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Patronage effects of changes to local public transport services in smaller cities

Aud Tennøy

Institute of Transport Economics, Department of Mobility, Gaustadalléen 21, 0349 Oslo, Norway

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ABSTRACT

The paper contributes to the scarce empirical knowledge concerning the effects of improving public transport services on patronage. It analyses cases in eight Norwegian cities, varying in size from 12,000 to 118,000 inhabitants, where bus services were reorganised into fewer, straighter, faster and simpler lines with higher frequencies. Walking distances to stops increased in some areas and services were reduced on less used routes. The interventions were followed by patronage growth of 3.3–17.6% per year over the evaluation period, contrasting the pre-change situation of lower growth or decline. Stronger focus on increasing public transport competitiveness versus cars, enhanced knowledge among planners and organisational changes leaving more power to the professionals stood out as important factors explaining why these interventions had been implemented. The results might be relevant for those involved in developing bus-based, regular, local public transport services for largely self-sustained small and medium-sized cities aiming at increasing patronage.

1. Introduction

Improving public transport competitiveness is understood to be an important part of strategies for reducing car traffic volumes and shifting urban mobility to more sustainable modes (Banister, 2008; Buehler et al., 2017; Newman and Kenworthy, 2015). Norwegian cities of all sizes have been inspired to work towards such shifts by the so-called zero-growth objective – according to which increasing transport demand caused by population growth in urban regions should not cause increases in traffic volumes (total kilometres by private car) – which successive governments have promoted since 2012 (Ministry of Local Government and Regional Development, 2012, 2017; Ministry of Transport, 2013a, 2017, 2021). This objective is linked to financing packages, such as Urban Growth Agreements and recompense schemes for improving public transport services and reducing car usage in urban areas (for further descriptions, see Ministry of Transport, 2013b, 2021; Tønnesen et al., 2019). A strong focus on the United Nations' (2017) Sustainable Development Goals has also encouraged Norwegian authorities to steer the development of land use and transport systems towards reducing car dependency and usage.

Small and medium-sized cities face a lack of documented knowledge when defining strategies for developing their public transport services to increase patronage and better compete with private cars. The research literature is lacking in empirical studies on how changes in public transport services have affected public transport competitiveness and patronage in general, and the meagre research that exists contains few studies focused on smaller cities (Redman et al., 2013). Research done in the context of larger cities might be helpful for smaller cities, but it cannot be assumed to be directly transferable. This is because large and small cities differ from each

E-mail address: ate@toi.no.

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other in relevant ways, such as urban structure, density, accessibility by car and in the characteristics of their public transport systems. Large cities often have rail-based or bus rapid transit (BRT) systems as the backbone of their public transport services. Published studies mainly focus on how introducing or change such systems, often involving major infrastructure investments, affected patronage or other issues (Buehler et al., 2017; Newman and Kenworthy, 2015; Redman et al., 2013). Local public transport in smaller cities is typically bus-based, and interventions often concern changes in services rather than infrastructure investments. The proportion of trips made by public transport is also significantly higher in larger cities than in smaller cities. This is evident in results from the Norwegian National Travel Survey 2018/19: the share of trips made by public transport (all daily journeys) was 30% in the capital and largest city, Oslo, 11–18% in the next three largest cities and 5–8% in the smaller cities (Grue et al., 2021). The same tendency has been found in Portugal (Silva et al., 2021), Germany (Reichert et al., 2016) and North America (Sidloski and Diab, 2020).

This paper contributes to the literature by providing novel empirical knowledge of how changes to bus-based, regular, local public transport services have affected patronage in eight small and medium-sized Norwegian cities and what factors influenced the decisions to implement these kinds of interventions. Since 2012, interventions recommended on the basis of knowledge developed through studies on larger cities have been implemented in several small and medium-sized Norwegian cities with an aim to increase bus patronage. The eight cases studied here are located in cities varying in size from 12,000 to 118,000 inhabitants, and the interventions were implemented in the period 2012–2019. Bus services were typically reorganised into fewer, straighter, faster and simpler routes with higher frequencies. Street terminals and pendulum lines running from one side of a city to the other, without long stay times in the centre, were introduced. Walking distances to stops increased in some areas and services were reduced or removed on less used routes. Campaigns were run to inform the public about the improved services, representing an interesting shift in attitude from a previous understanding that residents of small cities could not be persuaded to voluntarily ride a bus. This is the first study to investigate and compare these Norwegian cases.

Despite their sizes, these cities are largely self-sustained in terms of workplaces, workforce and most amenities (Statistics Norway, 2021a), and each one is the main city in the local region. The role of a city in the urban hierarchy is relevant when researching how changes in public transport services affect patronage and when discussing how public transport services could be developed to improve their competitiveness versus private cars (Aguilera and Mignot, 2004; Wiersma et al., 2016; Wolday, 2018). For smaller towns or cities located within commuting distance of a larger city, and wherefrom a large proportion of their workforce commutes to the larger city, the focus is often on the competitiveness of public transport for commutes to the larger city. In a smaller city that is the main city in its local region, the focus is typically on how the public transport system serves intra-urban trips and commutes to the city from neighbouring suburban municipalities and surrounding regions. The aforementioned cities can be characterised as of European style, as they have relatively high overall densities and defined cores. We believe the results of this study will be useful for those involved in developing public transport services to increase patronage in similar types of cities.

Some background information is needed to address what influenced the decisions to redesign public transport services in accordance with state-of-the-art knowledge to maximise patronage in many Norwegian small and medium-sized cities within the last decade. The 11 counties (with elected politicians) are responsible for local and regional public transport in Norway. County councils make decisions about goals, strategies, priorities and financing, while county administrations prepare cases for the councils and ensure that their decisions are implemented. Since around 2010, public transport agencies owned by the regional authorities have been responsible for defining the networks, carrying out procurement processes and organising and marketing the services (see also Longva and Osland, 2010). Mainly privately owned operators bid to operate the networks, through gross cost contracts typically running for eight years. County authorities are also responsible for developing non-binding regional land use plans and ensuring the coordination of land use and transport planning. However, decisions about land use development lie firmly with the municipal authorities, as defined in the Planning and Building Act (see also Tennøy, 2012; Tennøy and Øksenholt, 2018). Designing public transport systems is largely a question of prioritising and negotiating between conflicting goals and interests within the system described above. This does not necessarily result in public transport systems optimised to maximise patronage.

Two cases were selected for deeper study to gain a better understanding of what were key factors influencing that interventions aimed at increasing patronage were implemented in small and medium-sized cities across Norway in the last decade. Insights from these studies might be useful for others aiming at similar shifts in public transport priorities and designs.

