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The impact on bus ridership of passenger incentive contracts in Swedish public transport

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Preface

This study is the first part of the larger project *Incentives and Evaluation for Improved Public Transport*. The study has been conduted by VTI with funding from and in collaboration with K2 - The Swedish Knowledge Centre for Public Transport.

The authors are grateful to Skånetrafiken, and in particular Annika Bondesson and Erik Isacsson, for their good cooperation and for providing exemplary data. The paper also benefited from discussions with and comments from Kristofer Odolinski, Didier van de Velde, the procurement groups of the PTAs and bus operators, participants at a presentation at VTI, delegates at the ITEA Conference 2018 in Hong Kong, as well as participants in the Local Public Transport Procurement workshop in Rome, Persontrafikmässan 2018 in Stockholm, and Transportforum 2019 in Linköping

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Abstract

Over the years, passenger incentives have increasingly been used in Swedish public bus transport to increase ridership by introducing passenger incentive contracts. In those contracts, operator revenue comprises production-related revenue and a per-passenger–based incentive payment. In 2015, half of all active contracts were of this type, but there are few evaluations on whether the contract type increases ridership. Using rich passenger data, this paper analyses whether the ridership increase in the Skåne region can be attributed to the introduction of this contract type.

The results cannot prove that passenger incentive contracts have increased ridership more than traditional gross-cost contracts. This is probably because both the per-passenger payment and operator freedom to adjust traffic provision are too low. While simulation studies have previously shown that higher payments and freedoms would increase bus ridership, it is unclear whether public transport authorities should leave the freedom to adjust traffic provision to operators, given the authorities' social welfare responsibility. Instead, factors outside the contract, such as car-restricting measures and improved bus road space, might be more effective in increasing the number of passengers.

Sammanfattning

Under de senaste åren har upphandlade avtal med passagerarincitament använts i allt större utsträckning i svensk kollektivtrafik. Syftet har varit att öka resandet genom passagerarincitament riktade mot operatören. 2015 var hälften av alla aktiva busskontrakt av denna sort där operatörens ersättning är uppdelad på en produktionsrelaterad del, men även en betalning per påstigande passagerare. Men få utvärderingar har gjorts för att bevisa att avtalstypen ökar resandet. Genom att använda ett rikt data analyserar denna rapport huruvida passagerarökningen i Skåne län kan sägas bero på länets ökade användning av passagerarincitamentsavtal.

Resultaten kan inte bevisa att passagerarincitamentsavtalen har ökat resandet mer än de traditionella produktionavtalen, där operatören inte får betalt per påstigande. Detta är troligtvis på grund av att operatörens ersättning per påstigande varit för låg samt att operatören haft för få frihetsgrader för att påverka trafiken. Simuleringsstudier har tidigare visat att högre ersättningar och frihetsgrader skulle öka resandet. Det är dock oklart huruvida kollektivtrafikmyndigheterna, ur ett samhällsekonomiskt perspektiv, borde ge operatörerna dessa stora friheter, som bland annat kan inkludera frihet att sätta utbud och/eller taxor. För att öka resandet bör man istället överväga metoder som traditionellt ligger utanför kontraktet. Exempel är olika bilhämmande åtgärder i statsrummet och prioriterade busskörfält.

1. Introduction

The provision of local public transport is the responsibility of public transport authorities (PTAs) in most developed countries. While market failures (e.g., the Mohring effect), pollution and congestion externalities, and various distributional goals are the welfare economics motivations for providing subsidized public transport (Asplund and Pyddoke, 2018; Börjesson et al., 2017; Jansson, 1980; Mohring, 1972; Parry and Small, 2009), in contrast, the political goals and reasons for public transport interventions are frequently framed in less technical terms. Among the stated goals for public transport are desires to increase patronage and customer satisfaction, make mobility available for disadvantaged groups, and reduce car travel for environmental reasons (Pyddoke and Swärdh, 2017). The demand for public transport, however, results from complex interactions between land use, demography, infrastructure provision, taxation, public transport supply, and regulation (Bláfoss et al., 2018; Taylor and Fink, 2013). Continuous changes of the preconditions and social requirements for public transport create a further need to adjust the supply in terms of route network, service frequency, and pricing. As substantial public funding is involved, knowledge of the costs and benefits of possible alternatives is required. Recently, a substantial literature has emerged exploring socially optimal policy instruments for urban transport (e.g., congestion charges and parking pricing) and public transport supply (e.g. fares, frequencies, and bus sizes (Basso and Jara-Díaz, 2010; Börjesson et al., 2017; Kilani et al., 2014; Tirachini et al., 2014).

Since the 1980s, a growing share of public transport in developed countries has been tendered to private operators, and how contracts should be designed to incentivize cost effectiveness has received attention (Carlquist et al., 1999; Hensher and Wallis, 2005; Wong and Hensher, 2018). One important question has been how operators' specific knowledge and skills can be harnessed to contribute to the continuous adjustment of supply. One idea is that operators should be given specific incentives, both monetary and the freedom to adjust traffic provision, to increase ridership. There are several motivations for this: first, operators can directly observe where demand is increasing and therefore know where increased supply is desirable (i.e., market knowledge); second, to increase ridership, operators need some freedom to adjust supply; and third, freedom for the operator to make such adjustments would avoid the cost of renegotiating contracts.

The purpose of this study is to test whether Swedish bus contracts incorporating passenger incentives have contributed to increased ridership. The hypothesis is that, in these contracts, the ridership has increased more than in traditional gross-cost contracts. This is investigated using a rich dataset on bus ridership from 2010 to 2017 in the Skåne region of Sweden.

The Skåne region is an interesting and appropriate case because it developed a passenger incentive contract and then implemented this contract type starting in 2013. This gives good scope for identifying the effects of this contract type on ridership. Furthermore, Sweden in general constitutes an interesting case because increased ridership has been a vision of the Swedish public transport industry since most industry parties formed the

"Partnership for improved public transport" with the target of doubling public transport ridership between 2008 and 2020 (Partnersamverkan, 2009). Perhaps the most notable output of the partnership was the so-called passenger incentive contract recommendations, in which passenger incentive payments are integral to the ridership strategy. In 2015, half of all active Swedish bus contracts used this type of payment to provide part or all of operator revenue (Transport Analysis, 2017). The Skåne-type passenger incentive contract is largely representative of those recommendations, making the results generalizable to the overall Swedish context.

Public transport ridership has been analysed extensively in the transport literature, with Taylor and Fink (2013) and Bláfoss Ingvardson and Anker Nielsen (2018) covering much of it. This literature has addressed, for example, the effects of unemployment (Cordera et al., 2015), fares (Miller and Savage, 2017), car ownership (Beirão and Sarsfield Cabral, 2007; Taylor et al., 2009), population (Zhang and Wang, 2014), and taxation (De Borger and Mayeres, 2007). Empirical evaluations of the effects of contracts incorporating passenger incentives on ridership are, however, scarcer. There is a literature modelling or conceptualizing contracts incorporating optimal passenger incentives (or passenger subsidies), for example, in Australia (Hensher and Houghton, 2004), Norway (Carlquist et al., 1999; Fearnley et al., 2004), and Sweden (Wika Haraldsen and Norheim, 2018). These studies suggest, using theoretical methods and modelling, that socially optimal levels of public transport, ridership, and fares could be achieved by designing contracts appropriately. This also implies giving the operator more freedom in designing and running the services, in order to increase ridership (Stanley and Hensher, 2008; Wika Haraldsen and Norheim, 2018). However, few empirical evaluations consider the actual outcomes of using passenger incentive contracts (and payments).

While emphasizing the transition from a government monopoly to a competitively tendered regime, Bray and Wallis (2008) studied the effects of the new regime and contract on patronage in Adelaide, where operator revenue included passenger incentive payments of approximately EUR 0.5 (–0.5) for each additional (each fewer) passenger and about EUR 0.1 (–0.1) per unit increase (decrease) in passenger kilometre, both compared to a base year. Coming after years of decreasing ridership, the new contract was intended to increase the number of trips relative to a reference case chosen by the authors. The authors noted, however, that it was unclear what effects could be attributed to the new contract and payment model and what effects to external factors. Pyddoke and Lindgren (2018) studied two E20 "VBP contracts" in Stockholm in which all of the operator's revenue was from a passenger incentive payment of approximately EUR 1.5–2.5 per verified paying passenger (Pyddoke and Lindgren, 2016) and the operator was given considerably more freedom to adjust supply than in Stockholm's previous gross-cost contracts. The move to VBP contracts in these cases seems to have been driven by the rationale that the operators would be the drivers of increased supply and improved service to increase ridership. Comparing the outcomes of these contracts with gross-cost contracts without passenger incentives in Stockholm, the authors found only small differences in ridership increase, while the incentive contracts performed better in terms of costs, customer satisfaction, punctuality, and cancelled departures. The analysis was purely descriptive, and did not control for external factors by using, for example, econometric methods. Another Swedish study, by Pyddoke and Swärdh (2017), estimated the effects of Swedish-type passenger incentive contracts on ridership in 17 medium-sized Swedish cities using a panel data approach with yearly unbalanced data from 1997 to 2011. The cities mostly used conventional gross-cost contracts, but a few used net-cost contracts or incentive contracts, entailing increased payments with increased ridership. The contracts were not analysed in detail and the presence of a passenger incentive was represented by a dummy. Controlling for factors relating to population, income, and car ownership, the results of the study indicate that the contracts incorporating passenger incentives did not increase ridership more than gross-cost contracts. One interpretation of the results is that operators would need higher incentive payments and greater freedom to adjust traffic provision in order to be motivated to increase ridership. This conjecture is supported by modelling of Swedish bus contracts conducted by Wika Haraldsen and Norheim (2018), who found that passenger incentive payments must be approximately three to four times higher than they are now, and that considerable freedom needs to be given to the operator to determine the traffic supply and fares.

