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How to incentivize the usage of public transportation, and the effectiveness of such measures

Bachelor's thesis in Samfunnsøkonomi

Supervisor: Doriane Mignon

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Abstract

This paper looks at how decisionmakers could incentivize public transport, and how effective each method is towards this goal. Based on previous articles on the topic, three main methods have been chosen. These methods are expanding bus coverage, improving efficiency through adding bus lanes, and making public transport convenient to use for the passengers. Using annual reports and national travel habit surveys, the aim is to see how many new public transport journeys each of these methods bring.

While there are some limitations to factor into the results, the results show that bus lanes, representing increased efficiency, as well as expanding bus coverage, adding a mobile app, and GPS-tracking to buses, representing improved convenience, have the most impact on public transport journeys.

Sammendrag

Denne oppgaven ser på hvordan man kan insentivere bruk av kollektiv transport, samt hvor effektiv hver metode er. Basert på tidligere artikler om dette temaet, tre hovedmetoder har blitt valgt ut. Disse metodene er å utvide bussrutenes dekningsgrad, øke effektiviteten gjennom å bygge bussfelt og å gjøre kollektiv transport til et beleilig valg for passasjerene. Ved å bruke årlige rapporter og nasjonale reisevaneundersøkelser, er målet å se hvor mange nye kollektivreiser hver av disse metodene skaper.

Selv om det er noen begrensinger å ta med i betraktning, viser resultatene at det å bygge bussfelt, som representerer økt effektivitet, samt det å utvide bussrutenes dekningsgrad, lansere en mobil app og GPS-sporing på busene, som representerer å gjøre det beleilig å ta buss, har mest effekt på antall kollektivreiser.

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1. Introduction

1.1 Motivation

Car traffic is a major contributor to the carbon emissions of the world, and heavy traffic can have serious consequences for the air quality. To help combat this it is important to ensure daily commuting is done by public transport for as many people as possible. In Trondheim the government set a goal to increase annual public transport journeys proportional to the expected increase in population for the region, to ensure zero growth in car traffic in the region [22]. In order for this to be done, the government, together with the transport providers, would need to know what methods are available to incentivize the usage of public transportation. If one wants to incentivize public transport in an effective way, there must also be available data to show the effectiveness of these measures. From this we get our thesis.

1.2 Thesis

The thesis of this paper is: “How to incentivize the usage of public transportation, and the effectiveness of such measures”.

2. Literature review

The importance of public transport and how to incentivise it have been debated for several years, and studies have looked at data across entire countries down to specific college campuses. One such study was a case study of public transportation in Ho Chi Minh City in Vietnam. The population in Ho Chi Minh City, referred to in the article as HCMC, is heavily reliant on private transport instead of public transport [1], and had “approximately 7 million motorcycles in 2014” [1]. This led to problems with heavy traffic congestion, and the “degradation of urban environment from motorcycle’s exhaust fumes” [1]. The study goes on to look at the deciding factors for if an individual would choose private or public transport. It was found that “gender was a major factor of mode choice” [1], and women were more likely to choose private transport methods. This leads into another major factor, which is safety. According to the article, if “convenience and safety were upgraded, students were likely to switch to bus transportation” [1].

Another article discusses public transport reforms in Seoul, South Korea. Seoul struggled with high traffic congestion and dangerous air pollution, which was largely caused by private transport being the most popular mode of transport. In order to encourage the use of public transport, reforms were introduced that included, among other things, “dependable, on-time bus service while also providing better, real-time information for passengers.” [4]. These reforms also included new bus lanes, better bus stops, as well as safer and more comfortable buses [4]. As a result of this, “the number of bus passengers rose by almost a million passengers a day” [4], average bus speeds experienced a significant increase as traffic congestion decreased, and the number of bus accidents decreased by one third [4].

At Monash University in Melbourne, Australia, there was a different type of initiative to encourage the use of public transport. This initiative did not include any direct improvements to infrastructure or similar, but instead focused on informing students on all the possible transport options they had. The information given included the “appropriate bus and/or train timetables, a daily public transport ticket, appropriate for a journey from home to the university” [3]. The result was, among other things, a “reduction of 9.2 percent in car driver mode share” as well as a 5.9% increase in bus usage [3].

