Fearnley and Aarhaug *European Transport Research Review* (2019) 11:49
https://doi.org/10.1186/s12544-019-0386-0

European Transport Research Review

ORIGINAL PAPER Open Access

Subsidising urban and sub-urban transport – distributional impacts

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Abstract

Background and methods: This paper studies distributional effects of public transport (PT) subsidies focusing on the Greater Oslo region. We identify how different PT markets enjoy different levels of subsidies. We describe how subsidies are distributed along PT modes and their respective patronage. This is done by document studies and travel surveys, supplemented by expert inquiries.

Results: We find that high-income groups, served by regional trains and high-speed crafts, receive large per passenger and per passenger-kilometre subsidy, while lower-income areas, typically served by local and regional buses, metros and local trains, receive lower subsidies per passenger. Peak traffic receives higher subsidies than off-peak traffic. The overall distributional profile is, however, found to be moderately progressive, in particular because of the socio-economic profile of the average PT passenger relative to the population as a whole.

Keywords: Public transport, Subsidy, Distribution, fares

1 Introduction

Public transport (PT) receives much political attention in Norway. PT is seen as one of the solutions for reaching societal policy objectives of, e.g., creating more liveable cities, reducing the environmental impact of urban mobility, obtaining the political goal of zero-growth in car use in and around major cities, and providing a basis for increased economic activity [1]. This perception has among other things resulted in increased funding for PT. Aarhaug et al. [2] found that the number of PT passengers in Norway has never been greater. However, neither has public spending on PT. The cost increases, covered by increased subsidies, increase at a higher rate than passenger demand. This is in line with expectations from literature where the rules of thumb are price and level-of-service elasticities of demand in the region of 0.4 [3] and below 1.0 even in the long run [4]. It means that the marginal additional passenger is costlier to attract than the average passenger [2]. This raises concerns on the economic sustainability of this system. In extension, this transfer of the exchequer's public funds, from other usages to PT, and the distribution of these funds within PT, plays into the overall questions of the distributional effects.

In this paper we document the present subsidies to PT and their distributional effects. We also discuss these effects in the light of the overall political objectives related to transport and regional development, environmental and distributional concerns.

From a distributional perspective, the issues of increasing patronage for PT is interesting. On the one hand, PT is in general used by lower income groups, and thus PT subsidies are redistributive. On the other, increasing PT use necessitates increasing the user basis for the system. This is in part done by making the system more attractive to wider population segments, by for example increasing the levels of service on links that connect population centres. These centres are often the areas with the highest property values, and these PT services, as a consequence, are used by relatively affluent individuals. High paying jobs are mostly located in central parts of Oslo and therefore served by all modes of PT, while lower paying jobs are located in the suburbs and outskirts and are much less well served by PT [5]. Further, as will be elaborated in this paper, different PT modes serve quite different segments of the population.

Adding to this, the current fare systems in Norway includes a number of social rebates, which typically provide children under the age of six with free travel, children aged between six and seventeen with half fares,

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reduced season ticket prices for students, and half price for elderly (67+) and people on disablement pensions. These rebates contribute to the fact that while the cheapest adult single ticket (1 zone) in Oslo is NOK 36, the average ticket revenue per trip in Greater Oslo was NOK 11.8 in 2018 [6]. The other main source of this low average revenue per trip, are low-prized season tickets.

In Norway, the income tax is progressive while capital is subject to a flat tax rate. In total, the sources for public funding to PT subsidies are by themselves progressive (mainly income taxes and road tolls). More affluent people contribute more, in absolute and relative terms, to the public purse. This paper therefore considers only the distributional impacts of subsidies for PT operations.