To summarize, while the conceptual literature suggests that passenger incentives could increase ridership, the few studies evaluating real contract outcomes are less positive, as none has yet been able to attribute increased ridership to passenger incentive contracts. In addition, few studies use adequate quantitative methods, the exception being Pyddoke and Swärdh (2017). We argue that the study design and data could be improved, as the contracts studied varied over time and across the country. The superficially similar objects studied were not necessarily comparable, and the data were probably not detailed enough to allow proper inferences about the effects of passenger incentive contracts. Consequently, the main contribution of this paper lies in its improved methodology and use of richer data. The main methodological improvement lies in studying a region that gradually introduced a standard passenger incentive contract as the previous standardized gross-cost contracts matured. This allows better identification of the contract's effects and a larger, more homogenous sample than in previous studies. Furthermore, the data are richer. First, because they capture monthly ridership and supply for an entire region's bus network over eight years, route and time fixed effects can be used so that unobserved heterogeneity can be better controlled for than before. Second, the bus data are supplemented with high-resolution datasets on individual incomes and car ownership in residential areas near bus stops, giving further control variables. The data used here are therefore regarded as superior to those used in previous papers using either econometric or descriptive approaches. Overall, these improvements allow for better identification of the effects this contract type has on ridership, allowing a more convincing case as to whether or not it works.

The rest of the paper is organized as follows: Section 2 presents the institutional and contractual backgrounds of the Swedish public transport system and the Skåne region. Section 3 presents the empirical framework used, and Section 4 presents the data used for the empirical analysis. Section 5 presents the results, and Section 6 follows up with a discussion of these results. Section 7 concludes the paper. Section 9 contains an appendix.

2. Swedish public transport and the passenger incentives contract

Swedish public transport appears to have followed the industrial regulatory cycle formulated by Gwilliam (2008), going from a situation of private actors running commercial services with exclusive rights to one of regulated public monopolies as private car ownership increased throughout the 1960s and 1970s (Alexandersson, 2010). When procurement was introduced in the late 1980s, production became private and competitive tendering for publicly procured bus services became the dominant form of provision. Today, 95% of all publicly provided public bus transport service is competitively tendered. Results of the introduction of procurement were decreasing bus ridership and decreasing cost per bus kilometre (Alexandersson et al., 1998); the latter levelled off in the mid 1990s (Alexandersson and Pyddoke, 2010), but has increased 17% since 2008. Since 2008, ridership and supply have increased at the national level, as illustrated in Figure 1.

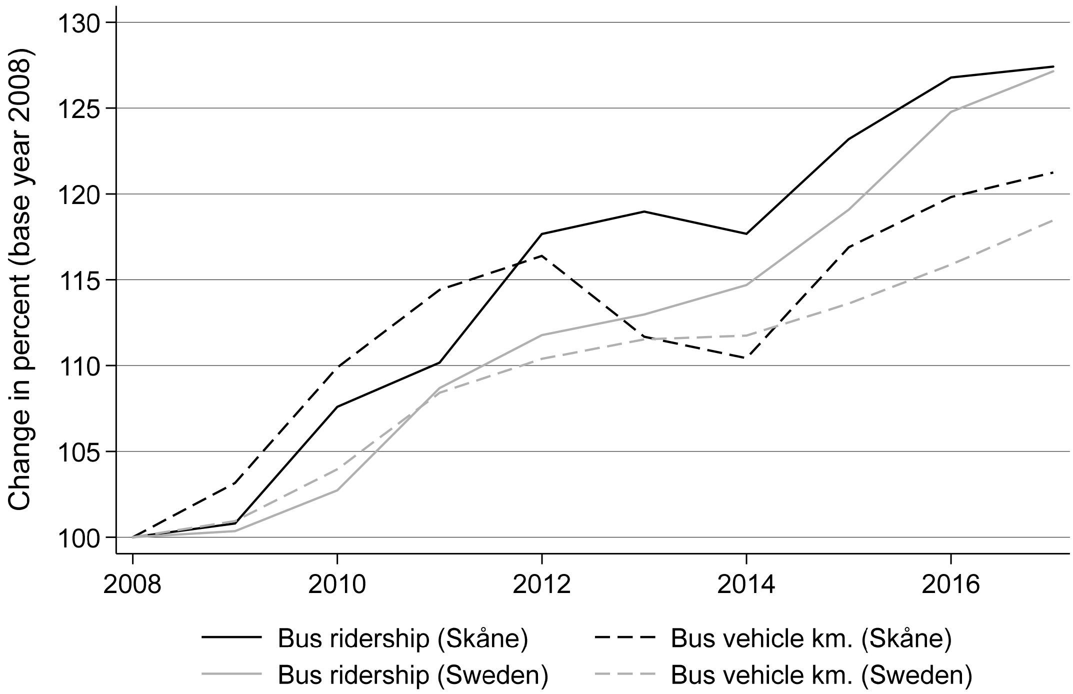

Figure 1

Development of ridership (solid lines) and bus vehicle kilometres (dashed lines) in Skåne (black lines) and Sweden (grey lines) between 2008 and 2017. Source: Transport analysis (2017).

In 2008, the Swedish public transport industry united in a cooperative venture known as the “Partnership for improved public transport” and adopted the targets of doubling public transport ridership from 2008 to 2020 and of “eventually” doubling its market share (Partnersamverkan, 2009). The partnership has since focussed on standardizing contracts and vehicle requirements for public procurements, in the interest of ultimately increasing ridership and service quality and reducing costs in public transport (Grönlund, 2017). One result of the contract standardization was the so-called passenger incentive contract recommendations – the foundation of the contract type examined here – dating to 2010 and revised more recently. As noted in the previous section, this was not the first time Swedish bus contracts contained some kind of passenger payment scheme, often in the form of net-cost contracts, although previous use was limited to a few cities.

In general terms, the recommended terms of a passenger incentive contract resemble those of a traditional Swedish gross-cost contract in the revenue component paid to the operator (cost for the PTA) for the traffic provision according to a fixed payment, usually small, which is combined with unit pricing. The latter is paid, for example, per kilometre, hour, and vehicle run, as well as for unplanned traffic and changes in traffic volume (Swedish frivolym, i.e., an increase or decrease relative to the base provision), and is set out in the bid for the contract and used in determining the procurement winner. A gross-cost contract typically includes quality incentives, for example, penalties for delays or cancelled departures, and the operator bears some revenue risk through the unit-priced service provision. However, gross-cost contracts in Sweden typically do not include incentives connected to ridership, a revenue component instead found in what is called the passenger incentive payment. While this does not exclude the use of quality incentives, the passenger incentive is predominant. The standard setup is that the operator is paid a set amount per passenger, usually determined by the PTA in the tender documentation, which could be paid according to the total number of boarding passengers specified in the contract, or the number of passengers exceeding a predetermined base level.

In the earlier versions of the contract recommendations, the partnership stressed that a “substantial part” of the revenue, at least 25% of the operator’s total revenue, should be tied to the passenger incentive (Partnersamverkan, 2010a). We have been unable to find either a conceptual or an empirical evidence base for this recommendation. Later versions of the recommendations no longer contain this recommendation (Partnersamverkan, 2018). This change is also evident when reviewing the active bus contracts in 2015, in which the average bus passenger incentive contract had a 6% share, or 20% weighted by vehicle kilometres run (Transport Analysis, 2018). Although data are unavailable for earlier years, the Swedish tradition has generally been to use gross-cost contracts, with contracts incorporating passenger incentives being seldom used. A sufficiently high payment, however, is insufficient if the PTA wants to induce the operator to increase ridership; the operator also needs some freedom to influence the traffic provision for the incentive to work, for example, by creating the timetable, designing the route network, or marketing the traffic in cooperation with the PTA. The partnership identified this need early on and envisioned that future procurements would be more performance based (Partnersamverkan, 2010b), but the PTAs have so far generally not given the operators increased freedom but retained the right to determine routes, service frequencies, and fares. An exception is the Stockholm region passenger incentive contracts (VBP contracts), in which the freedom is greater (Pyddoke and Lindgren, 2018). In many regions, the conditions for the operator's degree of freedom are regulated through so-called cooperation agreements.

This section describes the general setup of the Swedish-type passenger incentive contract, and although there are variations across and within Swedish PTAs, the mechanisms described here are standard. As 25% of all active contracts contained passenger incentives and 55% of all trips took place in such contracts as of 2015 (Transport Analysis, 2018), the use of passenger incentive contracts is widespread in Swedish public transport. Skåne is one region that has adopted this contract type, gradually introducing it when retendering expired gross-cost contracts. The remainder of the paper focuses on Skåne and its passenger incentive contracts. The primary reasons for this focus are given in Section 3, but first the region's public transport services are described.

2.1. Public transport in the Skåne region

Skåne is the southernmost and most populous of Sweden's 21 regions. Its public transport system, procured by Skånetrafiken, comprises two modes, bus and rail, which in 2017 had 165 million boarding passengers, and approximately 70% of the trips were made within the bus system. The bus contracts, which the rest of this paper refers to, are procured and competitively tendered according to geographical area and routes, and there are no multi-modal contracts. The contracts are divided between city (urban) and regional (rural) traffic, and 60% of departures are urban. As shown in Figure 2, the total number of boardings has increased from approximately six to eight million per month. The figures indicate that the increase is mostly due to increased urban ridership, while the rural ridership has increased only slightly.