The paper is organised as follows. Section 2 describes the theoretical understandings and relevant existing empirical studies. Section 3 covers the research design and data collection methods. Section 4 presents the findings, and they are discussed in section 5. Finally, section 6 offers concluding remarks.

2. What affects public transport competitiveness

Travel time differences between public transport and private cars are widely understood as affecting the competiveness between these modes of travel (Altieri et al., 2020; Buehler and Pucher, 2011; Downs, 2004; Goodwin, 1996; Lunke et al., 2021; Redman et al., 2013). Public transport service qualities, such as high frequency, short walking distances to stops, high speed, no or easy transfers and punctuality, reduce door-to-door travel time by public transport and are often mentioned as key success factors for increasing patronage (Buehler and Pucher, 2011; Curtis and Scheurer, 2016; dell'Olio et al., 2011; Dodson et al., 2011; McLeod et al., 2017; Nielsen et al., 2005; Redman et al., 2013; Walker, 2012).

A key question when designing urban public transport services to increase patronage is how available resources can be allocated most efficiently. This endeavour requires prioritising the aforementioned qualities. For instance, the designers can choose to provide high-frequency services on fewer lines with longer walking distances to stops or more lines with lower frequencies and shorter walking distances. They can design the system with loops, split lines and frequent stops that reduce walking distances but also speeds, or they

can design straighter lines with fewer stops and greater speed. As a rule of thumb, 400 m is often considered an acceptable walking distance to local public transport, but several authors have argued that people accept longer walks if the public transport services are of high quality (Soest et al., 2020). Tennøy, Knapskog and Wolday (2022) find that although short trips to stops would increase commuters' likelihood of using public transport in Norwegian cities, survey results suggest that higher frequencies and direct connections are more important than shorter walks in persuading more people to commute by public transport.

The literature largely agrees on what are the 'best practice principles' for designing urban public transport services that attract many users. They can be summarised as designing systems with fewer, straighter, faster and simpler lines with higher frequencies and concentrating resources to corridors linking areas with high densities of inhabitants, workplaces and other activities (Curtis and Scheurer, 2016; McLeod et al, 2017; Nielsen et al., 2005; Walker, 2008). Simple and logical routes, ticketing and fare systems make it easier to communicate the services to existing as well as potential users. Some downsides of these strategies are the increased walking distances to stops and reduction or removal of services on less used routes, which reduce public transport accessibility for those living in these areas and for those who cannot manage the longer walks to stops (Walker, 2008).

The conditions for affecting travel time differences in favour of public transport are influenced by a city's spatial structure and conditions for car usage. Dense and largely monocentric cities with high shares of dwellings, workplaces, shopping and services concentrated in and close to the city centre, and with dwellings concentrated along main public transport lines, offer better conditions for developing competitive public transport services compared to cities with the opposite characteristics (Buehler et al., 2017; Dodson et al., 2011; Næss et al., 2019; Newman and Kenworthy, 2015; Tennøy, Øksenholt and Aarhaug, 2014; Tennøy et al., 2022). Parking restrictions, congestion and road tolling hamper accessibility by car and consequently improve the competitiveness of public transport (Buehler et al., 2017; Newman and Kenworthy, 2015; Noland and Lem, 2002; Tennøy, Tønnesen and Gundersen, 2019). Smaller cities typically are less dense than larger cities and normally offer very good accessibility by car, providing less favourable conditions for public transport competitiveness. These factors are, however, less relevant in this study context due to the focus on the short-term effects of changes to public transport services.

A literature search retrieved few studies covering how changes to public transport systems in small and medium-sized cities have affected patronage. Khan et al. (2021) refer to strong patronage increases in cities in six Swedish regions which have implemented similar interventions in the urban public transport systems to those in the Norwegian cases studied here. Patronage is reported at the regional level, and the paper does not present data for effects on patronage in the cities except for the understandings of those interviewed. In their systematic review of 74 public transport improvement studies conducted in larger cities, Redman et al. (2013) find that most types of public transport improvements tended to achieve increased patronage, customer satisfaction or a modal shift away from private cars, with higher frequencies having the strongest influence. Buehler et al. (2017) describe how public transport service improvements in some of the largest European cities, together with other land use and transport policies, have resulted in a significant reduction in the share of car trips and increases in the shares of trips by public transport, bicycling and walking over a period of 25 years.

What decisions are made regarding how to develop public transport services might be influenced by goals and goal conflicts, knowledge and the distribution and exercise of power (Flyvbjerg, 1998; Lukes, 2005; Tennøy et al., 2016; Tennøy and Øksenholt, 2018). One well-known goal conflict is between maximising patronage, to achieve environmental and other benefits, and providing good coverage, to achieve social benefits and accessibility for those who do not drive cars, as addressed by Walker (2008). The knowledge and expertise of those designing the systems will obviously influence which interventions they suggest. Whether they are implemented relies on the decisions made by those in power. In the Norwegian context, all these factors might have been affected by the transition towards a competitive tendering system and the establishment of public transport agencies, as discussed in section 1. Other important issues are the governance conditions, as Khan et al. (2021) discuss. They identify three main conditions explaining the success of the six Swedish regions they studied – namely, political support, well-functioning collaboration between organisations and public support through citizen dialogue. These understandings were relevant when enquiring about the factors that influenced the decisions to implement these kinds of interventions in the Norwegian cities studied here.

3. Research design, case selection and data collection

The research was designed as a case study. The cases represent changes to public transport services in eight small and medium-sized Norwegian cities. The study investigated their effects on patronage as well as what factors influenced the decisions to implement these kinds of interventions. A case study design allows for studying each case within the local context and for making comparisons across cities and generating more general knowledge (Flyvbjerg, 2006; Stake, 1995; Yin, 2003).