There are some studies of the distributional effects of PT subsidies. However, in the public debates there is a common assumption that PT subsidies are redistributive. The literature on the issue finds mixed results. An early study by Frankena [7] concluded that PT subsidies in Canada were regressive. This is also a finding in studies focusing on developing countries [8]. Le Grand [9] attacked what he viewed a misguided perception that public expenditure improves equality. He argues that there may be distributional improvements through bus subsidies, and especially concessionary fares schemes, but the brunt of subsidies goes to support the demanding peak traffic which is mainly done by the richer parts of society. Once the capacity to cater for the peak traffic is in place the marginal cost of an off-peak concessionary fare passenger is negligible. Therefore, one cannot regard the concession a real benefit to the passenger. If the aim of the support is to promote equality, he concludes, the most obvious policy reform is to reduce the subsidies and spend the money saved on targeted support schemes to the groups of people in question. Pucher [10] found progressive distributional effects of transit subsidies in six different US metropolitan areas. Fearnley [11] concluded that UK bus subsidies are generally progressive while rail subsidies are regressive, i.e. that bus subsidies benefit low-income groups and rail subsidies tend to benefit the better off. Looking at Norway, an overall observation is that PT users are less affluent than average [12]. Bjørnøy and Westerlund [13], focusing on the city of Oslo and its surrounding Akershus region, also find that the consumption of PT is dominated by the less affluent and that, overall, PT subsidies are benefiting the poor to a larger extent than the general population. Levinson and King [14] qualify this argument by pointing to the fact that routes which typically serve low-income travellers are often profitable, contrary to heavily subsidized suburban commuter routes. Asensio et al. [15] used the example of Spanish urban areas and found support for the claim that PT subsidies are redistributive but, like Levinson and King [14], they questioned whether PT subsidy is the best policy tool to achieve income redistribution, and pointed to regional differences within Spain. Focusing on the affordability argument for subsidising PT, Serebrisky et al. [16] found, similar to Asensio et al. [15], that PT subsidies do not reach the poorest households, and are thus not the best tool to provide redistributive policies. Serebrisky et al. [16] found that the poor are not just poor in terms of being deprived of mobility, but they are poor in general. Their suggestions for remedies to social inequality are focused on developing countries and include demand side subsidies, monetary transfers to the poor through other welfare instruments, and an increase in the support for infrastructure used by the poor, such as walking and cycling – and to reduce the subsidies targeted at PT provision. Looking at the policy objective of PT authorities, Taylor and Morris [17] found that although the political policy objectives for PT often include distributional issues, serving minorities etc. the priorities actually followed by these agencies are more targeted at attracting a wealthier clientele. Focus is shifting from bus services, which are predominantly used by the poor, to rail and commuting systems used by the more affluent, similar to the findings of Garrett and Taylor [18]. Currie et al. [19] find that there is an interconnection between car ownership and property values, which results in poorer individuals being pushed out of the city, by high property prices, and end up being dependent on cars they cannot actually afford. Delbosc and Currie [20] use Lorenz curves for looking at equity related to PT subsidies and find that there is a correlation with higher number of non-vehicle household's living where PT provision is good. However, they do not enter a discussion of the fairness of this effect, as they can be explained by a number of factors. In a recent study, Börjesson et al. [21] calculate subsidy levels on different PT links in the Stockholm area and find that the subsidy levels are similar across income groups, except for the highest quintile. However, the subsidy levels vary much across the network they studied. From this literature it is clear that there is no consensus on the link between PT subsidies and distributional impact, and indeed whether PT subsidies are an efficient tool for redistribution of wealth. Results and conclusions appear to be sensitive to the context of the study area (place and time) and the study design. Therefore, there is in general a need for more evidence and new approaches. Further, there is limited information on the relative distributional impact of subsidies to different PT modes. This paper focus on these issues using the Greater Oslo area as a case.

This paper is organised as follows. Section 2 lays out important societal and theoretical rationales for subsidising PT and their prevalence in the Norwegian discourse. A short Section 3 describes our methods and data.

Section 4, results presents some general indicators of how PT is financed by subsidies and ticket revenues, respectively, and also demonstrate the use of prevalence of season ticket use in Greater Oslo. In Section 4.2, we study Travel Survey Data and show distribution of use by socio-economic indicators. Section 5 provides an overall assessment and section 6 concludes the paper.

2 Rationales for subsidising public transport

In the transport economics literature, the main (first-best) argument used for subsidising PT is the well-known Mohring effect. This is a network economic argument based on the assumption that the cost of traveling with PT includes both the ticket price and passengers' use of their own time, including waiting time, and that this time has an alternative value. Using these assumptions, Mohring [22] found that there will be an undersupply of PT, in his case of bus services, in a situation where the operating companies set the level of service (headway, or service frequency). His argument is that the operators have no incentive to take into account the alternative value of the passengers' waiting time in their decision on headways. This results in under-provision. Operating subsidies are a first-best strategy to alleviate this and improve social welfare. At present, the Mohring argument is only indirectly part of the decision to subsidise PT in Norway. Indirectly as it is part of the decision loop through the transport model system used [23, 24], but these models play only a minor role in the political discussions on subsidy levels. The validity of the Mohring justification for PT subsidies has been questioned. van Reeven [25], for example, argues that wait times don't justify subsidies of the Mohring type in situations with low headways. Similarly, one can argue that in a case with co-ordinating mechanisms such as smartphones with real time passenger information, which reduce the negative value of the headway in the Mohring model, the need for subsidies is also reduced.

A second-best argument for PT subsidies relates to the assumption that alternative modes of transport (i.e., the car) is under-priced. The full long-run social cost of car use includes externalities like congestion, wear and tear, land-take, local pollution, noise, accidents, CO_2 emissions, and so on. If the cost of all these externalities are not represented in the cost of car ownership and use, and provided that car and PT are substitutes, there is a 2nd best case for subsidising PT. These assumptions may in fact be contested. For example, Wardman et al. [26] and Fearnley et al. [27] find that there is very modest substitution between car and PT and especially so when prices change. There is also a question of whether car use is under-priced. Greater Oslo has a road toll ring which in recent years have been adjusted towards road pricing which –at least in part– internalise congestion costs as well as emission cost. Toll charges currently differ by time of day, vehicle weight and emission class (diesel, petrol including plug-in-hybrids, battery electric, and hydrogen). There are also car purchase and fuel taxes which are determined by emissions.