In the United States, a study done in Manhattan, New York, looked at how to make public transport more preferable to student commuters. The article states that “to make public transit as competitive as private modes of transit, efforts need to be directed at making public transport smooth, hassle free, timely, frequent, reliable, and fast.” [2]. In

Dublin, Ireland, researchers found that “the analysis shows that commuters travelling on an unreliable public transport service experience lower levels of commute satisfaction than those who commute on a reliable service” [7]. As also shown in both Seoul and Ho Chi Minh City, dependability and convenience play a major role in encouraging the use of public transport.

3. Data and analysis

3.1 Introduction

Across multiple studies from all over the world, the general consensus is that having dependable and safe public transport that has a good coverage of its area of operation, is the best incentive for increased use. This article will now look at how these results hold up in the region of Trøndelag, Norway, where AtB is in charge of the majority of all public transport. Specifically, the focus will be on the city of Trondheim, which has the fourth largest urban area in Norway and is also the city with the highest proportion of students in the country. This combines into a city with a high need for transportation. In the past 10 years, several major upgrades have been done to the public transportation system in the city. These upgrades will be examined one by one, and the effectiveness of each type of upgrade will be laid out.

3.2 Bus lanes

Bus lanes can be a great way of making public transport a competitive transport choice. Allowing buses to get priority on the roads, and potentially skipping traffic, leads to these buses being able to get between stops more efficiently. The more reliably buses can get between stops efficiently, the more dependable public transport is for passengers, which is a major factor in encouraging use.

In 2008, Trondheim started an environmental project called “Miljøpakken”, which allocated 7 billion Norwegian kroner towards reducing car use and encouraging environmentally friendly transport choices [8]. Over 15 years, these funds would finance projects towards these main goals. One such project was the introduction of bus lanes in

central Trondheim. The main transport vein through the city goes from the south, with large residential zones, office buildings, and NTNU, Norway's largest university, through the central part of the city, and towards more residential areas as well as industrial zones to the north. All this traffic to and from the city travels primarily on one to two roads. This is shown in figure 1. On these roads the city made it so that only buses could drive through certain sections

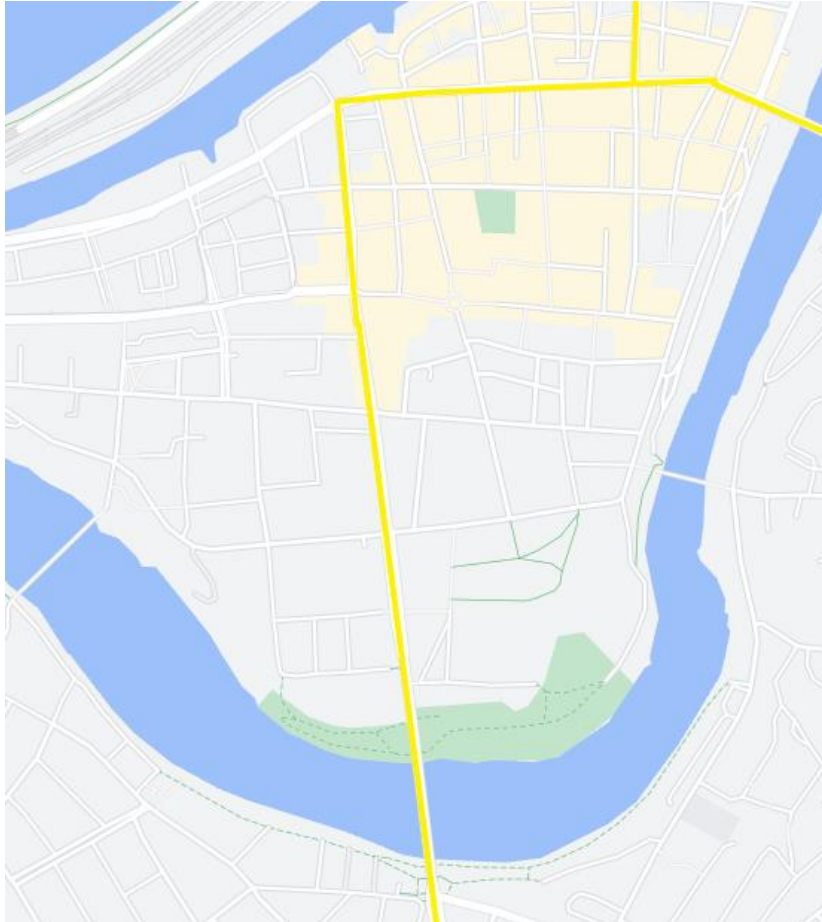


Figure 1: A map of central Trondheim with the main transport veins marked in yellow