Compared with the former gross-cost–like contracts, Skåne has designed an altered contract type containing a payment per boarding passenger. The operator is paid EUR 0.5 per passenger in city traffic and EUR 1 in regional traffic. This level is also adjusted according to the number of trips made in the first 12 months of the contract relative to the number of trips made the year before the contract start, although this does not greatly affect the amount. The national median passenger incentive is approximately EUR 0.5 (mean EUR 0.7). The operator receives the payment irrespective of the type of boarding passenger, including students travelling on the regular public transport system. According to contract data from Transport Analysis for 2015, passenger incentives on average constituted 21% of the total payments to the operator in Skåne for contracts containing this type of incentive, with the extremes being 7% and 35%. The passenger incentive payment is not a negligible part of the total payment, but not on par with the partnership recommendations discussed above. The Skåne-type passenger incentive contract thus reasonably approximates the payment design of Sweden on average and is very similar in all areas where this contract type has been rolled out. It also has many of the elements Hensher and Stanley (2008) identified in an "appealing" contract, for example, being area based, lasting over seven years, containing a passenger incentive, and recommending a division of roles.

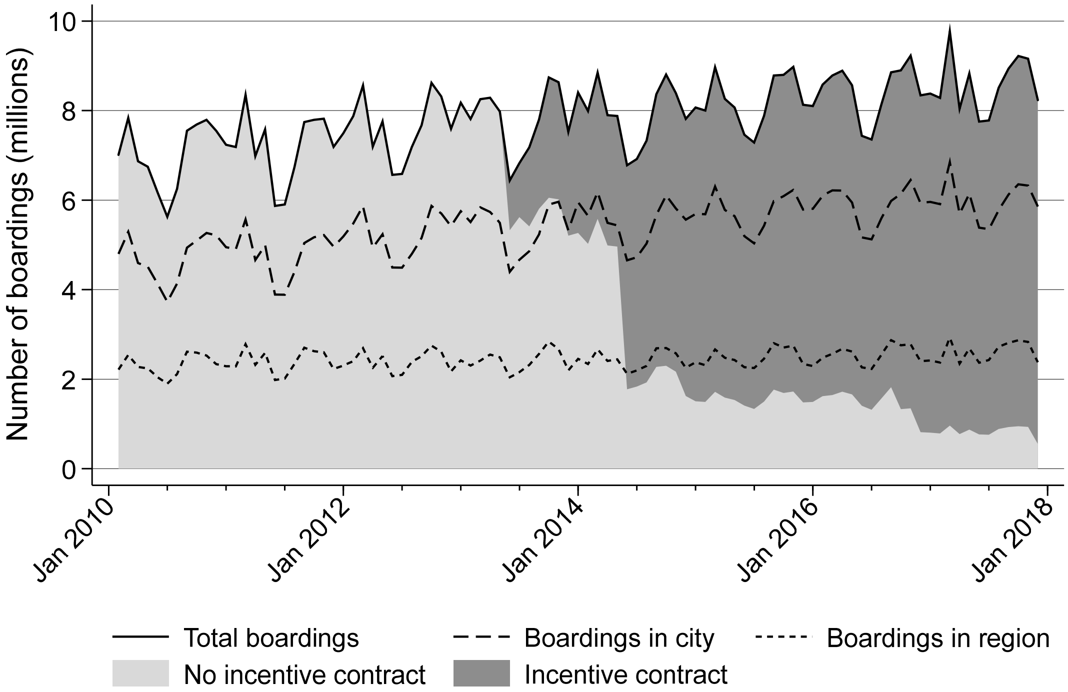

Figure 2

Development of ridership in the Skåne region, divided into trips made inside and outside incentive contracts and into total (solid line), city (long-dashed line), and regional bus traffic (short-dashed line). Source: Skånetrafiken.

In Skåne, as in the rest of the Swedish bus contracts, fares are set exclusively by the PTA, meaning that this is a measure the operator cannot alter. The operators' degree of freedom in the Skåne passenger incentive contract is regulated through cooperation agreements in the contract signed with the operator. While the agreement has been adjusted over the years, the main message and responsibilities have remained more or less the same. The agreement aims to improve the working relationship between the PTA and the operator to obtain "more, and more satisfied customers" and stipulates work processes for activities such as the business plan, timetable, local marketing, and media communication. Indirectly, the agreement also largely regulates the kinds of freedom given to the operators and how far reaching these are. The cost of activities within the agreement is borne by each party. Two groups, a working group and a steering committee, are formed with members from Skånetrafiken, the operator, and in some instances local municipalities and the Swedish Transport Administration. The working group meets once every month and deals with questions regarding daily operations and reviews statistics such as ridership and punctuality. This group's meetings entail informing each party of the current situation and providing feedback and possible suggestions to the steering committee. The steering committee meets twice a year and addresses timetable suggestions and upcoming business plans and the overall marketing plan. Although these issues are dealt with, the committee only approves the business plan and the local marketing plan; for other matters, such as setting the timetable, its function is "advising, engaging" and it "will work for the best possible result". Although the operator oversees the local marketing with Skånetrafiken, it is clear from the tendering documentation that the main responsibility and final approvals lie with the PTA. The traffic is packaged as a product from Skånetrafiken, and the vision is to make public transport more convenient for travellers, with clear integration within the region . The marketing must follow the marketing platforms of Skånetrafiken, which is also the single sender of the marketing message – that is, the operator cannot include its own logo or branding. Regarding the operator's freedom to influence the timetable design process, the operator is allowed to improve on the previous year's timetable and offer suggestions, but the final decision is made by Skånetrafiken. This is a standard way of involving the operator in the timetable process at other PTAs, and arguably gives little freedom to the operator. It also stands in contrast to the VBP contracts in Stockholm, where more influence is formally given to the operator. For example, the contract covering the areas of Handen, Nynäshamn, and Tyresö of Stockholm region contains wordings similar to those of the Skåne region contract, suggesting that the operator should make suggestions for improving the supply. However, in its bid, the operator suggested a traffic supply plan for the contract area, which will "work as the foundation for the operator's operations" (Stockholm E23 tendering documentation, Appendix 4A, point 1.3). While the Stockholm PTA has set some requirements and minimum frequency levels, it gives the operator more influence in designing the supply, that is, more freedom and an instrument to increase ridership. Relative to this, the operator's freedom regarding timetable design in Skånetrafiken's cooperation agreements must be regarded as minimal, at best. This was also enforced in early versions of the cooperation agreement, which stated that "Skånetrafiken owns the timetable and makes the final approval" (Skåne Busstrafik 2013 tendering documentation, Cooperation agreement, Appendix 2).

Skåne has increasingly been using passenger incentive contracts, and as of December 2017, fewer than 1 million boardings per month were covered by traditional gross-cost contracts. The first procurement using the passenger incentive contract type was in the "Busstrafik 2012" tenders covering four contract areas with traffic starting in June 2013 and contract durations of eight years. The previously tendered contracts in these areas were due to expire that year and were thus not cancelled or renegotiated early to implement the new passenger incentive contracts. Over the coming years, contracts approaching expiry were put up for tendering using the passenger incentive contract type. This means that this contract type was introduced gradually in Skåne and in areas where contracts were due to expire according to the terms set in the previous tender, which was often more than eight years previously. Four contract areas, however, were exceptions to this rule: Malmö central, Kristianstad city, Kristianstad region, and Trelleborg city and region; here, the contracts were renegotiated to include passenger incentive payments, the same degree of freedom as in the cooperation agreements of the standard passenger incentive contract, as well as other features of the new contract type. All four renegotiated contracts were implemented in 2014. Figure 3 illustrates the gradual introduction of the Skåne passenger incentive contracts for each contract area in Skåne. As of December 2017, 18 of 25 contract areas were covered by this contract type.