A related argument for subsidising PT operations, in particular in larger urban areas, would focus on the high capacity of PT operations on a corridor relative to the car. Road networks cannot realistically serve the large peak passenger flows and hence, the public must supply higher capacity rail and bus services.

The social case for PT subsidies relates to objectives of inclusive societies where access to jobs, education, services, and participation should not depend on access to private transport resources, wealth or health. This suggests that a minimum level of PT service should be offered at affordable rates even at times and places where the market base is not sufficient to sustain PT services. Subsidies are therefore required. However, in the literature there is an on-going debate of whether subsidies should be paid to the operator or to (low-income or impaired) passengers, see Levinson and King [14], who also list a few more formal and ethical reasons to subsidise public transport. There is also literature which considers PT subsidies an inefficient tool to reach policy objectives such as social equity and mobility for the less affluent [15].

Two concepts that are related to the social case for PT subsidies are non-use and option value of PT [28, 29]. The option value is the value people place on the existence of a PT alternative even if they don't usually rely on it. Non-use value, i.e. people's valuation of the fact that PT is available for everyone, has an altruistic element although non-users may also benefit, e.g. from the fact that PT contributes to reduced congestion. Both the option value and the non-use value are benefits over and above what can be observed in terms of usage and ticket purchase.

The linkage between PT subsidies and other policy objectives set by the Norwegian National Transport Plan [30] are less clear. The general assumption of the agglomeration effects, which result from increasing the population basis of the region, and thereby facilitating increased specialisation, can be achieved by correcting market failures due to under-provision of transport [31]. However, the role of PT in this argument is a bit unclear. On the one hand, PT should be considered transport infrastructure in line with other transport modes, and in particular high speed train services can be important in increasing the commuting catchment area of a city centre. On the other hand, these effects are in conflict with other policy objectives of reducing the amount of motorised transport [30].

There is an argument that PT, together with dense work-place development, is less polluting than the alternatives. This line of reasoning is based on an assumption that a new workplace located near a transport hub will produce less energy consumption and less emissions from commuting, compared with a different localisation of the same new workplace, see [32, 33].

There are also broader perspectives, which question the need for, and usefulness of, PT subsidies. Politically and fiscally, it is obvious that for a local government, PT services with low patronage can be costly to provide and pay for by means of taxes. Generally, and especially for highly subsidised services, there is a justified worry that high subsidies result in over-production and maladjustment of supply [25, 34, 35].

3 Methods and data

This study aims to document and discuss the present subsidies to Norwegian public transport, and their distributional effects. For practical purposes we have focused on the Greater Oslo region. This region includes more than half of the PT trips conducted in Norway [36] and includes both urban and rural areas, and all PT modes (train, metro, tram, bus and ferry). It therefore gives substantial insight which is also of relevance for other metropolitan areas.

National statics are drawn from Statistics Norway [36] and supported by inquiries to key individuals from PTAs. Regional statistics and data on passenger numbers, ticket revenues and subsidies are drawn from the local PT authority in the Greater Oslo region, Ruter, as well as studies conducted by Nore et al. [37] and Aarhaug et al. [38] for wider geographical coverage. Travel behaviour is drawn from the 2013/14 national travel survey (NTS) documented in Hjorthol et al. [12].

The data processing and analyses in this study consist primarily of combining and processing publicly available data from these different sources. This is then interpreted through references to the academic literature and expert inquiries in order to present a consistent picture of the current situation relation to PT subsidies in Norway. This forms the basis for our results and discussion.

4 Results

4.1 Ticket revenues and subsidies

The foremost PT mode in Norway with respect to passenger numbers, is the bus. Buses serve a variety of purposes in different Norwegian cities. In all cities except Oslo and Bergen, buses provide both the trunk routes as well as the branches. In the Greater Oslo region, which consists of Oslo municipality and the surrounding Akershus county region, buses predominantly provide services to areas not served by rail-based networks (metro, tram and train).

Looking at national subsidy levels and ticket revenues for all bus services from 2005 to 2017, a clear pattern emerges. Ticket revenues per trip are more or less constant, in running prices. If they were inflation adjusted, they would in fact drop slightly. Over the same time period, subsidy per trip has increased, also when controlling for inflation. This is illustrated in Fig. 1. In 2017, bus passenger revenues averaged 41% of total revenue and subsidies 59%.

In the time period described in Fig. 1, PT services have expanded substantially. This is both due to more routes being offered and increased service frequency. The development can be sequenced in two steps. First, the reorganisation of PT services from direct political control in terms of planning and execution to indirect control through PTAs gave a more efficient service [39]. Second, services have been expanded.