In early 2011, a report showed that buses had increased their travel speed by 20% through central Trondheim compared to in 2008, and the proportion of road users during rush hour increased from 55% to 68%. The total increase in bus passengers in this time period also increased by 18-20% [8]. Just between 2009 and 2010, there was an increase of approximately 1.5 million new passengers [23] This shows the previously discussed results of the introduction of bus lanes. Buses become more efficient, which means they are more dependable, and this leads to more passengers.

The environmental package in 2008 is not the only major improvement in Trondheim in recent years. In 2016 a second package was allocated to the city, for the same purpose as earlier. This time 3.76 billion Norwegian kroner is provided over 8 years [10]. Several

projects on roads that see significant public transport usage were completed by 2018, and among these projects were multiple new bus lanes [9]. Finding the results of these projects proves to be a more complicated task due to COVID-19 shutting down the country for significant portions of 2020. The long-term effect can therefore not accurately be shown, as data from 2020 will be artificially lowered due to lockdown in the city. Instead, data on the number of bus journeys from 2019 will be compared to 2018. The results can be seen in the following table:

Year	Passenger numbers
2018	30.8 million
2019	31.6 million

Table 1: Numbers from 2018: [11]. Numbers from 2019: [13]

Using data from the annual report of AtB from 2018 and 2019, it can be seen that there was an average increase of 0.80 million journeys between 2018 and 2019. It should be noted that this increase cannot solely be attributed to the addition of new bus lanes. The majority of projects that were completed by the end of 2018, and that would likely have a positive effect on the number of passengers, were the addition of new bus lanes. Even so, there were other projects that could interfere with the data, which includes improving bus stops, making it more comfortable to wait for the bus, and improving the road quality, making it more comfortable to ride the bus. An increase in population could also have an effect here, but between 2018 and 2019 there was an increase of 2640 people in Trondheim [16], which likely do not account for the average increase of 0.8 million journeys.

To find out approximately how much the number of passengers increased due to the increase in population, the results from the corresponding travel habit survey are used. An important assumption is necessary in order to find this approximation. This assumption is that the portion of the increased population using public transportation take two bus trips every school and workday, to and from their home. With this in mind, the travel habit survey from 2019 is used, which shows that 12% of people were using public transport as their main mode of transportation [19].

Increase in population	12% of average monthly increase
2640	317

Table 2: Numbers from [16].

From the table above it can be seen that there was, on average, 27 new regular passengers on the public transportation system per month. To continue with the calculation, the number of workdays in 2019 must be found. After removing 104 days due to weekends and removing 10 additional days due to public holidays that fell between Monday and Friday, there were 251 workdays in 2019. With this number, together with the assumption of two trips per workday, we can find the approximate increase in passengers that the population increase led to.

Total number of public transport journeys
159 134

Table 3

With an average increase of 0.80 million journeys in late 2019 compared to late 2018, and only approximately 0.16 million of those being explained by the increase in population, one could conclude that an increase of 0.64 million journeys was due to other factors, such as bus lane improvements.

Another way to see how these projects have affected the use of public transport, is directly through the travel habit surveys. In 2009/2010, it was reported that only 8% of the population of Trondheim used public transport as their main mode of transportation [19]. This was also the period where “Miljøpakken” was first implemented, which is mentioned earlier in this section. The next survey was done in 2013/2014 and reported that 11% of the population was using public transport as their main mode of transportation [19]. This 3% increase further shows the effect that the first “Miljøpakken” projects in 2009 had on the usage of public transportation in Trondheim. The second project mentioned in this section finished in 2019, and the survey completed in this year showed that the percentage of public transport users increased from 11% to 12% [19]. The projects in 2016-2019 having less of an effect compared to the projects in 2009 can be due to the location of the projects. The bus lanes built in 2009 were built on the main traffic vein through Trondheim, while the bus lanes built in 2016-2019 were built on roads that, even if they saw a decent amount of traffic, cannot be compared to the traffic on the main road.