The search for cases to include in the study on effects on patronage adhered to the following criteria. Cases were to exemplify changes to regular local public transport services in largely self-contained small and medium-sized Norwegian cities. This left out cases concerning on-demand services and inter-city connections, cases located in the capital city of Oslo, cases in smaller cities interwoven in metropolitan regions dominated by a larger city (mainly Oslo) and cases in more rural areas. The case in Drammen was included although the city is part of the Oslo metropolitan area, with 14% of the workforce commuting to Oslo, as well as a generally high

percentage of commutes out of and into the municipality[1] (Statistics Norway, 2021a). The justification for including this case is that the interventions studied concerned the bus network serving intra-city transport and connections between the city and its more rural neighbouring municipalities. The availability of data to analyse the effects on patronage of the interventions was another requirement. Publicly available data are normally aggregated to the regional level. Some authorities publish data for patronage development for specific cities and urban regions, but there are variations in how these areas are defined over years and between authorities. Thus, we depended upon public transport authorities providing data enabling analyses of specific parts of the networks (here, the case cities), either because we asked, because they routinely reported data this way or because they had compiled data to analyse the effects of interventions they had implemented. Those providing data were, however, cautious with respect to violating data-sharing regulations set to ensure fair tendering processes. Together, these factors reduced the number of relevant cases, and they affected what data were available for the individual cases and what analyses could be conducted. Some older but potentially interesting cases were excluded because the data quality was poor. Other cases were excluded due to shifts in passenger registration methods in the relevant evaluation period. The rapid development of ticketing and counting technologies in the past decade or so reinforced this problem. This also caused problems in establishing reliable and comparable pre-change patronage trends. Finally, cases where post-change data would be collected after March 2020, when the Covid-19 pandemic caused substantial reductions in patronage, were excluded. This left out some potentially very interesting cases that hopefully will be analysed and reported in future studies.

Information about interventions in the public transport services and data depicting the effects on patronage were collected from regional authorities, public transport agencies and published consultancy evaluations as well as from annual reports and other open sources. In line with Redman et al. (2013), our understanding was that most analyses on the effects of changes in public transport services on patronage are reported in consultancy reports rather than in scientific papers, and public transport authorities have data that could be analysed to understand the effects of these changes on patronage. Emails were sent to public transport authorities in all Norwegian counties to ask if they had or knew of relevant studies or evaluations. We also enquired about relevant changes to the public transport services in cities located within their jurisdiction where data were available or could be retrieved to analyse effects on patronage. Through previous projects and our networks, we knew of interventions and changes that could be relevant and interesting, and we asked specifically if data were available to enable analyses of these. During the project period, we repeatedly asked for cases, data, evaluations and studies. We believe that by applying this approach, we detected and considered a high share of relevant Norwegian cases.

Following these procedures, eight cases of changes to the public transport services were identified as relevant within our criteria: the cities of Drammen, Fredrikstad/Sarpsborg, Kristiansand, Haugesund, Bodø, Hamar, Hønefoss and Kongsvinger. See the locations of these cities in Fig. 1. Drammen, with 118,000 inhabitants, is the largest city in the sample and the smallest town is Kongsvinger, with 12,000 inhabitants. These are the populations in the continuous urban settlement, as defined by Statistics Norway (2021b) – that is, clusters of buildings inhabited by at least 200 persons, and where the distance between buildings does not exceed 50 m. The route structures of all cities are radial, and transfers are only possible in the city centre, where all routes meet.

Patronage data include data from ticket sales, ticket validation and automated passenger counts (APC). Aggregated data for all lines in the local public transport system in each city were analysed to avoid the well-known problem of measuring single lines, where changes in patronage on one line could be a result of passengers transferring to or from other public transport lines, meaning that the measured effect does not represent a change in the total public transport patronage in a city. When using APC, changes influencing the number of transfers in a public transport system would be registered as changes in patronage, since passengers are counted every time they board. Ticketing data have uncertainties concerning how period and single tickets are distinguished and effects of changes to the ticketing system. In sum, there are uncertainties related to all patronage data sources despite the exclusion of cases with poor data. These uncertainties might affect the results, and there is no way of knowing the uncertainties of each case.

The aim was to collect pre-change patronage data to establish a firm statistical baseline with which to compare post-change data. However, the availability of pre-change patronage data varied and was poor in several cases due to shifts in counting methods and reporting routines. This resulted in shorter and more unreliable pre-change baselines than desired, and in a few cases, statements from the authorities were the sole source of information about pre-change trends. Post-change data were collected for the subsequent two to four years after the interventions were done. The lengths of evaluation periods were restricted bydata availability in some cases and by the pandemic in other cases. The intention was, however, to measure the short-term effects of changes to the services to reduce the impacts of other factors, such as land use development and altered accessibility by car.

Data concerning population size, growth and density were retrieved from Statistics Norway (2021b). Statistics concerning bus passengers and some other variables were available on an aggregate regional level from Statistics Norway (2021c, 2021d), and these were used to draw a general baseline for bus patronage development in Norwegian cities. These data are also uncertain due to similar factors as described above, and information about data collection methods, geographical delimitations, etc. are incomplete.

The cases are presented in similar ways, including key information about the case cities, pre-change patronage trends, motivations for the interventions, the actors and processes involved, the interventions, post-change patronage development, costs and financing, and data sources. The data and information that were available for the different cases varied. Owing to the large variance in interventions, urban contexts and types of data, as well as the mentioned uncertainties, the findings have not been quantitatively

[1] Commuting data from Statistics Norway (2021a) show that 47% of the workforce living in Drammen municipality commutes to workplaces located in other municipalities, with 14% commuting to the nearest neighbouring municipalities, 14% to Oslo and 19% to other municipalities. Further, 52% of those employed by businesses located in Drammen municipality live in other municipalities, with about half of these in neighbouring municipalities. The distance between the city centres of Drammen and Oslo is about 40 km.

Fig. 1. Location of the eight case cities.

analysed to determine the most efficient and effective interventions. We agree with Redman et al. (2013) that statistical evaluations of heterogeneous data would not produce meaningful results. Instead, data directly related to effects on patronage (annualised pre- and post-change patronage development, population growth) are summarised in a table, and the results are compared across cases. The findings are discussed against theoretical understandings and findings from previous studies to answer the question concerning whether and how these kinds of interventions in public transport services affect patronage in small and medium-sized cities.

Data from the case descriptions also provided background information for investigating what factors influenced the decisions to implement these kinds of interventions. The main source of data in this part of the study was interviews with professionals involved in the processes in Hamar and Haugesund, supported by document studies (Hamar Municipality, 2018; Hedmark County, 2012; Hedmark County and Hedmark Trafikk, 2017; Innlandet County, 2020; Rogaland County, 2016, 2018). Semi-structured interviews were conducted with three professionals related to each case, who were working for the county administrations, public transport agencies and city municipalities (six interviews in total). The main topics covered in the interviews were objectives and goal conflicts; why the specific interventions had been chosen; what knowledge they had relied on; what support and resistance they had experienced; and how the actors had collaborated in the processes. All interviews were conducted through a video link, with two researchers present. Interviews were transcribed and approved by the interviewees. To analyse the material, the researchers retrieved the relevant information from each interview and summarised across interviewees for each case. The essence of this process is presented as findings in the paper. Hamar and Haugesund had been selected as cases in another part of the same project concerning how land use and transport planning processes affect the chances of improving public transport competitiveness (Skartland, 2021, 2022a). They were selected because they are small cities where authorities had taken actions to increase patronage and succeeded. The interviews were primarily conducted by Skartland as part of her PhD, and the author of this article was co-interviewer in four of the six interviews. The transcribed interviews have been analysed specifically for this paper by the author.