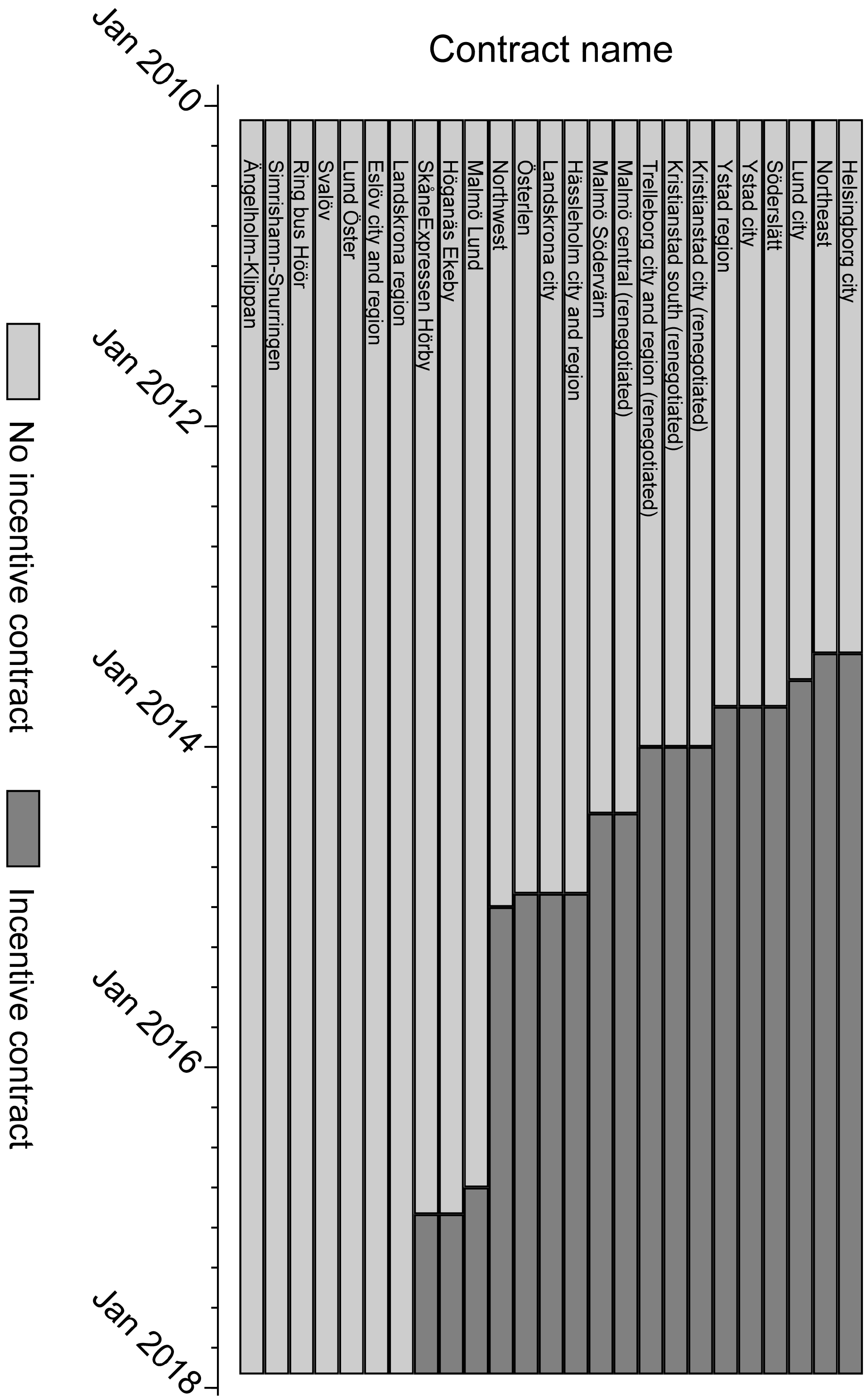

Figure 3

Timeline of procured bus contracts in the Skåne region from January 2010 to December 2017, divided by whether the contracts were traditional production-based gross-cost contracts (light grey) or passenger incentive contracts (dark grey). Source: Skånetrafiken.

3. Empirical framework

The standard that Skånetrafiken developed for its passenger incentive contracts, in terms of both degree of freedom for the operator and the per-passenger payment (EUR 0.5 per boarding passenger in city traffic, and EUR 1 in regional traffic), makes the implemented passenger incentive contracts fairly similar. These contracts are regarded as the treatment group. Also, the "contract generation" before the passenger incentive contracts was fairly uniform, which beneficially increases the homogeneity of the control group. However, because the same passenger incentive was implemented at the same time for all routes in all contracts, it is impossible to infer the effect on ridership of the passenger incentive payment in isolation. This is because the introduction of the incentive payment coincides with the implementation of the contract type, which, compared with previous contracts, also includes further changes in the degree of freedom for the operator implemented through the cooperation agreement and quality incentives. Homogeneity in these dimensions would be ideal for external validity, if an estimate of the impact of the passenger incentive payment itself is sought. Consequently, the estimated effects of this paper will concern the effects on ridership following the introduction of the Skåne-type passenger incentive contract, not the passenger incentive itself. It is thus the effect of the contract type as such that is evaluated. Furthermore, the estimated effect will be biased and is not the true effect of the passenger incentive contract itself. This is because the contracts are always implemented with a new procurement round, in which more changes are made. The most notable changes are probably newer bus fleets and rescheduled traffic supply, both of which could increase ridership but are not consequences of the passenger incentive contract as such. It is argued here, however, that these coinciding changes are all aimed at increasing ridership – that is, the direction of the bias will be upwards and the effect on ridership of the passenger incentive contract will be overestimated. Results presented by Mouwen and van Ommeren (2016), however, indicate that this potential bias might not be large, as more than one tendering round was found not to increase ridership. All contracts in Skåne have been tendered at least twice. Following this, if a bias still exists, most of a statistically significant estimate is likely attributable to the passenger incentive contract, while an insignificant estimate is interpreted as indicating that the passenger incentive contract does not affect ridership.

Because Skåne has standardized passenger incentive contracts, the region is well suited for an investigation of the effects of introducing passenger incentive contracts. A second important reason why Skåne is a good case is the way it implemented this contract type. Figure 3 illustrates the contracts included in the estimation sample and at what times passenger incentive contracts were introduced. Since 2013, the contract type has been implemented in 14 of the 15 contract areas procured . The treatment group comprises the routes covered by contracts that became passenger incentive contracts, and the control group comprises the routes covered by contracts not yet subject to passenger incentives. As the implementation generally followed the re-procurement of the contracts, the analysis avoids an apparent self-selection problem if the contract type were only introduced in areas where it would have the highest potential; this would result in overestimation of the effects of the passenger incentive contracts.

In addition to the 14 passenger incentive contracts introduced upon re-procurement, four contracts were renegotiated to include passenger incentives as of 2014 and could suffer from the self-selection problem discussed. While potentially a problem, we argue it is not a major one and that its extent can be determined. It is not evident that the decision to renegotiate these contracts, run by different operators also operating other gross-cost contracts, was made because the areas had greater potential for ridership increases. If that were the case, more contracts similar to these would have been renegotiated at the same time (e.g., Ängelholm–Klippan or Lund Öster). While applying to only four of 18 passenger incentive contracts, and irrespective of the reason for renegotiation, this complicates the identification of the effect. However, because the four renegotiated contracts are nearly identical to the re-procured contracts, one can treat them as similar, i.e., as if we are comparing the same contract type. Furthermore, if the selection bias existed, estimation of the sample excluding these four contracts would result in a higher estimated coefficient. For this reason, additional analyses are conducted excluding these four contracts. If the estimated coefficient were to differ substantially, this would indeed be an issue; with a similar or lower estimate, however, this is not regarded as a problem for identifying the effect.

To properly account for the ridership effect, controlling for the operation environment is desirable, as routes differ in traffic supply and type (i.e., city or regional traffic). These two factors arguably affect both the magnitude of ridership and the development over time. In the estimations, the number of departures, average route length, average snow depth, population, share of population owning a car, and median income are used as control variables to account for this. Some of these are variables that affect ridership, as previous literature has repeatedly shown (Bláfoss Ingvardson and Anker Nielsen, 2018; Holmgren, 2007; Taylor and Fink, 2013). Route fixed effects are used, which are thought to capture unobservable route conditions. Furthermore, time fixed effects via year, month, and year*month dummy variables are included to account for time trends and common time shocks in the Skåne public transport system. Finally, operator fixed effects are included. The use of fixed effects also limits the need for certain control variables that previous studies (Holmgren, 2007; Taylor and Fink, 2013) have deemed important for estimating ridership properly: fares (the whole Skåne region has an integrated ticketing system and standardized fares), vehicle taxation (which is done at the national level in Sweden), and fuel price. The effects of these variables are likely captured by the fixed effects, as the variation is very similar over the whole region over all studied years.

Given the reservations as to what can be measured in this study, it must be emphasized that the Skåne case and the fine data used here give one of the best prospects yet, both in Sweden and internationally, to infer the potential effects of using passenger incentive contracts to increase ridership. There are benefits in analysing a single region with respect to homogeneity and thus the control over observable and unobservable factors. The only previous study using an econometric framework to analyse passenger incentives, by Pyddoke and Swärdh (2017), used multiple regions, creating (unobserved) heterogeneity that is difficult to control for. This is also often the case in studies investigating public transport demand in general. Pyddoke and Swärdh (2017) also used a smaller and less rich datasets in term of the quality and number of control variables, making proper controlling for both observable and unobservable factors more difficult as well. It is also worth noting these problems have seldom, if ever, been discussed in the previous literature. While the effects might be overestimated, this paper arguably still gives new and better insight into whether ridership effects exist and, if so, their potential magnitude.