The exact effect new bus lanes have cannot be measured completely accurately, but these bus lanes make up the majority of the projects, and travel habit surveys also show an increase in the percentage of public transport passengers in the same period. It can

therefore be assumed that they also cause the majority of the increase in passengers. This assumption is further supported by the existing literature, as bus lanes have been shown to lead to a significant increase in average bus speeds both in Seoul [4] and in Trondheim in 2011 [8]. An efficient bus is a more dependable bus, and dependability is a major factor in encouraging public transport.

3.3 Bus coverage

Bus coverage and how often these buses depart are key factors when it comes to making public transport convenient and dependable. In 2011, 90% of the population of Trondheim had a bus stop or bus route within 400 meters of their residence [8]. Even with an extensive coverage already in place, further improvements can always be made. For AtB, the main focus has been on improving the existing coverage and frequency of bus departures.

As part of the environmental package in 2016, the city of Trondheim got financing that went towards so-called super buses [17]. These super buses are meant to be the bus equivalent of metro lines. They are longer than any other buses in the city and have more doors than usual to make getting on and off the bus a more efficient process. Three lines were implemented that went between the major residential areas around the city, and through the downtown area of Trondheim [17]. These buses also depart every 10 minutes, making them a convenient choice for passengers. The first 14 buses came to the city in August of 2019 [18], so to see the effect of this improvement we must compare passenger number from early 2019 to late 2019. Due to coronavirus, comparing passenger numbers in 2020 would not be possible due to the lockdown caused by COVID-19 during that year.

Early 2019:

January	February	March	April	May	Average
3 million	2.9 million	3.2 million	2.4 million	2.6 million	2.82 million

Table 4: Numbers from [13]

Late 2019:

September	October	November	Average
2.7 million	3 million	3.2 million	2.97 million

Table 5: Numbers from [13]

The reason December is not included is also the reason that the months of June and July are not included. Trondheim has a high number of students, many of whom will travel outside the city during vacations and between semesters. With December marking the end of the fall semester, and June/July marking the end of the spring semester, these months will always show significantly lower number of passengers compared to the rest of the year. As an example, in 2018 the number of passengers in July was 1.4 million, and in 2019 it was 1.5 million [13]. This is over 1 million passengers lower than the average number of passengers in both early 2019 and late 2019. A similar, but not as strong, effect is seen in December of both 2018 and 2019, where the number of passengers drop from 3.2 million in November to 2.4 million in December [13].

As shown by the average number of passengers, there is an increase of 0.15 million passengers after the new bus coverage was implemented. As before, not all of this increase can necessarily be attributed to these new bus lines, but due to the increased frequency, greater passenger capacity of each bus, and locations that the buses service, it would be reasonable to assume this improvement is a significant factor in this increase. In section 3.2 the travel habit survey from 2019 is mentioned, showing how the percentage of public transport user has gone up 1%, from 11% to 12% [19]. This seems to lend further strength to the argument that providing better bus coverage has incentivized the use of public transport.

It also raises a problem when it comes to accurately measuring the effect each type of improvement has on the use of public transport. The use of passenger numbers from AtB reports, combined with travel habit surveys, provide a strong evidence base for whether improvements that have been done had a positive or negative effect. The problem comes from the fact that multiple projects are often done simultaneously within a period of time, so the numbers from the reports and surveys can be considered a combined result from several different projects. Based on existing literature, one can make assumptions on which type of improvement had more of an effect compared to the other types but getting an accurate result might not be so clear. This will be further discussed in section 5 of this paper, where the robustness and limitations will be laid out.