4. Findings

Descriptions of the eight individual cases are presented in section 4.1. Effects on patronage are summarised and compared across cases in section 4.2. Results concerning what factors influenced the decisions to implement these interventions are summarised and analysed in section 4.3.

Table 1
Summary of results relating to effects of interventions on patronage.

Case city[a]	Population, 2018[b]	Density, Pop/km^2, 2018[c]	Patronage year 0[d]	Patronage growth Year 1	Patronage growth Year 2	Patronage growth Year 3	Patronage growth Year 4	Post-change average annual patronage growth	Pre-change annual patronage growth[e]	Annual population growth[f]
Drammen (4.1.1)	118,000	2,287	4,465,293 (2016)	7%	6%	7%	–	6.5%	2.5% growth per year, 2014–2016	−2.1%
Fredrikstad/ Sarpsborg (4.1.2)	112,000	1,941	795,173 (2017)	5%	5%	–	–	5.1%	4.1% growth per year, 2013–2016	1.1%
Kristiansand, Vågsbygd (4.1.3)	80,000 24,000	2,541	1,198,977 (2015)	1%	−5%	8%	11%	3.3%	No data[g]	1.4%
Haugesund (4.1.4)	45,000	2,164	711,665 (2015)	37%	13%	−1%	6%	12.6%	1% decline per year, 2011–2015	0.6%
Bodø (4.1.5)	41,000	2,911	1,306,379 (2012)	13%	6%	7%	18%	10.9%	5.4% decline per year, 2007–2011	1.2%
Hamar (4.1.6)	28,000	1,997	480,643 (2012)	16%	9%	29%	15%	17.1%	6.1% growth in 2011–2012	1.0%
Hønefoss (4.1.7)	16,000	1,760	289,597 (2015)	5%	9%	7%	12%	8.2%	2.1% decline in 2014–2015	1.2%
Kongsvinger (4.1.8)	12,000	1,525	124,283 (2014)	12%	14%	–	–	12.8%	0.7% growth per year, 2011–2014	0.1%

[a] See information about interventions, sources, etc. in sections given in brackets.
[b] Data for urban settlement areas,Statistics Norway (2021b).
[c] Data for urban settlement areas,Statistics Norway (2021b).
[d] For most cases, this is the 'real year 0' – that is, the year before the interventions were implemented. For other cases where data for the 'real year 0' were not available, it is the first year after the interventions.
[e] See supplementary information in Appendix B.
[f] Average annual population growth for the same years as for average annual patronage changes (data from Statistics Norway, 2021b).
[g] For the city of Kristiansand, where Vågsbygd is located, the trend showed average patronage growth of 0.7% in 2011–2014 (Statistics Norway, 2021c).

4.1. Descriptions of individual cases, interventions and results

Population figures are given for continuous urban settlements in 2018. Some case descriptions include references to the proportion of trips made by public transport. They are based on calculations relying on a combination of data from the National Travel Surveys conducted in 2013/14 and 2017/18 for the urban settlement areas. These data were not available for all cases. See Table 1 for a summary of key information, including annual population growth. See Appendix A for absolute patronage figures, Appendix B for information about pre-change trends and Appendix C for information about costs and financing.

4.1.1. Drammen

In Drammen (118,000 inhabitants, 10.5% of trips by public transport), stepwise changes to the public transport services were implemented in the period 2014–2019 after the signing of a new contract for bus services. Relevant actors collaborated through the established Buskerudbyen cooperation to develop the services. The stated aims were to increase patronage and the proportion of trips made by public transport and to achieve the zero-growth objective. This was also part of the preparations for applying for financing through an Urban Growth Agreement. In 2014, the public transport services between the city and neighbouring municipalities were improved by reorganising lines and increasing frequencies. From 2016 onwards, the city lines, on which we focus here, were redesigned. The route structure was simplified by merging lines and adjusting routes, and the frequencies increased on the main lines and other important axes. The route changes were followed by strong patronage growth on the city lines of 6.5% per year in 2016–2019. In comparison, the growth was 2.5% per year from 2014 to 2016, when only the services to neighbouring municipalities had been improved. Increased costs were covered through contributions from the recompense schemes for improving public transport services and reducing car usage in urban areas (Ministry of Transport, 2013b) and a reallocation of resources. Data were provided by the public transport agency Brakar AS, owned by Viken County. Data were collected through APC.

4.1.2. Fredrikstad/Sarpsborg

The twin cities Fredrikstad and Sarpsborg constitute a continuous urban settlement (112,000 inhabitants, 6.4% of trips by public transport). The route structure in the pre-change situation was characterised by high coverage and overall low frequencies. It was complicated with many lines, many of which had short operating hours or ran only during rush hours and on school days. The routes had many stops, and speeds were generally low. There was only one clearly defined trunk line with high frequency throughout the day. With the aims of attracting more passengers, achieving the zero-growth objective and signing an Urban Growth Agreement, the route structure was simplified into a clearly defined route hierarchy of trunk lines and local city lines. The two cities are now connected by three trunk lines, and each city is internally served by four main city lines organised as radial pendulum lines. New public transport nodes connect the trunk lines and city lines. Frequencies were increased on the trunk lines and main city lines. Services were reduced in less used parts of the system and walking distances to stops increased in several areas. The changes were followed by a passenger growth of 5.1% per year from 2017 to 2019, an increase from the 4.1% growth per year from 2013 to 2016. Costs were covered through contributions from the recompense scheme and a reallocation of resources. Data were provided by the public transport agency Østfold Kollektivtrafikk, owned by Viken County. They included APC data and data for sold and validated tickets.