3.1. Models

When considering the effect on ridership of introducing a passenger incentive contract, one could consider an average or gradual effect. The average effect is given by simply including an indicator variable in the estimation model, which takes a value of 1 from the month a route (and similarly contract) is converted to a passenger incentive contract, and 0 otherwise. The associated estimation model is defined as follows:

$$\ln\left(R_{ijt}\right) = INC_{it}\gamma + \boldsymbol{\delta}_i + \boldsymbol{\zeta}_j + \boldsymbol{\eta}_t + \boldsymbol{X}'_{ijt}\boldsymbol{\beta} + \epsilon, \qquad (1)$$

where R is the ridership on route *i* with operator *j* at time *t*. R also includes school trips, as these are subject to the incentive payment as well. INC is the indicator variable taking a value of 1 at the times when route i is run under a passenger incentive contract, and γ is the estimated coefficient, expected to be positive and significant to affirm an increase in ridership following the introduction of passenger incentive contracts. Furthermore, δ_i and ζ_j, are route and operator fixed effects, respectively, while ηt is time fixed effects in the year, month, and year–month dimensions. X is a vector of the six control variables discussed earlier with the associated coefficient vector β. The number of departures, population, and income are logged. Finally, ε is an assumed normally distributed idiosyncratic error term. While the average effect is thought to capture the potential effect on ridership, it is not very informative as to when this effect occurs. Therefore, a second model is also used, analysing the gradual effect on ridership. The idea is that the effect on ridership does not manifest itself instantaneously when the passenger incentive contract is introduced, but could be lagged. That is, ridership could remain unchanged for the first year but increase in the second and third years, and so on. This effect is intended to be captured by the following estimation model

$$\ln\left(R_{ijt}\right) = INC_{it}^{Y1}\gamma_1 + INC_{it}^{Y2}\gamma_2 + INC_{it}^{Y3}\gamma_3 + INC_{it}^{Y3+}\gamma_{3+} + \boldsymbol{\delta}_i + \boldsymbol{\zeta}_j + \boldsymbol{\eta}_t + \boldsymbol{X}'_{ijt}\boldsymbol{\beta} + \epsilon, \qquad (2)$$

where INC^{Y1}, INC^{Y2}, INC^{Y3}, and INC^{Y3+} are indicator variables. INC^{Y1} takes the value of 1 in months 1–12 of a passenger incentive contract, INC^{Y2} in months 13–24, INC^{Y3} in months 25–36, and INC^{Y3+} in months 37+; γ_1 to γ_{3+} are the corresponding coefficients and are interpreted in the same way as γ. Model (1) is referred to as the baseline model in the remainder of the paper

3.2. Simultaneity between ridership and supply

When estimating the effect of passenger incentives on ridership, transport supply (here, the number of departures) is an important variable to include. However, there may be a two-way relationship between the two, i.e., supply affects ridership, but ridership could also, probably with a delayed effect, affect supply. This means that the estimated coefficients could be biased because the simultaneity bias results in an endogeneity problem, and that a causal interpretation of the magnitude is more difficult to make. One remedy could be a two-stage least squares (2SLS) estimator with one or more instruments for supply. The observational level of this study's data (i.e., route and month) have, however, made it difficult to find suitable instrument candidates. In addition, conditional on valid and proper instruments being used, which is generally not easy to ensure, the 2SLS estimator will still be less effective than the fixed effects estimator. Instead of using an instrumental variable approach, the facts that INC is the variable of interest and that it exhibits a low correlation of 0.079 (see Table 9 in the appendix; covariance 0.038) with the supply variable are utilized to infer the effect of INC on ridership.

Because endogeneity is caused by exogenous shocks in the error term, which in this case is correlated with the supply, it induces a shift in the estimated supply as the shock is channelled through there as well. This will also cause the other coefficient estimates to be biased, as the bias is "smeared" out in the model. This would indeed have been a substantial problem if the purpose of the paper had been to infer the causal effect of supply on ridership, but it is not. Because of this, a sensitivity analysis is carried out to determine whether the endogeneity bias of the INC variable seems to affect the conclusions drawn from the baseline model. This analysis is done by running Equation (1) again, but without the supply variable, which is instead absorbed in the error term. Now, the exogenous shock, previously channelled through the supply, causing biased coefficients, is not channelled through any explanatory variables. However, an omitted variable bias is produced, resulting in biased coefficients of variables correlated with supply. This is not an issue here, however, as INC is uncorrelated with supply. Consequently, if omitting supply does not cause the INC coefficient to change substantially (in terms of both the coefficient's size and significance level) so that the inferences from the baseline model are changed, the simultaneity bias is not an issue when interpreting the effect of the passenger incentive contracts. Because of a fairly high correlation between supply and population, the population variable is also omitted from the estimation in a second sensitivity analysis.

In light of the potential endogeneity problem, one should interpret the absolute size of the coefficients from the baseline model with care and judge whether a potential endogeneity bias exists and, if so, the size of this bias. This is especially true for variables highly correlated with the supply variable. Finally, the supply variable used is the number of departures per route and month, which is probably more challenging to adjust than, for example, vehicle kilometres. This could further reduce the problem.

3.3. Power and level of significance

In the scientific literature, the importance of statistical power and a priori probabilities in hypothesis testing has been increasingly discussed, largely concerning how p-values are used and how new findings can be claimed (Benjamin et al., 2018; Brodeur et al., 2016; Ioannidis et al., 2017). While a p-value is indeed the probability that an estimate is equal to or greater than the estimated value, there is also an a priori probability that the tested hypothesis is true, which is determined by, for example, previous scientific findings, industry knowledge, and researchers' prior beliefs (Benjamin et al., 2018). To make proper inferences, the a priori probability must also be considered. Established results (e.g., that supply affects public transport ridership) would have higher a priori probabilities, while in claiming new effects, the probability would be lower. In economics, overall transport research, and other fields, a p-value of 0.01, 0.05 or 0.1 has traditionally been regarded as strong evidence that the null hypothesis is false. That threshold is often not set with regard to the a priori probability, however, which leads the way to rejecting a true null hypothesis (i.e., type-I error) and reporting false positive results (Dreber Almenberg and Johannesson, 2018). One suggested remedy, apart from using Bayesian methods (Held and Ott, 2018) or preregistration (Nosek et al., 2018), is to increase the statistical power by lowering the p-value threshold for a new finding to be regarded as statistically significant to 0.005 (Benjamin et al., 2018). However, increasing the statistical power (the probability of making a type-II error, that is, failing to reject a false null hypothesis) increases the risk of making a type-I error. This is, arguably, another argument for carefully weighing the two against each other when deciding on the p-value threshold.

In the present study, there are two reasons to believe that the a priori probability that the hypothesis investigated, i.e., that passenger incentive contracts have increased ridership above that in gross-cost contracts, is low. First, no previous studies have confirmed that the Swedish passenger incentive contracts, or similar international ones, have led to increased ridership. Second, in the Skåne case analysed here, there are reasons to believe that the contracts have not incentivized the operators to increase ridership as modelling studies discussed in the introduction section suggest. Because of this, it is argued that the a priori probability is low in this study. Consequently, the chosen threshold for the coefficient of the passenger incentive contract variable to be regarded as statistically significant is chosen to be 0.005. While this certainly increases the risk of making a type-I error, the risk of falsely accepting the null hypothesis is regarded as less serious than falsely rejecting it. Policy implications from science should be adequately proven and established, which is why new findings (which this would be, if the null were rejected) must be well established. Rejection of the null hypothesis at a p-value below 0.005 would confidently show that the passenger incentive contracts are indeed working in the present case. A p-value chosen at the "conventional" level, given the a priori probability, would not, and could lead PTAs to make decisions based on wrong inferences. Again, note that this p-value is chosen only for the variables of interest here, i.e., the passenger incentive contract indicator variables. The control variables, as discussed earlier, are supported by previous evidence that they affect ridership, which is why they are regarded as statistically significant at the levels 0.01 and 0.05.

4. Data

As discussed in the introduction, previous studies have used data that in many respects have trouble capturing the performance of the studied contracts because they either did not use homogenous contracts or were deficient in the number of contracts and/or time dimension analysed. The main dataset used here was constructed using the monitoring systems of Skånetrafiken. More specifically, the data source for the number of trips was ticket machines, and the number of departures was determined from a route planning system. When boarding the bus, each traveller must validate a ticket to make the trip. That validation is counted towards the number of trips made on that specific departure and day and is stored in the monitoring system. For that system, the number of trips made was extracted for each route and month for all bus routes in the Skåne region. Similarly, the numbers of planned departures were extracted from the systems and matched with the corresponding routes and months.

Knowing the contract design from the procurement documentation, and with some help from the Skåne PTA Skånetrafiken, each route could be assigned to contract areas, traffic types (i.e., city and regional traffic), and when the contract became subject to incentive payment.

A concern when using data from ticket machines is non-validation of tickets. If passengers board buses without validating their tickets, the number of passengers would be underestimated, and a bias might be imposed on the estimations. This is not deemed a problem as travellers in Skåne must validate their tickets with the driver. However, there are two exceptions. First, the Malmöexpressen route has allowed boarding through all doors for a long time and thus incurs the risk of underreporting trips. Consequently, this route is excluded from the estimations. The second exception is Lund city where Skånetrafiken started a pilot project in April 2017 allowing boarding through all doors on the nine bus routes. However, this was not considered very problematic for analysing the present research question, because Lund city public transport has been run on a passenger incentive contract since June 2013. The potential effect on ridership of the passenger incentive contract should already have occurred in 2017, and the potential ridership underreporting after April 2017 should not affect the present analysis.

Another source of error when using ticket machine data to study passenger incentive contracts is that operators might encourage their drivers to strive harder to validate all tickets, to ensure both that the travellers are making actual validations and that the drivers are actually logged into the ticketing system when beginning their work shifts. The first error source is related to the discussion in the previous paragraph and is not deemed a problem. The second source of error is also expected to be minor. Although the operators are now incentivized to ensure that the ticket system is always online, before the start of the sample period studied here, Skånetrafiken introduced a monetary penalty for departures when vehicles were run with an offline ticket machine. The size of the penalty is EUR 100–500 per departure run without the ticketing system being online, which is arguably at such a level that the operators should already have ensured satisfactory online ticket validation before their revenue was tied to ridership in the passenger incentive contracts. Therefore, this factor is not expected to have improved systematically over the sample period.

About nine million individual trips cannot be assigned to a route or contract and are dropped from the analysis as they are unusable. Table 1 shows the number of unassigned trips by year and type of traffic (not to be confused with observations in the analysis, i.e., the number of trips summed per month and route). No clear pattern is apparent, mainly because the total number of unassigned trips is fairly stable over time. The city bus traffic has, however, seen a larger share of unassigned trips over the years, but this seems to be merely a redistribution from the "Other" category. The total number of unassigned trips remains largely the same. In summary, discarding these nine million trips annually is not thought to affect the estimates or inferences of the analysis.