There are several factors that have contributed to the observed stable ticket prices and increasing subsidies per trip over time [2]. Focusing on the Greater Oslo area (Oslo and Akershus), a conscious policy has consisted of stabilising and even reducing[1] ticket prices over time, and transferring passengers from single tickets, often purchased from the driver, to cheaper prepaid tickets and heavily rebated multi trip or season tickets.[2] In 2011, a total of 88 different ticketing zones and 77 different ticket types were reduced to eight zones and seven ticket categories. This simplification also reduced the average fare. In addition, restrictive policies towards car use have tightened over this period. The total effect of these policies has been to reduce the marginal price for a PT trip and an increase in PT use. The average number of bus trips per inhabitant in Oslo and Akershus increased from 90 in 2005 to 131 in 2017 [36]. A focus on PT market shares and customer satisfaction has led to improved peak services and higher quality and thereby higher operating costs per passenger.

From the NTS data, we observe that season ticket holders (month and year) have a higher probability of traveling by PT during the peak hours in Akershus compared to Oslo (Fig. 2), and that the share of season ticket holders, as proportion of the total number of passengers, is higher in peak hours than outside (Fig. 3.). The pattern is more pronounced for residents in Akershus compared to Oslo – which suggests that PT fills different roles in the two counties.

Figure 2 is constructed so that the sum of all hourly percentages in each county adds to 100. In other words, the figure cannot be used to indicate the absolute levels of PT use between the counties, but the relative distribution through the day.

[1]In 2007, the price of monthly travel passes in Oslo was reduced by 24% from NOK 720 to NOK 550 as part of a political compromise.

[2]Monthly travel cards in Greater Oslo would cost the same as about 20 single tickets, or 10 return trips.

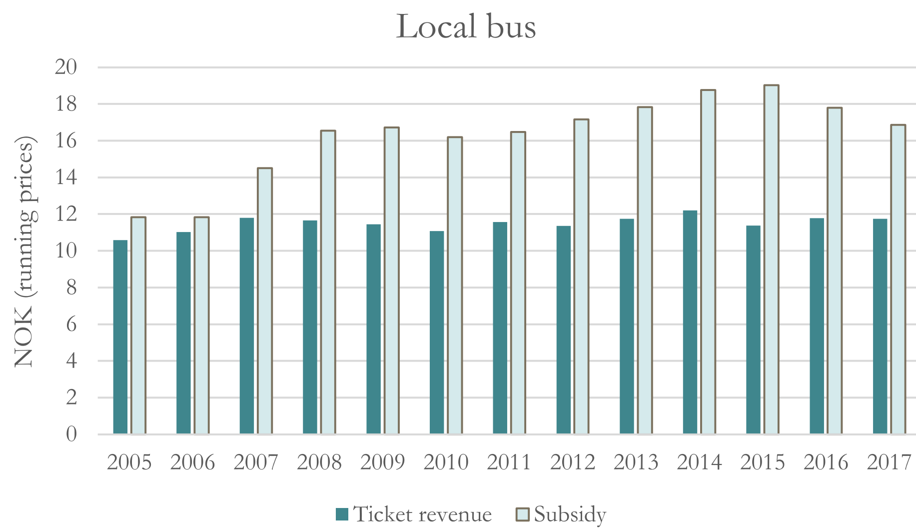

Fig. 1 Ticket revenues and subsidies per bus trip in Norway, 2005-17. NOKs (the average exchange rate over the period was NOK 8.3=€1). Source: Statistics Norway source table 06668

Looking at Figs. 2 and 3 together enables a couple of interesting observations. The peak is shorter and earlier in Akershus compared to Oslo, and this points towards higher usage for commuting, and longer commutes. Less usage of PT in Akershus between the peaks points towards a higher percentage usage for commutes, and lower for other trip purposes. The season ticket shares in Oslo is higher throughout the day and at about 90%, while it is changing more in Akershus, with shares almost at Oslo level during peak hours, and down to about 70% off peak.

Figure 4 illustrates ticket revenue and subsidy per trip, together with the estimated subsidy share based on the 2017 annual report from Ruter (the PTA for Greater Oslo) and an estimate based on different sources for train. Urban buses and metro have the lowest total revenues (which approximate their operating costs) and the lowest subsidy levels at around 20%. Ticket payments per passenger are remarkably similar over the different modes, even though average trip length is different, cf. Hjorthol et al. [12]. The difference in costs is largely covered by subsidies. The highest levels of subsidies, both in NOKs and as proportion of total revenue, are found in ferries and trains, but note that train subsidies are based on estimates. Regional bus services and urban tram service have similar subsidy levels of just less than 50%. As regional bus services on average cover longer distances this points towards higher subsidies both in absolute and relative terms for longer trips, which again have a higher share of commuters with heavily rebated season tickets. The percentage subsidy does not change if we use passenger kilometres (PKM) instead of