4.1.3. Vågsbygd in Kristiansand

Vågsbygd (24,000 inhabitants) is a suburban part of the city of Kristiansand (80,000 inhabitants, 10.9% of trips by public transport). In the pre-change situation in Vågsbygd, coverage had been prioritised over frequency and speed, resulting in a relatively high number of lines with low frequencies. As part of a strategy to increase patronage and make the system more cost efficient, internal lines in Vågsbygd and lines towards the city centre (Metro lines) were more clearly defined, and they were reorganised and simplified. Lines were merged and straightened, ring lines were removed and local pendulum lines were introduced. Overall walking distances to public transport stops increased. In 2018 and 2019, frequencies increased on a Metro line and on the main internal line. The merging of three local lines into one in 2015 resulted in 6% passenger growth the first year. From 2015 to 2019, the number of boarding passengers in the Vågsbygd area increased by 3.3% per year. The pre-change trend in Kristiansand was 0.7% growth per year in 2011–2014, but we do not have information about pre-change trends for Vågsbygd. Kristiansand was also preparing to apply for an Urban Growth Agreement. A road capacity expansion between Vågsbygd and the city centre in 2014 reduced congestion and improved car accessibility by car. This was expected to reduce patronage, but the authorities believed the public transport service improvements had countered this. Data for sold and validated tickets were provided by the public transport agency Agder Kollektivtrafikk AS, owned by Agder County.

4.1.4. Haugesund

In Haugesund (45,000 inhabitants), patronage was low and declining by about 1% per year. In an attempt to reverse this trend, the route structure was adjusted and simplified in 2015. Some lines were straightened to increase speed, some lines with few passengers were reduced or removed and frequencies on routes with higher patronage were increased. In 2016, the prices were reduced from NOK 31 to 10 for a single ticket and to NOK 350 for a monthly pass, and this was thoroughly covered by the local press. The changes were followed by a patronage growth of 12.6% per year in 2015–2019. The steepest growth (37% the first year) took place in the period after rerouting and before the price reduction. The changes and effects were evaluated by a consultancy firm (Norconsult AS, 2017) that reported a loss of NOK 1.7 million related to the fare reduction the first year and that this was compensated by increased patronage by 2017. The firm also conducted a passenger survey documenting that 69% of the new bus passengers were former car drivers and 24% were former cyclists. Data for sold and validated tickets were provided by the public transport authority Kolumbus AS, owned by

Rogaland County.

4.1.5. Bodø

Bodø (41,000 inhabitants, 5.5% of trips by public transport), experienced a patronage decline of 5.4% per year in 2007–2011, as described in the consultancy report by Nielsen Consulting AS (2016). In 2012, to reverse this trend and to improve efficiency, the route network was simplified by replacing the bus terminal with a street terminal and by reducing the existing 14 city lines to four by changing to pendulum lines and closing four lines. Frequencies increased on the remaining lines, and all lines were directed to pass the street terminal in the city centre. Services to the airport and the university were substantially improved and the ticketing and fare systems were simplified. Simplifying the bus and fare systems made it easier to provide accessible information about the services. The total number of departures in the system remained about the same and the route production (kilometres per year) on city line increased by 13%. In 2015, bus fares increased by 18% and incentives for using period tickets were introduced; in addition, road tolling was introduced in October and frequencies increased on two routes in December. Patronage increased by 10.9% per year in 2012–2016, which was significantly stronger growth than expected, according to the consultancy report. The same report describes an NOK 5.5 million cost increase the first year due to increased route production and that increased income due to patronage growth covered this within the first years. An NOK 4.3 million net profit was estimated in 2013–2016. Bodø was among the first of the smaller Norwegian cities to change its bus system according to these principles, and this case has served as an example for other cities. Data from passenger statistics were provided by Nordland County.

4.1.6. Hamar

In Hamar (28,000 inhabitants, 7.6% of trips by public transport), changes to the public transport services were introduced in the period 2012–2016 to increase efficiency and patronage and to reduce car usage. The route structure was simplified by removing loops on and straightening two lines and by replacing one line with another. The frequencies on all remaining lines increased. On the two lines with the highest patronage in the pre-change situation, the 15-minute frequencies during rush hours only were expanded to most of the day. On two other lines, the frequencies doubled from every 60 min to every 30 min throughout the day and the operating hours were reduced on one of these lines and extended on the other. The latter line was extended at both ends to the centres of the neighbouring municipalities, wherefrom many commute to Hamar, and pass through Hamar's city centre on the way. This was followed by the largest growth by far among the lines, and by 2016 this had become the line with the highest patronage. The growth on this line constituted most of the total growth for all city lines in the evaluation period – 17.1% per year in 2012–2016, although all city lines experienced growth. In comparison, the patronage growth was 6.1% in 2011–2012 and − 1.1% in 2010–2011. The public transport services were also marketed in new ways by using the popular local ice hockey and football teams in their campaigns. Improved services on some lines were mainly financed by a reallocation of resources from other lines. No data were available for the total cost and income effects of the service changes and the patronage increase. Data retrieved from the ticketing system were provided by the public transport agency Innlandstrafikk, owned by Innlandet County.

4.1.7. Hønefoss

Hønefoss (16,000 inhabitants) had experienced a period of patronage stagnation and decline. Its bus services were characterised by high coverage and low frequencies. To attract more passengers, the system was reorganised into fewer lines organised as pendulum lines. Lines were straightened, loops were removed and frequencies were increased on main lines. The changes made the system easier to communicate and understand, as illustrated in Fig. 2. Patronage on the city lines increased by 8.2% per year in 2015–2019. In

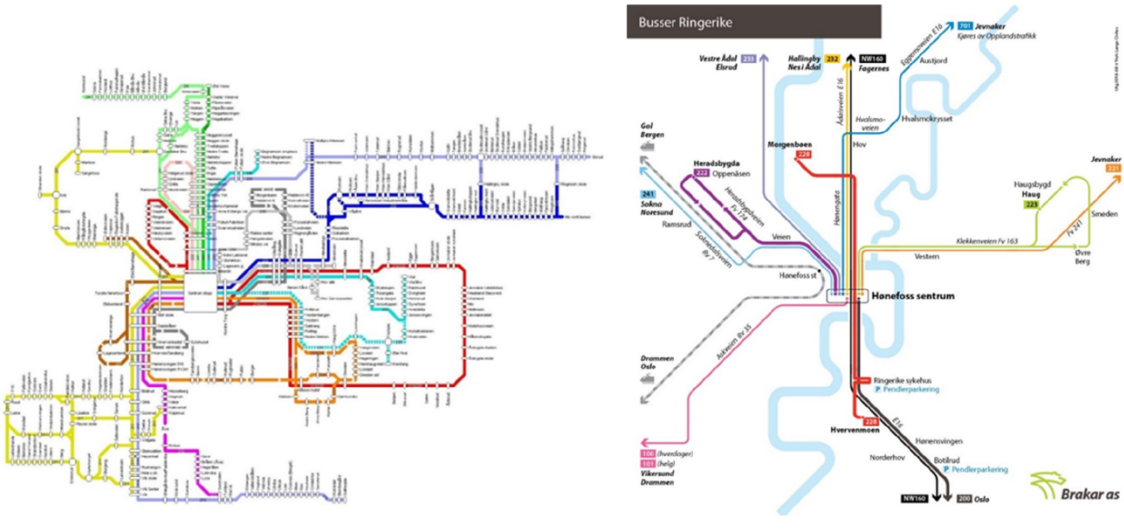

Fig. 2. The route structure in Hønefoss before (left) and after (right) the reorganisation of the system, from Brakar AS.