Table 1
Unassigned observations for each sample year and traffic type.

	2010	2011	2012	2013	2014	2015	2016	2017
City bus	5,487,229	5,642,651	6,112,767	6,252,217	6,260,734	6,208,052	6,361,323	5,966,360
Region bus	2,626,264	2,711,514	2,704,597	2,685,541	2,625,713	2,689,627	2,757,062	2,589,607
Other	933,051	838,114	754,222	444,671	39,023	36,698	0	0
Total	9,046,544	9,192,279	9,571,586	9,382,429	8,925,470	8,934,377	9,118,385	8,555,967

As for the control variables other than the number of departures, these are mapped to each route and year using General Transit Feed Specification (GTFS) files provided by Samtrafiken, which include coordinates for each stop and route. These are utilized to obtain the geographic path of each route and year. If a route has several variations, the longest route in each year has been chosen. Because Swedish GTFS files are available only from 2012, a necessary assumption has been made that the routes in 2010 and 2011 are identical to those in 2012. While this might not hold entirely, it is regarded as a negligible problem because the geographic paths of the routes included in the sample do not seem to have changed much, judging from Skånetrafiken's systems. Consequently, the assumption should not affect estimations and inferences. When mapping the other data layers, a 500x500-metre square area around each stop on a bus route has been assumed. While the size of this area could be discussed, the chosen size does not seem to affect estimates or inferences much. For this reason, we do not explore this matter in detail here.

Route distance is calculated as the Euclidian distance between each stop along a route's geographic path. Population, income, and per capita car ownership per route and year are constructed using data from Statistics Sweden (SCB). These data are either aggregated from 100 × 100-metre squares (for population) or per individual and his/her residential position (for income and car ownership), which overlap with the 500×500-metre areas around a route's bus stops. Both levels of aggregation are assumed to be at this level so that precise measurements of these variables can be made per route and year. Population is measured as the yearly total population, both adult and youth, along the route. Median income is the median disposable income of working individuals in a given year, deflated to 2019 price levels and converted to Euros using an exchange rate of SEK 10.22 per EUR (as of 7 January 2019). Car ownership is first calculated from the number of private cars registered to individuals residing along each route. However, because this variable is highly correlated with population, it is transformed in a second step into car ownership per thousand adult individuals along the route. Both the income and car ownership variables are missing all values for 2017. For that reason, a linear regression imputation of these using total population is conducted. Finally, the variable measuring the mean snow depth is constructed using weather station data from the Swedish Meteorological and Hydrological Institute (SMHI). The measurements are per day but are summed per month; measurements from the weather station nearest a route are used.

The full sample used in the estimations consist of 17,074 observations at the month and route levels, with descriptive statistics for the full sample given in Table 2 and the city and region traffic samples in Table 3 and Table 4 respectively.

Table 2
Descriptive statistics for the full estimation sample.

	Mean	Median	S.d.	Min	Max	Source
Ridership (#)	43,295	13,650	73,543	1	524,371	Skånetrafiken
ln(Ridership)	9.37	9.52	1.87	0	13.2	
Departures (#)	1,687	1,151	1,673	2	8,600	Skånetrafiken
ln(Departures)	6.84	7.05	1.25	0.693	9.06	
Route distance (km)	18.2	15.6	13.1	1.19	90.8	Samtrafiken/GTFS
ln(Route distance)	2.66	2.74	0.733	0.174	4.51	
Avg. snow depth (cm)	1.05	0	4.18	0	52.6	SMHI
Population (#)	27,060	18,103	23,311	630	115,983	Statistics Sweden
ln(Population)	9.83	9.8	0.913	6.45	11.7	
Car ownership (per 1000 pers.)	455	458	103	232	802	Statistics Sweden
ln(Car ownership)	6.09	6.13	0.233	5.45	6.69	
Median disposable income (EUR)	25,480	25,270	1,752	22,121	35,248	Statistics Sweden
ln(Median disposable income)	12.5	12.5	0.0666	12.3	12.8	
Indicator variables						
Incentive	0.348	0	0.476	0	1	Skånetrafiken
Incentive (year 1)	0.11	0	0.313	0	1	Skånetrafiken
Incentive (year 2)	0.0903	0	0.287	0	1	Skånetrafiken
Incentive (year 3)	0.0797	0	0.271	0	1	Skånetrafiken
Incentive (year 3+)	0.0676	0	0.251	0	1	Skånetrafiken
Observations	17,074					

The data consist of monthly observations at the route level divided among 26 contracts covering a total of 227 routes. They span the years 2010 to 2017. *Ridership is the total ridership adjusted for school trips. SMHI = Swedish Meteorological and Hydrological Institute.

Table 3
Descriptive statistics on city traffic.

	Mean	Median	S.d.	Min	Max
Ridership (#)	86,648	32,728	105,592	7	524,371
Departures (#)	2,904	2,622	2,027	4	8,600
Route distance (km)	8.91	8.03	4.98	1.19	46.8
Avg. snow depth (cm)	0.806	0	3.27	0	39.2
Population (#)	35,984	27,271	26,664	2,358	115,983
Car ownership (per 1000 pers.)	404	394	73.9	283	587
Median disposable income (EUR)	25,561	25,451	1,641	22,121	33,923
Incentive	0.484	0	0.5	0	1
Incentive (year 1)	0.132	0	0.339	0	1
Incentive (year 2)	0.127	0	0.333	0	1
Incentive (year 3)	0.119	0	0.324	0	1
Incentive (year 3+)	0.105	0	0.307	0	1
Observations	*5,917*				

The data consist of monthly observations at the route level divided among 11 contracts covering 75 routes. They span the years 2010 to 2017

Table 4
Descriptive statistics on region traffic

	Mean	Median	S.d.	Min	Max
Ridership (#)	20,303	8,208	28,968	1	178,514
Departures (#)	1,041	762	949	2	4,955
Route distance (km)	23.2	20.8	13.4	3.58	90.8
Avg. snow depth (cm)	1.18	0	4.58	0	52.6
Population (#)	22,327	15,179	19,747	630	95,930
Car ownership (per 1000 pers.)	482	497	106	232	802
Median disposable income (EUR)	25,437	25,132	1,808	22,251	35,248
Incentive	0.276	0	0.447	0	1
Incentive (year 1)	0.0983	0	0.298	0	1
Incentive (year 2)	0.071	0	0.257	0	1
Incentive (year 3)	0.0586	0	0.235	0	1
Incentive (year 3+)	0.0476	0	0.213	0	1
Observations	*11,157*				

The data consist of monthly observations at the route level divided among 19 contracts covering 152 routes. They span the years 2010 to 2017

5. Results

The main results of the analysis are given in Table 5 and Table 6 with models (5) and (6), and all models use the logged total number of trips per route and month, ln(Ridership), as the outcome variable. In all models, standard errors are clustered at route level to control for within-route correlation.

Starting with the estimated coefficients of interest here, the effects on ridership of introducing a passenger incentive contract (see Table 5) est a sequential build-up of the models from Equations (1) and (2). In model (1), which includes only an indicator variable for the passenger incentive contract, the estimate is large but statistically significant only at the 10% level. When progressively including the control variables and fixed effects, the estimate drops considerably. In model (5), the first model whose results are in focus, the estimate is indeed positive. However, the estimate is not statistically different from zero at the 0.5% level, which was chosen in line with the discussion in Section 3.2. For model (6), which allows for the gradual effect on ridership, a similar pattern is evident, with positive estimates but no significant effects .

Turning to the models run on only the city and regional traffic samples, respectively, models (5-C), (6-C), (5-R), and (6-R) given in Table 6 produce results no different from those discussed in the previous paragraph. It cannot be proven that the passenger incentive contracts have contributed to increasing ridership.

For the control variables, the effects are in line with expectations and are all positive and statistically significant at the 90% level, except for snow depth and car ownership. Recall, however, the potential endogeneity bias discussed in Section 3.1.1. Focusing on the results of models (5) and (6) and the corresponding models for the city and regional samples, one notices decreasing returns to scale with an increasing number of departures. Over all routes and time, increasing the number of departures by one per cent would, on average, give a 0.86% increase in ridership. This is also the estimate for the regional traffic, while for city traffic the figure is slightly lower. While the snow depth is not statistically significant for either city or regional traffic, route distance has a positive and significant effect at the 0.05 and 0.5% levels for regional and city traffic, respectively, implying that route distance indeed increases ridership. The estimate is considerably higher and with a narrower confidence interval for regional traffic, implying that the effects of population changes along the route are more important for regional than city traffic. Finally, the income variable has a positive and significant effect on regional traffic, while it does not for city traffic.

Table 5
Results with sequential model build-up.