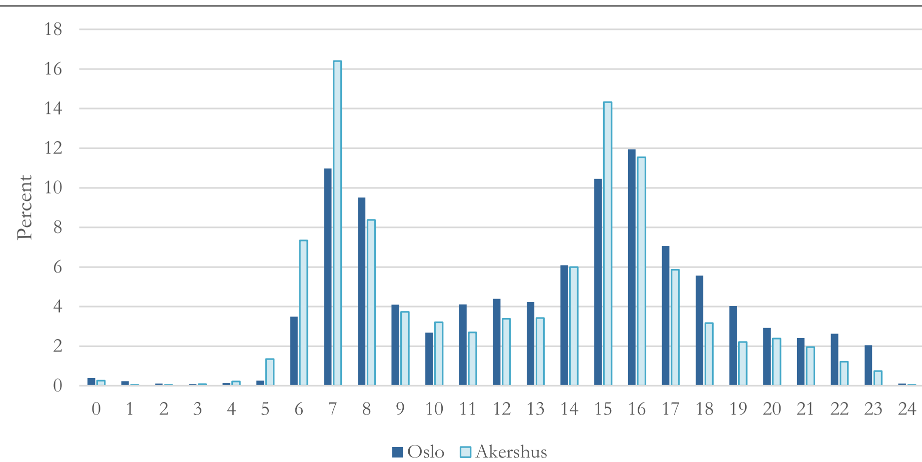

Fig. 2 Distribution of PT trips made by season ticket holders, by region and by hour of the day (Oslo city and its surrounding Akershus county) (NTS) (n= 5665, 2304)

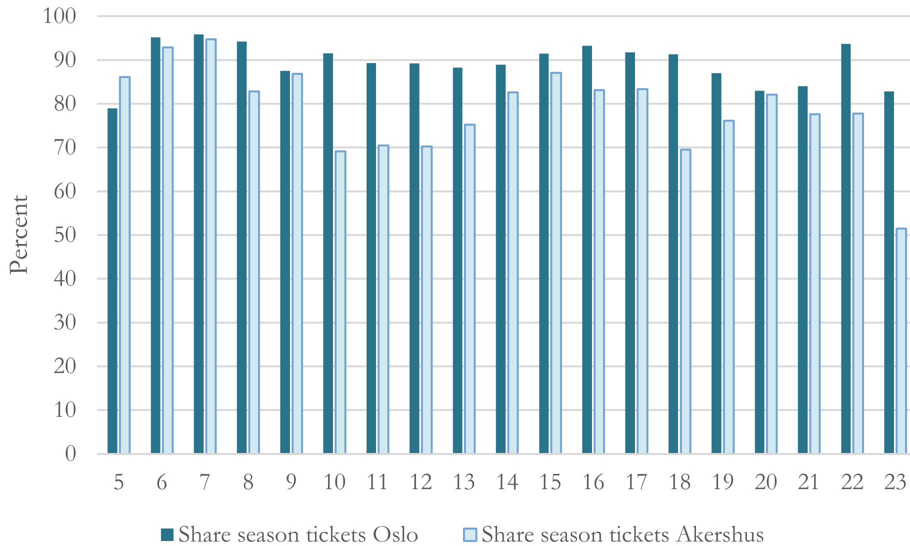

Fig. 3 Share of season ticket holders in Oslo and Akershus by hour of the day (NTS) (n= 5665; 2304)

trips as the unit of analysis, since both ticket revenue and subsidy are only available as aggregated numbers. Regional buses have in absolute terms the lowest cost per PKM with approximately 1.7 NOK/PKM, followed by the metro at 2.4 NOK/PKM and urban bus with 2.7 NOK/PKM. Trams and regional ferries (including high-speed craft) come in at 5.3 and 6.2 NOK/PKM, respectively, while urban ferries have 16.7 NOK/PKM. From the available data it is not possible to compute a value for train cost per PKM. The main argument against using PKM, however, is the unreliability of the estimates. Even with modern automated passenger counting systems, the data on how far a passenger travels is still very unreliable.

4.2 Income groups and their use of different PT modes

The main trend in Norway [12] is that PT and in particular bus services are most important for persons with low levels of income. This is not unique to Norway, but is also found internationally. See Bureau and Glachant [40] and Fearnley [11] for French and UK examples. The

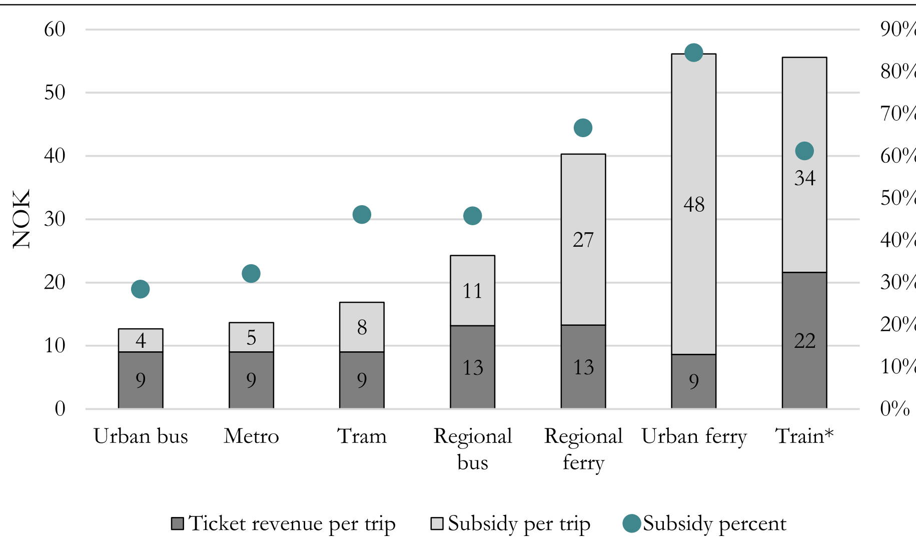

Fig. 4 Ticket revenue and subsidy per unlinked passenger trip in NOKs (left axis) and subsidy as share of total revenue in percent (right axis). Source: Ruter annual report 2017 and for train subsidies Nore et al. [37]. Train is marked by * to indicate uncertainty, especially of subsidy levels. The raw data behind the train column is of low quality. The presented estimate is therefore made conservatively. It is likely to be an underestimate of real public purchases