3.4 Passenger convenience

Providing passengers with real-time information about when buses are going to arrive, making it easy to purchase tickets online, as well as having any other relevant route information available online can be a deciding factor for when it comes to choosing public transport or not. Real-time information can be considered as some of the most vital information for any passengers, as the actual arrival time of a bus can have significant variations from the planned arrival time.

In Trondheim, AtB added GPS tracking to all their buses, built screens at central bus stops that show the arrival times for all incoming buses in real-time, and added the same arrival times to their mobile app. This project was finalized in 2013, so in order to measure the effect of this, we can look at passenger numbers in 2014 and 2015. These results are shown in table 4:

Year	Number of passengers
2013	23.3 million
2014	24.2 million
2015	25 million

Table 6: Numbers from 2013: [20], from 2014 [21], and from 2015: [15]

It is important to note that it is not guaranteed that this increase in passengers is not necessarily tied only to the aforementioned project. The cause could potentially also be a general population increase, or other improvements tied to public transport. It is likely that population increase does not account for all of the increase in passengers here, as between 2013 and 2015 the population increased by only 5324 [16]. To find out approximately how much the number of passengers increased due to the increase in population, the results from the corresponding travel habit survey are once again used. Using the travel habit survey from 2013/2014, the results show that 11% of the population used public transport as their main mode of transportation [19]. Then the population increase between 2013-2014 and 2014-2015 are found, in order to isolate the years.

Year	Population increase from previous year	11% of population increase
2014	2374	262
2015	2950	325

Table 7: Numbers from [16]. (The 11% number is rounded up from 261.14 and 324.5, as partial people are not possible)

It is assumed that all of the 11% are in school or work during the week, meaning they have to travel to and from work. This means an average of 2 daily trips using public transport for each person. Furthermore, weekends and public holidays must be taken into account. In 2014 there were 252 workdays, having removed 104 days due to weekends as well as 9 public holidays. In 2015 there were 253 workdays, having removed 104 days due to weekends as well as 8 public holidays. The disparity in the number of public holidays is due to the fact that, depending on the year, the number of public holidays that fall on a day between Monday and Friday might differ. The following shows the approximate number of public transport journeys that were caused by the increased population in 2014 and 2015:

Year	Total number of public transport journeys
2014	132 048
2015	164 450

Table 8

Between 2013 and 2014 there was an increase of 0.9 million new public transport journeys, and approximately 132 048 of these were due to the increase in population. For the time period between 2014 and 2015, there was an increase of 0.8 million new public transport journeys, while approximately 164 450 of these were due to the increase in population. With these results in mind, one can conclude that it is highly likely that at least 0.7 million of the new public transport journeys in 2014, as well as 0.6 million of the new public transport journeys in 2015 were caused by improvements to the public transport system.

4. Results

4.1 Bus Lanes

After taking into consideration both the projects between 2008 and 2011 and the subsequent projects between 2016 and 2019, as well as factoring out the effect of an increase in population, we get the following results:

	2008-2011	2016-2019	Average
Increase in number of passengers	1.5 million	0.64 million	1.07 million
Increase in percentage of population using public transport	3%	1%	2%

Table 9

The average increase in the percentage of population that use public transport after adding bus lanes is 2%, and the average increase in number of passengers is 1.07 million. These results show a similar trend as the results of the studies in the literature review, which is that the addition of bus lanes can have a significant impact on the usage of public transport. The effect of adding bus lanes would likely decrease as more and more bus lanes are added in, and this will be further discussed in section 6.

4.2 Bus coverage

When improving bus coverage in Trondheim, the effect it has can be shown in the table below:

	2019
Monthly increase in number of passengers	0.15 million
Extrapolated yearly increase	1.8 million
Increase in percentage of population using public transport	1%

Table 10

The first thing to note about these results is that they come from 2019 which is also one of the years used for bus lanes, meaning there is most likely some overlap between the effects of bus lanes and the effect of bus coverage. Even so, there appears to be an average increase of 0.15 million monthly passengers between early 2019 and late 2019. This means that, if this monthly increase held up over a 12-month period, there is a potential of 1.8 million new public transport journeys in a year.