contrast, patronage declined by 2.1% in 2014–2015. Patronage also increased on regional lines. Improved services on some lines were mainly financed by a reallocation of resources from other lines. No data were available concerning the total cost and income effects of the service changes and the patronage increase. Data were provided by the public transport agency Brakar AS, owned by Viken County.

4.1.8. Kongsvinger

In Kongsvinger (12,000 inhabitants), the route structure was simplified from four lines to two pendulum lines in 2015. The aim was to increase the proportion of trips made by public transport. Emphasis was placed on connections to the city centre and the railway station. Frequencies were increased to one departure per hour on the city line corresponding with train departures in 2016. The changes were followed by a patronage increase of 12.8% per year in 2014–2016. In comparison, patronage growth was 0.7% per year in 2011–2014. No data were available concerning the total cost and income effects of the service changes and the patronage increase. Ticketing data were provided by the public transport agency Innlandstrafikk, owned by Innlandet County.

4.2. Summary and analysis of patronage effects across cases

Results directly related to effects on patronage (annualised pre- and post-change patronage, annualised average patronage growth and annualised population growth) are summarised in Table 1.

Across the eight cases, the main finding is that the reorganisation of city bus services into fewer, straighter, faster and simpler lines with higher frequencies was followed by patronage growth, despite increases in walking distances to stops and reduced services in less populated areas. Most cities also simplified their ticketing and fare systems and ran campaigns to inform the public about the improved services, and fares were reduced in one city. The patronage increases varied from 3.3% to 17.1% per year (average) over the evaluation periods. In all cities, the patronage growth was stronger in the years immediately following the interventions than it had been in previous years, and in three cities, the trends were reversed from patronage decline to growth. In all cases, the patronage growth was substantially stronger than the population growth in the same period. According to data from Statistics Norway (2021c), there has been a slow and steady patronage increase in bus services in Norwegian urban areas, for which there are data (including the largest cities discussed here), of about 3.6% per year from 2012 to 2019. Excluding the largest cities and the cities discussed in this paper, the growth was 2.4% per year from 2012 to 2019. The patronage growth in all cases studied here was, therefore, larger than the growth in public transport patronage in other comparable Norwegian cities, the pre-change growth and the population growth. Thus, our understanding is that the enhanced post-change patronage growth in the investigated cities was caused by the changes to the public transport services. Results of the survey in Haugesund suggested that the majority of new bus riders were former car users (Norconsult AS, 2017). Similar surveys have not been made in the other cities.

The available data did not enable sharp analyses to explain differences among the cities with respect to patronage development, but we assume this is a result of differences in the pre-change services, the particular interventions that were implemented and urban contextual factors. In Hamar, the extension of a pendulum line to the centres of the neighbouring municipalities, together with increased frequencies and longer operating hours, seems to have made it an attractive alternative to private car use for commutes. The patronage increase on this line was, on average, 90% per year in 2013–2016, and this constituted most of the growth in the Hamar case. New ways of communicating and marketing the services were emphasised as part of the success. In Bodø, it was suggested that the more visible and easy-to-understand bus services after the interventions were an important part of the explanation as to why the trend was reversed from a pre-change annual 5.4% patronage decline to 10.9% annual growth, in combination with improved services to destinations attracting many people (Nielsen Consulting AS, 2016). In Vågsbygd, Kristiansand, the merging of three local lines into one straighter and faster line with higher frequency and visibility resulted in significant passenger growth. Across the cases, it seems that the simplification of services, ticketing and fare systems made the services easier to communicate. In combination with service improvements on lines with high patronage potential, this seems to have been key to increasing patronage in several cases.

4.3. Factors influencing the decisions to implement these kinds of interventions

Interviews with representatives of the county administrations, the public transport agencies and the municipality related to each of the two cases of Hamar and Haugesund are first summarised case by case and then analysed across cases.

4.3.1. Hamar case

When asked about overall objectives, all three interviewees in the Hamar case referred to regional strategies and plans, the zero-growth objective and the related financing opportunities. These factors provided the motivation to improve public transport services to compete better with private cars and attract more passengers. The interviewees agreed that this also required steering land use development towards less car-dependent locations and reducing (or not improving) car accessibility. Important goal conflicts concerned neighbouring municipalities allowing car-based sprawl, that national road authorities recently had opened a new motorway that improved accessibility by car, and ongoing discussions with national road authorities concerning reallocation of road space to public transport lanes to prioritise public transport accessibility within and through the city (see also Skartland, 2021).

The public transport agency interviewee reflected in accordance with state-of-the-art knowledge (as discussed in section 2) when explaining what changes they had considered and made to the public transport services. Different measures had been implemented in the past to increase patronage with only modest success. To develop their strategies and plans, they had, therefore, sought knowledge of what works in seminars and popular science literature (e.g. Nielsen and Lange, 2015, was mentioned), contacted successful cities to learn from them (e.g. Bodø and Oslo) and used consultants with experience from other cities. This had clearly influenced their decisions

to extend and improve the services on the line that gained the largest patronage growth, to experiment with new ways of marketing the services and to appoint a position in the organisation to talk to passengers and businesses about how the services could be improved. The positive experiences strongly influenced their action plan for 2018–2021 (Hedmark County and Hedmark Trafikk, 2017), where standardising marketing and information were among the main goals and a main strategy was to extend city lines in other small cities in the region to attract commuters.

The public transport agency was well aware of the conflicts between the coverage and patronage goals also on a regional scale. It wanted to use more resources on city lines, straighten out lines and reduce services in less populated areas but had experienced resistance for such decisions and had not been allowed to take this as far as it believed was right. The county administration interviewee said that the introduction of a public transport agency and the tendering system had positively affected public transport thinking, planning and development. This had become less 'political' and more 'professional'. It was, however, still necessary to test whether proposed measures had political support before formally proposing them, and this had restricted which interventions could be carried out. As part of the preparations for the 2018–2021 action plan, county representatives initiated dialogue with representatives from the municipalities about their land use plans and what they saw as important to prioritise when designing the public transport services. This had resulted in useful inputs, as well as a better understanding among the municipalities of the necessity of prioritising, and of developing land use within the catchment areas of existing public transport services.