dominant finding is that bus services are used mostly by persons from low-income households who lacks alternatives, while rail-based services attract a broader user group with higher incomes.

In our case, the Oslo and Akershus region, we find that the use of PT is different between the city (Oslo) and its surrounding region (Akershus). PT usage is higher in Oslo by all income segments (Fig. 5).

PT use in Akershus is high among the lowest income group, with about 0.9 PT trips per person on average per day, while the slightly higher income groups have very low PT usage. The lowest PT use for Akershus dwellers is observed among persons with incomes between NOK 300000 and 400,000 per year. For persons above this income level, PT usage is in fact increasing with income. In Oslo, the pattern appears to be one of slightly falling dependence on PT as incomes rise.

It is also interesting to observe average incomes of persons using different modes of transport in the Greater Oslo region, based on NTS data. Figure 6 shows that car as driver, cycling and taxis have the most affluent users in Oslo. E-bike users are even wealthier on average, but the number of observations is few. Looking only at Oslo, there is no significant income differences between the different PT modes, and they all lie below the average income level. In Akershus, the story is slightly different, with higher income persons using rail-based modes, and low-income groups using buses. The average bus passengers in Akershus enjoys an almost 30% lower income than the average passenger on rail-based PT modes.

5 Discussion

PT is serving different needs in different parts of the Greater Oslo region. Within the city of Oslo, there is little socio-economic difference between passengers on different PT modes, and between PT and other modes, as illustrated in Fig. 6. In the surrounding areas, here defined as Akershus county, the usage is different. PT is mostly used by two groups: Commuters and persons without access to private car. These groups do not necessarily have overlapping needs. Commuters typically require peak-hour transport to Oslo or a regional centre, while persons without access to a private car have a much wider set of needs. The data presented in this paper suggests that train and boat users in Akershus are mostly similar to the car owning population in terms of income. Tram and metro services in Akershus are marginal in terms of coverage, limited to a few affluent communities in Bærum municipality (see Fig. 7b). The NTS shows that persons without access to private car mostly travel by bus, and not by train. As subsidy levels are higher for train and boat operations, compared to bus-operations, this suggests that the highest levels of subsidies within PT are being used to serve relatively well-off individuals. Services that are dominated by lower-income passengers, require and receive less support in the form of subsidies.

This raises questions regarding how the ticketing system is used to finance PT operations. On the one hand, off-peak travellers seem to finance the cost their trips incur through their ticket, and there is low marginal cost of off-peak service production. Recall that the cheapest single ticket is NOK 36, which is well above the average cost of serving bus, metro or train passengers. Peak hour traffic, on the other hand, is more expensive to produce, and use is more dominated by persons who are more affluent. The passengers on these services also pay less as they use season tickets which provide large rebates for their average trip and zero cost to their marginal trip.

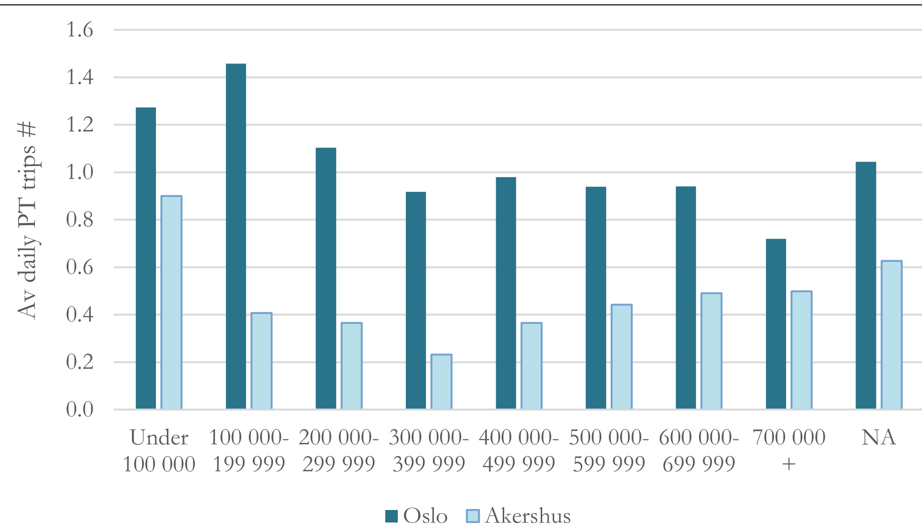

Fig. 5 PT trips per day, by income bands (NTS)