4.3 Passenger convenience

After factoring out the effect of an increased population, the effect of improving passenger convenience can be seen in the results below:

	2014	2015	Average
Increase in number of passengers	0.7 million	0.6 million	0.65 million

Table 11

In this case, the improvements to passenger convenience were the main project type during the time period of 2013-2015. This means that the effects seen in the table above is more likely the isolated effect of the improvements listed in section 3.4. With an average increase of 0.65 million passengers, it is clear that passenger convenience can have a significant effect when it comes to incentivizing public transport. These results are similar to the findings in Ho Chi Minh City, Vietnam [1], New York, USA [2], Melbourne, Australia [3], and Seoul, South Korea [4]. In all these cities passenger convenience is mentioned as a highly important factor, and the results from Trondheim further give evidence to this.

5. Robustness and Limitations

The main limitation for this paper is getting completely accurate results when it comes to how much of an effect each type of improvement has on the usage of public transport. Using official reports from Atb, together with travel habit surveys for the relevant time period, a strong evidence base can be created for whether the projects that have been completed had a positive or negative effect, as well as showing the total effect of all projects. Where the available data falls short is when it comes to seeing the individual effect of each project. This means that, due to the fact that AtB often have multiple projects going in the same time period, one cannot necessarily see how much of an effect each type of project has on for example passenger numbers.

Another limitation is that in order to get a better understanding of how much of an effect adding a bus lane, improving bus network coverage, or making the passenger process easier might have, one has to make certain assumptions. Based on existing literature, one can see how the same type of projects discussed in this paper, affected the usage of public transport all over the world. With this data in mind, the first assumption has to be made, which is that these results would be valid also in Trondheim and Trøndelag. Considering the literature reviewed in section 2 stems from several different countries and continents, the results form a strong foundation on which to base the assumption that said results are relevant for this paper as well.

The second assumption that is made is related to population growth. When factoring out the effect of population growth it is assumed that the population grows with the same amount every month. It is also assumed that the new potential passengers use the bus twice a day during workdays, once going to school/work and once going back. These assumptions allow for the calculation of a number that shows the approximate increase in passengers due to the increase in population, but it also means that the results cannot be considered as entirely accurate.

Another limitation is saturation. Saturation here refers to the fact that, for example, adding bus lanes to the main transport vein through central Trondheim where a large number of bus routes go, such as in the project in 2009 [8], will affect a significantly greater number of people compared to adding bus lanes to a road where only one or two routes go. As more and more of the main transport roads are fitted with bus lanes, new projects that implement

bus lanes will see less of an effect compared to previous projects. There are a few ways to get around this, such as looking at the change in passengers on specific routes compared to the normal number of passengers for the same routes. This percentage value would provide a more balanced look at how the addition of bus lanes affect bus usage. During the creation of this paper, passenger numbers for individual routes were not available, meaning it was not possible to calculate this percentage value. As such, saturation remains a limitation when looking at the results achieved throughout this paper.

The findings listed in section 4 should not be taken as an exact measurement of what the result will be when implementing bus lanes, improving bus coverage, or making public transport more convenient for passengers. Instead, these results further strengthen the evidence behind the findings from the literature review. Should decisionmakers wish to incentivize public transport, the methods discussed in this paper have proven to have a significant effect when it comes to increasing passenger numbers.

6. Conclusion and Further work

6.1 Conclusion

As discussed in section 5, the results shown in section 4 can not be used as an accurate representation of how much passenger numbers would increase when implementing the improvements from section 3. This is due to overlapping time periods for several projects, as well as lack of data from individual bus lines. Nevertheless, these results do give further evidence to the results from the articles discussed throughout the literature review in section 2. Similarly to findings from all over the world, making public transport efficient and convenient to use appears to be the most effective ways of incentivizing public transport. Building more bus lanes to increase efficiency and improving passenger convenience through expanded bus coverage, mobile app etc, all lead to significant increases in public transport journeys.

6.2 Further work

Public transport and how to incentivize its usage will always be a highly relevant topic as long as climate change remains a problem in our society. As such, there is a lot of potential for further work within the topics of this paper. As the population and data evolve, the methods that were the most effective now might not be as effective in the future. In order to keep public transport as a realistic contender with personal transport, decisionmakers will need the most up to date information to make the most efficient choices.

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