4.3.2. Haugesund case

The interviewees related to the Haugesund case also referred to regional and municipal strategies and plans stating the zero-growth objective and the related financing opportunities when asked about overall goals and objectives. They, too, emphasised the necessity of steering land use development in directions to reduce car dependency and restrict car accessibility to achieve zero growth in traffic volumes, and they referred to similar goal conflicts as the Hamar interviewees (see also Skartland, 2021). There were, however, different understandings among the authorities concerning whether improving public transport services could be an important part of the strategy to achieve the zero-growth objective in Haugesund.

Patronage had been low and declining in the city over a long period. The county administration interviewee said they were unsure about what could be done to increase patronage in Haugesund and if this was feasible in a city of this size and structure. The municipal interviewee expressed similar concerns, explaining that they focused more on how they could increase bicycling to achieve zero growth in traffic volumes, as they believed this would have better chances of succeeding. At some point, the county administration decided to make an effort to increase patronage. The county administration implemented interventions it referred to as 'in accordance with common knowledge' – increasing frequencies on the main routes, removing loops and straightening lines to increase speed, and reducing services in less populated areas. Later, the county administration also pushed through the fare trial, where fares were substantially reduced. The idea behind this was that bus trips within Haugesund are short and the fares need to be low to be understood as 'right', and even small increases in patronage and income would result in a break-even. There were doubts and discussions about whether lower prices would affect patronage, but as the situation was, it was worth testing it out. As it turned out, the route changes were followed by significant patronage growth which continued after the fare reduction was implemented, and the local newspaper started to write positively about the public transport services.

In this case, it seems that the public transport agency was reluctant, while the county administration was initiating the interventions and ensuring that they were implemented. The county administration interviewee said that it was no secret that the administration was dissatisfied with how the public transport agency had marketed the services in Haugesund and how it had reported patronage development. The public transport agency interviewee agreed that the interventions had affected patronage positively, but put more emphasis on local protests concerning the reduction of services in areas with less use.

4.3.3. Comparison across cases

Although zero growth in traffic volumes was stated as an important overall goal in both cases, they differ with respect to understandings of what role public transport improvements could play. In the Hamar case, there was overall agreement that increasing patronage on the city bus lines was necessary to achieve the zero-growth objective. In Haugesund, important actors doubted the feasibility of this and believed other strategies would be more efficient. The Hamar case seems to represent one of well-functioning collaboration and dialogue between the authorities involved, while this seems not to have been the situation in Haugesund. Discussions concerning coverage versus patronage were found in both cases, and they resulted in less consistent interventions with respect to increasing patronage. Further, in both cases, it seems that a key factor explaining why interventions resulting in increased patronage were implemented was professionals possessing relevant state-of-the-art knowledge and who had the necessary power to ensure that the interventions were carried out. Another key factor was the strong focus on the zero-growth objective and related financing opportunities.

5. Discussion

The findings reported in section 4 suggest that state-of-the-art knowledge developed through studies on larger cities, as discussed in section 2, is valid for smaller cities. Cities varying in size from 12,000 to 118,000 inhabitants reorganised their bus services into fewer, straighter, faster and simpler routes with higher frequencies, while walking distances to stops increased in some areas and services were reduced on less used routes. In all cases, the changes were followed by increases in patronage varying from 3.3% to 17.1% per year in the evaluation periods. The increases came after periods of lower patronage growth or patronage decline in the cities, and the growth was larger than the general growth in bus patronage in comparable Norwegian cities and larger than the population growth in

the cities. On this basis, it was concluded that the passenger growth was caused by the public transport service interventions. The findings are in accordance with those by Khan et al. (2021) about strong patronage growth in Swedish regions and cities that had followed similar principles, and together the studies illustrate that patronage can be substantially increased in smaller cities. The findings also support Walker's (2008) contention that coverage often needs to be sacrificed to maximise patronage within limited budgets. It was noted that simplifications of services, ticketing and fare systems improved the conditions for communicating and marketing the services, and this seems to have contributed to the results.

Key factors in explaining why these kinds of interventions have been implemented in small and medium-sized cities across Norway in the last decade are related to goals, knowledge and power. The conflict between coverage and patronage goals, as discussed by Walker (2008), was evident in the cases, and coverage concerns continued to impact how resources were used. It seems, however, that the continuous and agreed focus on the zero-growth objective changed the priorities towards improving public transport competitiveness versus private car usage. Those responsible for designing the systems described the reasons why they had chosen to implement these specific interventions in ways indicating that the state-of-the-art knowledge described in section 2 is now common knowledge in these milieus. They had acquired knowledge through seminars and dialogue with other cities, through best practice guides (e.g. there were references to Nielsen et al., 2005; Nielsen and Lange, 2007, 2015, 2016) and through consultants specialising in public transport planning and spreading knowledge across regions and cities. Such forms of knowledge transfer have previously been identified as important regarding other issues relating to land use and transport planning (Tennøy et al., 2016). The enhancement of knowledge and competence among public transport planning professionals in recent years might be an important part of the explanation for these successful public transport interventions, including the simplification of services, ticketing and fare systems and the marketing of these services. New priorities and enhanced knowledge might be related to the introduction of the tendering system and public transport agencies, as discussed in section 1. The public transport agencies are operating more independently from the political decision-makers and can take a more professional and less political perspective when suggesting changes to public transport services. The political decision-makers still have a strong influence on setting priorities. Contrary to what Khan et al. (2021) find in the Swedish regions, none of the interviewees referred to political support as important for their success. Instead, some said they had been allowed to carry out the interventions due to politicians keeping their distance and refraining from intervening.

To contribute to the continuous exchange of knowledge and experience, the findings regarding the effects of public transport interventions on patronage presented in this paper have been organised in an open database, and public transport planning professionals have been invited to share their data and experiences in a systematic way through the database[2].