	(1)	(2)	(3)	(4)	(5)	(6)
Incentive	0.222+	0.020	0.030	0.032	0.038	
	(0.130)	(0.035)	(0.024)	(0.030)	(0.024)	
Incentive (year 1)						0.033
						(0.022)
Incentive (year 2)						0.053+
						(0.031)
Incentive (year 3)						0.030
						(0.036)
Incentive (year 3+)						0.015
						(0.044)
Control variables						
ln(Departures)		1.187***	0.869***	0.798***	0.861***	0.861***
		(0.033)	(0.070)	(0.071)	(0.045)	(0.045)
ln(Route distance)		0.315***	0.050+	0.051+	0.076***	0.078***
		(0.042)	(0.029)	(0.028)	(0.024)	(0.024)
Avg. snow depth		0.005***	0.002***	-0.002	-0.002	-0.002
		(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
ln(Population)		0.511***	0.616***	0.566***	0.530***	0.530***
		(0.060)	(0.096)	(0.099)	(0.101)	(0.101)
ln(Car ownership)		0.067	-0.011	-0.184	-0.071	-0.067
		(0.195)	(0.267)	(0.309)	(0.264)	(0.262)
ln(Median income)		-0.599+	-0.239	1.096+	1.148*	1.117*
		(0.352)	(0.204)	(0.578)	(0.553)	(0.554)
Route fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	Yes	Yes	Yes
Operator fixed effects	No	No	No	No	Yes	Yes
R2 adj. (within)	.	.	0.380	0.431	0.476	0.476
R2 (overall)	0.003	0.931	0.914	0.908	0.917	0.918
Number of routes	227	227	227	227	227	227
Observations	17,074	17,074	17,074	17,074	17,074	17,074

*** p<0.005, ** p<0.01 * p<0.05 + p<0.1. Standard errors in parentheses are robust to within-route clustering and heteroscedasticity. Outcome variable is ln(Ridership) in all regressions. Time fixed effects are year and month fixed effects, respectively, and year*month fixed effects.

Table 6
Baseline results (columns 2-3) and restricted samples on city traffic (4-5) and region traffic (6-7).

	Baselines		**City bus**		**Region bus**	
	(5)	(6)	(5-C)	(6-C)	(5-R)	(6-R)
Incentive	0.038		0.031		0.032	
	(0.024)		(0.042)		(0.031)	
Incentive (year 1)		0.033		0.031		0.025
		(0.022)		(0.041)		(0.028)
Incentive (year 2)		0.053+		0.028		0.057
		(0.031)		(0.050)		(0.044)
Incentive (year 3)		0.030		0.045		0.007
		(0.036)		(0.062)		(0.047)
Incentive (year 3+)		0.015		0.038		-0.011
		(0.044)		(0.081)		(0.059)
Control variables						
ln(Departures)	0.861***	0.861***	0.831***	0.831***	0.859***	0.861***
	(0.045)	(0.045)	(0.094)	(0.094)	(0.050)	(0.050)
ln(Route distance)	0.076***	0.078***	0.081*	0.083*	0.086**	0.083**
	(0.024)	(0.024)	(0.038)	(0.038)	(0.031)	(0.031)
Avg. snow depth	-0.002	-0.002	0.002	0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln(Population)	0.530***	0.530***	0.297*	0.294*	0.607***	0.603***
	(0.101)	(0.101)	(0.146)	(0.143)	(0.119)	(0.120)
ln(Car ownership)	-0.071	-0.067	-0.211	-0.204	0.118	0.116
	(0.264)	(0.262)	(0.331)	(0.324)	(0.325)	(0.321)
ln(Median income)	1.148*	1.117*	1.169	1.165	1.267+	1.255+
	(0.553)	(0.554)	(0.921)	(0.909)	(0.675)	(0.704)
Route fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Operator fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R2 adj. (within)	0.476	0.476	0.374	0.373	0.532	0.532
R2 (overall)	0.917	0.918	0.925	0.925	0.904	0.904
Number of routes	227	227	75	75	152	152
Observations	17,074	17,074	5,917	5,917	11,157	11,157

*** p<0.005, ** p<0.01 * p<0.05 + p<0.1. Standard errors in parentheses are robust to within-route clustering and heteroscedasticity. Outcome variable is ln(Ridership) in all regressions. Time fixed effects are year and month fixed effects, respectively, and year*month fixed effects.

5.1. Sensitivity analyses

Two analyses are conducted to check how sensitive the results are with respect to the assumptions and conditions applied.

5.1.1. Endogeneity bias

A potential endogeneity problem was discussed in Section 3.1.1, and two additional regressions to infer the impact on the estimated incentive contracts were suggested in which supply and population were omitted from the regression. The results of these regressions are found in Table 7.

Table 7
Sensitivity analysis of the simultaneity bias from ln(planned)

	(5)	(5-E1)	(5-E2)
Incentive	0.038	0.015	0.032
	(0.024)	(0.040)	(0.040)
Control variables			
ln(Departures)	0.861***		
	(0.045)		
ln(Route distance)	0.076***	0.068+	0.137***
	(0.024)	(0.039)	(0.036)
Avg. snow depth	-0.002	-0.003	-0.003
	(0.002)	(0.002)	(0.002)
ln(Population)	0.530***	0.372+	
	(0.101)	(0.195)	
ln(Car ownership)	-0.071	-0.514	-1.201***
	(0.264)	(0.536)	(0.301)
ln(Median income)	1.148*	1.780*	2.575**
	(0.553)	(0.828)	(0.980)
Route fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Operator fixed effects	Yes	Yes	Yes
R2 adj. (within)	0.476	0.207	0.198
R2 (overall)	0.917	0.437	0.248
Number of routes	227	227	227
Observations	17,074	17,074	17,074

*** p<0.005, ** p<0.01 * p<0.05 + p<0.1. Standard errors in parentheses are robust to within-route clustering and heteroscedasticity. Dependent variable is ln(Ridership) in all regressions. Time fixed effects are year and month fixed effects, respectively, and year*month fixed effects.

Model (5-E1) excludes only the supply variable. While the point estimate drops by some two percentage points, the standard error is close to double, implying that the confidence interval has increased substantially. The estimate from model (5) is well within the confidence interval of model (5-E1), and the coefficients do not differ when tested. The same holds for model (5-E2), in which the point estimate is 0.6 percentage points lower than in model (5). Here, again, the standard error has increased substantially, and the coefficient is no different from that in model (5). The conclusion from these tests is that the potential endogeneity problem does not seem to affect the estimated coefficient of the passenger incentive variable. This means that the inferences drawn from models (5) and (6) and the results of the study are valid.

Regarding the control variables, there are changes in the point estimates and standard errors, which decrease when variables are excluded. While all coefficients retain their signs, their magnitude increases. The most likely reason for this is the exclusion of two important control variables, leading to an omitted variable bias that affects the remaining variables correlated with them. While not evident from the results table, it is likely that the potential simultaneity bias channelled through the supply variable indeed affects the estimates in model (5) to some extent. However, the signs are likely still correct and are in line with expectations.

5.1.2. Selection bias from renegotiated contracts

As discussed in Section 3, four contracts did not see the introduction of passenger incentives after the previous contracts were completed, but these incentives were included through renegotiation during the contract period. A sensitivity analysis of this matter was conducted to infer whether the results are sensitive to treating these four contracts the same as the other passenger incentive contracts. Models (1) to (6) in Table 5 were re-run with a restricted sample excluding these contracts (2,297 observations), and the results are shown in Table 8, models (1-Res.) to (6-Res), which correspond to the ones in Table 5.

In general, the inferences do not change as the results are similar to those of the baseline model. Consequently, the decision to include the four contracts in the baseline estimation can be regarded as appropriate.

While some estimates in models (5-Res.) and (6-Res.) are statistically significant at the 10% level, this is not enough to be considered a finding that passenger incentive contracts have caused an increase in ridership, as discussed in Section 3.2.

Table 8

Results when excluding renegotiated contracts. The four excluded contract areas are Malmö central, Kristianstad city, Kristianstad region, and Trelleborg city and region (2,297 observations).

	(1-Res.)	(2-Res.)	(3-Res.)	(4-Res.)	(5-Res.)	(6-Res.)
Incentive	0.252+	0.036	0.041	0.042	0.045+	
	(0.146)	(0.038)	(0.025)	(0.032)	(0.024)	
Incentive (year 1)						0.038+
						(0.022)
Incentive (year 2)						0.061+
						(0.034)
Incentive (year 3)						0.039
						(0.037)
Incentive (year 3+)						0.030
						(0.046)
Incentive (year -1)						
Control variables						
ln(Departures)		1.169***	0.877***	0.811***	0.877***	0.878***
		(0.030)	(0.075)	(0.075)	(0.047)	(0.047)
ln(Route distance)		0.334***	0.047	0.047	0.078***	0.079***
		(0.036)	(0.032)	(0.031)	(0.026)	(0.026)
Avg. snow depth		0.005***	0.002*	-0.002	-0.003	-0.003
		(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
ln(Population)		0.544***	0.637***	0.589***	0.564***	0.565***
		(0.059)	(0.104)	(0.106)	(0.104)	(0.104)
ln(Car ownership)		0.166	0.061	-0.110	0.041	0.049
		(0.181)	(0.300)	(0.338)	(0.264)	(0.264)
ln(Median income)		-0.541	-0.351	0.867	0.876	0.840
		(0.375)	(0.222)	(0.633)	(0.576)	(0.580)
Route fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	Yes	Yes	Yes
Operator fixed effects	No	No	No	No	Yes	Yes
R2 adj. (within)	.	.	0.404	0.456	0.505	0.505
R2 (overall)	0.004	0.929	0.911	0.905	0.916	0.916
Number of routes	198	198	198	198	198	198
Observations	14,777	14,777	14,777	14,777	14,777	14,777

*** p<0.005, ** p<0.01 * p<0.05 + p<0.1. Standard errors in parentheses are robust to within-route clustering and heteroscedasticity. Dependent variable is ln(Ridership) in all regressions. Time fixed effects are year and month fixed effects, respectively, and year*month fixed effects.

