changed hours of working
    d. Attended a different school
    e. Attended school for more time each day
    f. Attended school for less time each day
    g. Shopped at different stores
    h. Visited friends or family less frequently
    i. Visited friends or family more frequently
    j. Not applicable

Question 8. Ranked on a scale from 1-10, with 1 being least important and 10 being most important, how important is living nearby frequent and usable public transport services for you?
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5
    f. 6
    g. 7
    h. 8
    i. 9
    j. 10

Question 9. Expand on why you think it is important or unimportant.

Question 10. If a, b, d, or f to 2a, ranked on a scale from 1-10, with 1 being least important and 10 being most important, how important is working/studying nearby frequent and usable public transport services for you?
    a. 1
    b. 2
    c. 3
    d. 4

    e. 5

    f.   6

    g. 7

    h. 8

    i.   9

    j.   10

Question 11. Expand on why you think it is important or unimportant.

Question 12. Do you have anything else to add? If you have anything else you would like to share/add about this topic, share it here.

Thank you for participating in this questionnaire.