6. Concluding remarks

This paper has documented that eight small and medium-sized Norwegian cities developed their public transport services in accordance with state-of-the-art knowledge and achieved patronage growth ranging from 3.3% to 17.1% per year in the evaluation period, in contrast to lower growth or decline in the pre-change situation. This suggests that knowledge acquired through studies on larger cities might be relevant for smaller cities. It further contributes to the understanding that patronage can be increased in smaller cities if this is prioritised and the systems are reorganised into fewer, straighter, faster and simpler routes with higher frequencies. Simplifying the systems made the services easier to understand and market, which might have had an independent effect on patronage growth. A stronger focus on goals to increase public transport competitiveness while reducing car usage, together with enhanced knowledge and competencies among public transport planners, and organisational changes leaving more power to professionals stood out as important factors explaining why Norwegian cities have implemented similar interventions in their public transport services in the last decade.

We believe these results are interesting and useful for those involved in planning bus-based, regular, local public transport services in largely self-sustained regional small and medium-sized cities aiming at increasing patronage. Limited attention has been paid to this in previous research, and this study and the findings make a relevant contribution to the existing literature. Providing attractive public transport services that improve accessibility and reduce car usage might contribute towards societal goals related to more climate-friendly, attractive, liveable, healthy and inclusive cities. Thus, the findings might be useful for cities aiming at achieving the United Nations' (2017) Sustainable Development Goals, such as good health and well-being (no. 3), reduced inequalities (no. 10), sustainable cities and communities (no. 11) and climate action (no. 13).

CRediT authorship contribution statement

Aud Tennøy: Conceptualization, Methodology, Data curation, Investigation, Formal analysis, Writing – original draft, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[2] The database is available at https://www.tiltak.no/tema/database-effekter-av-endringer-i-kollektivsystemene/.

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Submission declaration

This work has not been published previously in any scientific journal, and it is not under consideration for publication in any other scientific journal.

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Appendix A:. Absolute patronage figures

Case city	Year − 2	Year − 1	Year 0	Year 1	Year 2	Year 3	Year 4
Drammen (4.1.1[a])	4,253,280	4,327,550	4,465,293	4,759,530	5,045,000	5,398,000	–
Fredrikstad/ Sarpsborg (4.1.2)	–	–	795,173	836,673	878,749	–	–
Kristiansand, Vågsbygd (4.1.3)	–	–	1,198,977	1,207,353	1,141,246	1,229,831	1,367,436
Haugesund (4.1.4)	–	724,907	711,665	970,337	1,098,813	1,083,172	1,143,375
Bodø (4.1.5)		–	1,306,379	1,480,514	1,567,920	1,677,573	1,977,084
Hamar (4.1.6)	–	453,134	480,634	556,861	608,637	784,280	905,239
Hønefoss (4.1.7)			289,957	304,077	331,444	354,645	397,202
Kongsvinger (4.1.8)	–	–	124,283	138,641	158,146	–	–

[a] This refers to the section in the paper where the case is described.

Appendix B:. Pre-change trends

Case city	Description
Drammen (4.1.1[a])	Annual reports from the public transport agency Brakar (2016, 2018) displayed an average patronage growth of 2.5% per year in 2014–2016.
Fredrikstad/Sarpsborg (4.1.2)	The annual report for Bypakke Nedre Glomma (2020) displayed an average patronage growth of 4.1% per year in 2013–2016 in a wider geographical area with more lines compared to the case area analysed in the paper.
Kristiansand, Vågsbygd (4.1.3)	No information about a pre-change trend in Vågsbygd was available. For Kristiansand city, where Vågsbygd is located, the trend was an average patronage growth of 0.7% in 2011–2014 (Statistics Norway, 2021c[b]).
Haugesund (4.1.4)	A consultancy report (Norconsult AS, 2017) calculated an average 1% patronage decline per year in 2007–2015. Passenger statistics were retrieved from Rogaland County, Department of Transport (2020).
Bodø (4.1.5)	A consultancy report (Nielsen Consulting AS, 2016) calculated an average 5.4% patronage decline per year in 2007–2011.
Hamar (4.1.6)	Annual reports displayed a patronage growth of 6.1% in 2011–2012 (Hedmark County, 2014) and a patronage decline of 1.1% in 2010 due to a route reduction (Hedmark County, 2011).
Hønefoss (4.1.8)	An annual report from the public transport agency Brakar (2016) displayed an average patronage decline of 2.1% from 2014 to 2015. The particular data reported for geographical areas/lines varied, and data for this specific area were reported only for these years. A long period of patronage stagnation and decline was stated as the main reason for interventions.
Kongsvinger (4.1.9)	An annual report from Hedmark County (2014) displayed a patronage growth of 0.7% per year between 2011 and 2014.

[a] This refers to the section in the paper where the case is described.

[b] Statistics Norway (2021c) was not used as a primary data source in the analyses because it does not describe which routes or geographical areas were included (we know they differ from the routes and areas included in our data), how data were collected, when there have been shifts in counting methods, etc. The figures in their statistics display that there are flaws in the data.

Appendix C:. Costs and financing of interventions

Case city	Description
Drammen (4.1.1[a])	Increased costs due to increased route production were covered through a reallocation of resources within the system and contributions from the recompense scheme for improved public transport services and reduced car usage in urban areas (Ministry of Transport, 2013b). We have no information about the total costs or extra financing of the specific interventions in the case.
Fredrikstad/Sarpsborg (4.1.2)	Extra costs were covered by a reallocation of resources within the system and through contributions from the recompense scheme. We have no information about the total costs or extra financing of the specific interventions in the case.
Kristiansand, Vågsbygd (4.1.3)	An aim of implementing the interventions was to increase efficiency and reduce costs. We have no information about the results regarding costs or savings resulting from the interventions.
Haugesund (4.1.4)	Improved services on some routes were mainly financed by reallocating resources from other routes. The consultancy report (Norconsult, 2017) describes an NOK 1.7 million loss related to the fare reduction the first year and anticipates that this would be compensated by increased patronage in 2017 if the positive patronage trends continue (as they did).
Bodø (4.1.5)	The consultancy report (Nielsen Consulting AS, 2016) suggests that the increased route production had required an NOK 5.5 million cost increase the first year compared with previous years. The extra costs were covered by increased income due to increased patronage within a few years. A net profit of NOK 4.3 million in the period 2013–2016 was estimated.
Hamar (4.1.6)	Improved services on some routes were mainly financed by a reallocation of resources from other routes. We have no information about the costs of the specific changes in the case.
Hønefoss (4.1.7)	Improved services on some routes were mainly financed by a reallocation of resources from other routes. We have no information about the costs of the specific interventions in the case.
Kongsvinger (4.1.8)	Improved services on some routes were mainly financed by a reallocation of resources from other routes. We have no information about the costs of the specific interventions in the case.

[a] This refers to the section in the paper where the case is described.

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