6. Discussion

Given the results presented in the previous section, it cannot be proven that the increase in ridership in Skåne between 2010 and 2017 was due to the introduction of the passenger incentive contracts in used since June 2013. This implies that the new contract type performs no better than did the previous gross-cost contracts, and that the operators do not seem to have had the proper incentive to increase ridership.

A likely explanation of this result is that the incentive mechanisms, i.e., both the incentive payment and the operator's degree of freedom, are too weak in the passenger incentive contract. This was also outlined in the description of the contract type in Section 2.1, where the degree of freedom was considered low. A natural starting point for the discussion is therefore whether higher incentive payments and more freedom could induce operators to strive harder to increase ridership, thereby attaining policy makers' goals. The results of Wika Haraldsen and Norheim (2018) give important insights into this matter. First, neither low nor high incentive payments without operator freedom will affect ridership, as the operator cannot adjust the traffic. Although having higher incentive payments than those in Skåne, the Stockholm VBP contracts have suffered from similar issues, resulting in no improvement in ridership compared with traditional gross-cost contracts (Pyddoke and Lindgren, 2016). Second, even coupling the incentive payment with freedom for the operator to determine fares and/or service frequency, the per-passenger payment still needs to be higher than today (i.e., over seven times higher, EUR 3.5 versus 0.5). These are probably the key insights into why the Skåne-type passenger incentive contracts, which are representative of the typical Swedish passenger incentive contract, have not been useful. That such effects could be achieved with higher incentives and more freedom has, however, been demonstrated by Wika Haraldsen and Norheim (2018).

One must also consider the potential pitfalls for the PTAs in giving operators more freedom and higher passenger incentives. Over the decades, studies have shown that letting the operators determine fares and supply without regulation will reduce supply and increase fares (Basso and Jara-Díaz, 2010; Jansson, 1979, 1980; Mohring, 1972), which are also the directions these decision variables go in when the operator is given such freedom in the contract (Wika Haraldsen and Norheim, 2018). Bray and Wallis (2008) noted, however, that higher per-passenger payments and freedom (risk) need not deliver greater incentives. High passenger incentives could also create adverse effects in the traffic network, for example, shorter bus routes. This would happen because the operator would want to maximize the number of boarding passengers and thereby validations in the interest of maximizing revenue. Hensher and Wallis (2005) also noted this risk. On the other hand, the operator might become more inclined to properly validate tickets, which could result in higher revenues for the PTA, making the parties more interested in collecting and analysing data. As public transport is organized by public entities to keep fares and supply at levels that ensure socially desired outcomes, it is questionable whether the PTAs should adopt passenger incentive contracts for the sake of increasing ridership.

High incentives and considerable freedom come with a significant loss of control and increased risks of incentives giving rise to unexpected and unwanted results, for example, the possibility of downsizing supply during economic downturns, which is possible in gross-cost contracts. Such passenger incentive contracts are highly complex, their incentives and freedoms difficult to optimize, and their consequences difficult to foresee.

The alternative is probably not to return to traditional gross-cost contracts in which the operator is simply a producer of kilometres. Although not fulfilling their goal, passenger incentive contracts have one component that could be worth keeping and developing, perhaps primarily for better public transport provision rather than as a means of increasing ridership: the cooperation agreement and, by extension, some form of trusting partnership between the PTA and operator. This cooperation could be developed to enhance mutual respect and increase consideration of the ideas of all parties – not only between PTAs and operators, but also, for example, between the local municipalities and national transport agencies in charge of the road space and regulations. However, for the goal of increasing ridership, types of incentives other than the passenger incentive could have better potential.

When it comes to increasing public transport ridership, the most effective way to do this is likely not through contracts. With the high quality levels in Swedish public transport, there is arguably little potential to increase ridership by adjusting today's quality incentives. The accessibility improvements in buses have also been substantial over the last decade, reducing this potential. This is in line with Taylor and Fink (2013), who argued that public transport ridership is affected more by external than internal factors. Instead, measures making public transport more attractive relative to other modes are more suitable. Close at hand are improvements in the road environment prioritizing public transport modes, in turn leading to higher average speeds and more reliable and attractive service. Taxation and regulation addressing the externalities of private road traffic, such as noise, pollution, and congestion, are also measures that would increase public transport ridership, while primarily being instruments to improve social welfare (Basso and Silva, 2014; Börjesson et al., 2017; Kilani et al., 2014; Tirachini et al., 2014). The higher the cross-elasticities of car drivers changing to public transport, the more effecitive these instruments will be in increasing ridership. In the Swedish context, however, these measures are not the responsibility of the PTAs or operators. Local roads and public transport are governed by the municipalities, whereas the national government determines most taxes and regulations. It is therefore, again, imperative that the relationships and cooperation among these parties be well functioning.

Although passenger incentive contracts could not be shown to increase ridership, they are nevertheless frequently used in competitive tendering. It is unclear whether this contract type has had any effects on competition. The four largest operators in Sweden have a substantial presence in the Skåne region, and this shows no signs of changing, as smaller operators likely lack the knowledge and analytical skills needed to prepare competitive bids for passenger incentive contracts. The bidding process requires data on current ridership in the contract areas, preferably at a disaggregated level and transparently available to all potential operators, as well as on projected ridership development over the contract term of at least eight years, giving the expected revenues for upcoming years. This projection entails considerable uncertainty concerning how operator freedom in the contracts can be used, the effects of various measures, the overall development of the public transport system in Skåne (e.g., new train routes), tax reforms, and, perhaps most importantly, different willingness to assume and expectations regarding risk. These are all factors that will affect the operator's bid and its ambitions over the contract period. There is a risk that overly optimistic operators may win the tender because they price traffic provision cheaply, hoping to compensate for this by achieving a large increase in ridership. If this increase does not occur, the operator could face economic difficulties that will plague the service development until the contract ends.

Finally, while this study has been unable to prove that the ridership increase in Skåne was due to its passenger incentive contracts, the effects of these contracts on costs and quality were not investigated. Previous studies have not found such contracts to be associated with higher costs (Pyddoke and Lindgren, 2016; Vigren, 2016), but rather the opposite. This is counter to the expectation that operators would price the risk associated with not knowing future ridership. However, with a passenger incentive contract not delivering increasing ridership, the passenger incentive payment will be lower than expected in the operator's bid, so the total payment will be lower. Future studies of this matter are needed that also consider that aspect. More studies are also needed of how quality and customer satisfaction are affected by this contract type. One expectation would be that those two factors would both increase, as they are dimensions that the operator can affect somewhat through driving experience, driver behaviour, and vehicle cleanliness. Should costs and quality indeed develop in favourable directions, passenger incentive contracts could well prove to have beneficial secondary effects, though the question remains as to whether this contract form is the most effective way of achieving these effects.

7. Conclusions

This study has analysed whether the Swedish-type passenger incentive contract for bus transport provision has increased ridership more than the traditional gross-cost contract. In this contract type, the operator, in addition to the production revenue, receives a payment per boarding passenger, which is thought to incentivize it to increase ridership. Because this contract type is commonly used in Sweden and few evaluations have examined its effects, this study fills a gap in the research literature.

An econometric analysis was conducted using monthly data on bus routes in the Skåne region between 2010 and 2017. The region is appropriate for study, because Skåne has developed something akin to a standard for the region's passenger incentive contracts, and because it introduced these contracts gradually as previous gross-cost contracts expired. The rich available data in combination with a thorough identification strategy is what most clearly separates this from previous studies of the same issue.

The results indicate that the ridership increase in Skåne over the last decade was not attributable the region's passenger incentive contracts, and this holds for Skåne's traffic as a whole, as well for its city and regional traffic, respectively. This result is likely because the passenger incentive payments are too low and the operators' freedom as specified in the contracts is insufficient. While improving on those factors could indeed increase ridership, the PTA must carefully analyse whether granting more freedom (and, in turn, decision power) to the operators is appropriate given the social responsibility of the public transport services. The PTA must also consider whether this type of contract is the most effective way of increasing ridership, or whether there are other ways that are less complicated and more powerful.

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9. Appendix – Correlation table

Table 9
Correlation table

	ln(Ridership)	Incentive	Incentive (year 1)	Incentive (year 2)	Incentive (year 3)	Incentive (year 3+)	ln(Departures)	ln(Route distance)	Avg. snow depth	ln(Population)	ln(Car ownership	ln(Median income)
ln(Ridership)	1.000											
Incentive	0.057	1.000										
Incentive (year 1)	-0.013	0.482	1.000									
Incentive (year 2)	0.012	0.432	-0.111	1.000								
Incentive (year 3)	0.036	0.403	-0.103	-0.093	1.000							
Incentive (year 3+)	0.071	0.369	-0.095	-0.085	-0.079	1.000						
ln(Departures)	0.928	0.079	-0.006	0.025	0.046	0.079	1.000					
ln(Route distance)	0.137	-0.087	-0.034	-0.049	-0.052	-0.010	-0.044	1.000				
Avg. snow depth	-0.044	-0.150	-0.072	-0.068	-0.057	-0.056	-0.060	0.033	1.000			
ln(Population)	0.721	0.028	-0.009	0.001	0.017	0.046	0.573	0.173	-0.055	1.000		
ln(Car ownership)	-0.514	0.018	0.010	0.019	0.013	-0.013	-0.417	0.084	0.032	-0.796	1.000	
Ln(Median income)	-0.074	0.261	0.087	0.199	0.147	0.002	-0.008	-0.204	-0.147	-0.089	0.164	1.000

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