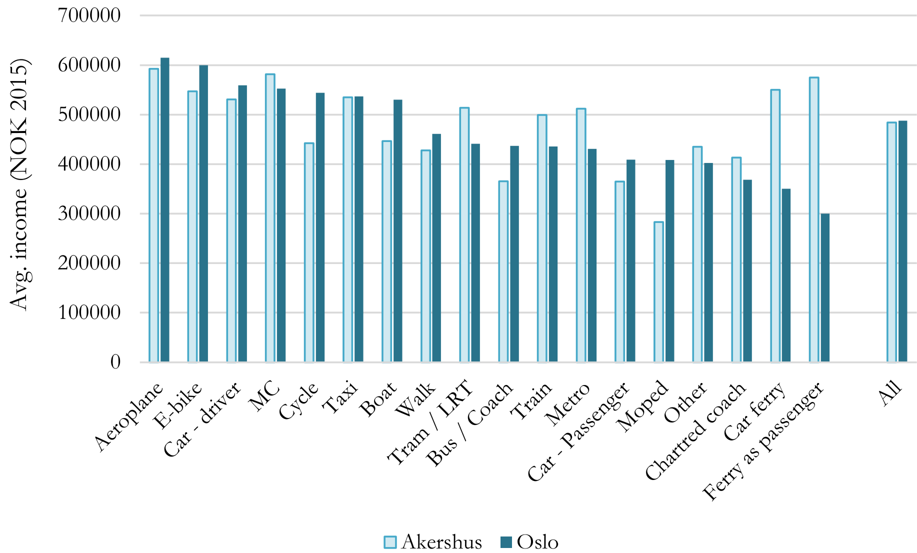

Fig. 6 Average personal income for different transport modes (NTS)

This argument can be validly criticised by pointing to the fact that utilisation rates in peak hour traffic are much higher, possibly resulting in higher cost recovery per vehicle. Still, marginal increases of supply in peak periods has proven more expensive to provide than average production in the Norwegian case [2, 41]. Also, peak traffic is very directional with the result that average load factors are not particularly high, even during peak. As peak hour marginal cost of production is higher than average costs, while direct marginal cost of using these services are zero, this points to a misallocation of supply.

From a transport – or regional development – point of view, high subsidy levels to relatively well-off individuals need not be inefficient. It can be that the marginal societal disutility of having these individuals traveling by car is higher than the cost of the subsidy (cf. the second

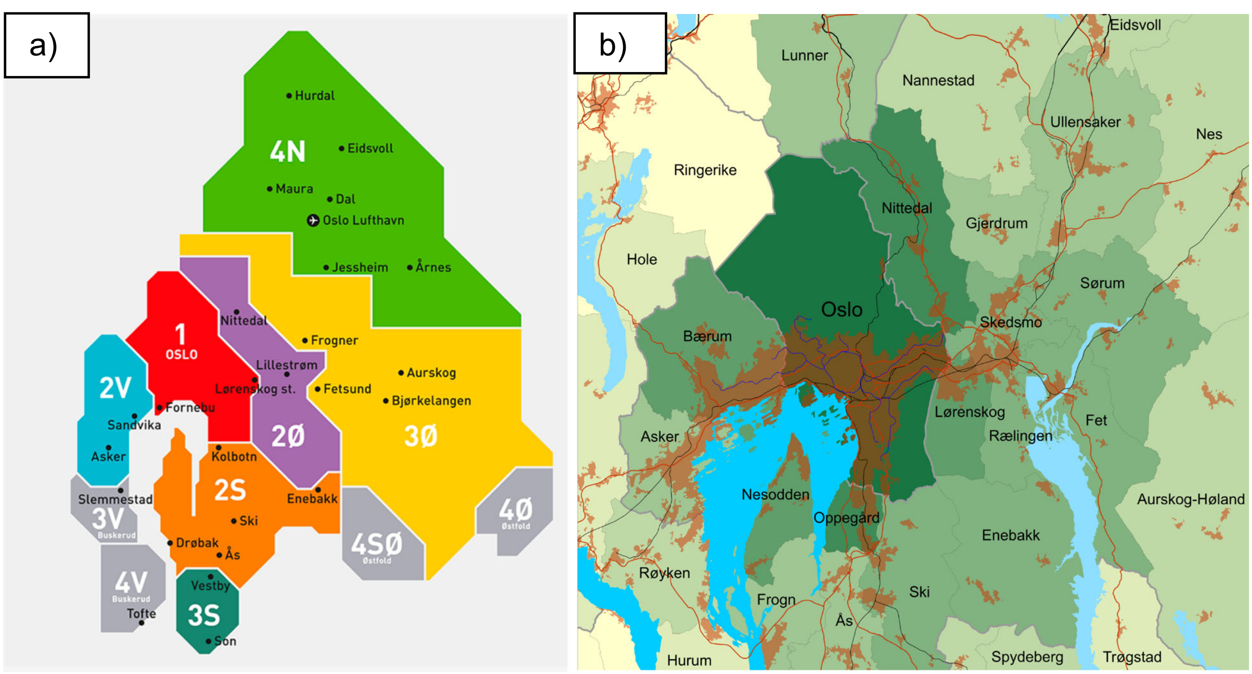

Fig. 7 Map 1. **a**) PT zones in Oslo and Akershus municipality (source: Ruter.no); **b**) main roads (red), railways (black) and metro lines (purple), overlaid on buildt-up area (brown), and commuting shares (shades of green) (source: Institute of Transport Economics)

best argument for PT subsidies), or that it is beneficial in a regional perspective to promote strong labour market regions through long distance commuting by PT and to reduce the wealthy population segments' propensity to live in the central parts of the region. In each of these cases the distribution of the subsidies between modes can be justified from an efficiency argument. From a distributional perspective however, this way of prioritizing between the modes conflicts with the stated policy objectives of using PT as a means of achieving redistribution.

Data from the Greater Oslo region shows that long distance commuting by PT is mostly conducted by relatively affluent persons. This points towards the issue of self-selection in urban residency choices cf. [42]. From previous studies we know that affluent persons may choose to live in areas with longer commutes, but other positive characteristics when commuting is seen as a second tier argument in their choice of residence [43]. The present study may also indicate that comfortable PT modes, such as train and high-speed craft, may contribute to reduce the importance of commuting relative to other factors in residential choice.

6 Conclusions

Over time, Norwegian subsidy levels have increased while average ticket prices have remained stable. Subsidies currently make up nearly 60% of total financing of local PT operations in Norway. There are strong theoretical, efficiency and social rationales for subsidising PT. Progressive distributional effects of PT subsidies are often assumed in the public and political debates, yet the distributional impact of PT subsidies is rarely examined. This paper has cast some new light on the question with a focus on PT in Greater Oslo. However, our paper finds mixed results along several dimensions:

First, the evidence suggests that season ticket holders, of whom a large share are commuters with (high) incomes, receive generous rebates while the cost of providing peak capacity is the largest. Off-peak passengers and passengers on single tickets pay a much larger share of the cost their trips incur. We therefore consider the distributional effect of season ticket rebates to be moderately regressive.

Second, there is a modal aspect in which passengers on urban bus and metro pay the largest share of the cost of their trip, while more affluent train and boat passengers pay the least share of their costs. (Note that ferry plays a limited role as PT mode in our study area.) Given the income distribution of different PT modes, lower subsidy rates to bus and larger subsidy levels to rail sum up to regressive distributional effects.

Third, the lowest income group, i.e. those earning less than NOK 100,000 per annum, rely on PT the most. This is the case both in the city of Oslo and its surrounding Akershus region. In the city of Oslo, PT use falls steadily with income. A different pattern is evident for the Akershus region, where commuting dominates: those with higher incomes rely more on PT than those with middle incomes. In total, these socio-economic profiles suggest a progressive distributional effect of PT subsidies, although with some differences within the region.

Fourth, PT passengers' average income are lower than those of motorists and of the total average. This holds for all PT modes in Oslo and for bus in Akershus. This means that PT subsidies redistribute wealth and income from the relatively rich to the relatively poor. For train and metro in Akershus, however, the opposite holds true.

Fifth, the cost of attracting the last (marginal) PT passenger is higher than the average passenger cost. These discretionary passengers are typically relatively better-off (they would typically be car-owners, commuters and reside in central areas with high property values) and therefore, the distributional effects of such PT *subsidy increases* would typically be regressive. In addition to these passengers the marginal passengers can be users of new branches of the PT system with very low ridership and therefore, high subsidy irrespective of these user's income.

Overall, this study concludes that the effect of PT subsidies in the Greater Oslo region is moderately progressive in that they redistribute wealth from high-income groups to lower-income groups. People on relatively low incomes use PT to a higher extent than the wealthier and therefore, they benefit more from PT subsidies.

However, within PT the highest subsidies per trip and per passenger kilometre, are paid to the PT users who are most affluent: peak travellers and longer-distance commuters. The picture is not clear-cut, but there is a clear tendency. The longer distances are mostly catered for with train and high-speed craft services, which are more expensive to provide, both in terms of per passenger and per passenger kilometre cost. In summary this means that PT subsidies only have a limited function as a tool for redistribution.

Using PT as a tool for regional development, by promoting rail, is to some extent in contrast to the use of PT for redistribution purposes. A similar situation occurs with respect to using PT as an alternative to the private car for environmental reasons. This may be sound policy in terms of reducing greenhouse gas emissions or local pollution, but this reduces the redistribution arguments for PT subsidies.

Acknowledgements
Not applicable.

Authors' contributions
Both authors have read and approved the manuscript.

Funding

The work on this paper has been funded by the SMARTMOB-project, supported by Akershus county.

Availability of data and materials

Statistical data used in this work is publicly available at the sited sources.

Competing interests

The authors have no competing interest.

Received: 10 July 2019 Accepted: 13 November 2019

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