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Does Regular School Transport Influence the Provision of Public Transport Services? Evidence From Norway

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Abstract

Basic education and public transport services are often provided by local or regional governments. In Norway, they fall within the remit of two different tiers of government, with public transport being the responsibility of regional government (*fylke*), while basic education (primary and secondary schools) is the responsibility of local government (*kommune*).

Current efforts to consolidate and reorganize the school structure have yielded mixed results. On the one hand, such changes can help reduce public spending by exploiting economies of scale in the provision of education, for instance by having fewer and larger schools. On the other hand, they are likely to lead to cost increases by expanding the geographic coverage of school transport. Furthermore, transporting schoolchildren during peak commuting hours may exacerbate cost increases for regional governments.

Our paper examines the cost effect of changing the school structure with respect to transport provision. Applying econometric analysis to panel datasets at the municipal and regional levels, we seek to identify the impact of the number of pupils and school size on the costs of providing school transport. We combine these data with data on transport provision to look at the effects of school-related transport on costs and competitive tendering in public transport. We show that a school closure can increase the cost of providing public transportation both by increasing the cost of maintaining the current level of public transport services and by necessitating the expansion of the supply. The empirical results indicate that municipalities' economic gains from school consolidation generally outweigh the corresponding cost increases related to the provision of public transport.

Keywords:
education
school transport
public transport
service provision
school structure
competitive tendering
Norway

Introduction

Basic education and public transport services are often provided by local or regional governments. In Norway, they fall within the remit of two different tiers of government, with public transport being the responsibility of regional government (fylke), while basic education (primary and secondary schools) is the responsibility of local municipal government (kommune). This creates possibilities for conflicts of interest between different tiers of government.

Background

From the perspective of regional authorities, the transport of schoolchildren represents a cost. Specifically, it represents an opportunity cost whereby the resources dedicated to transporting schoolchildren could be used to provide infrastructure or services for other segments of the population. There is considerable anecdotal evidence for this being a significant cost in terms of public transport provision, cf. Iversen and Nyhus (2015) and Aarhaug et al.

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(2017). For example, one Telemark county government representative made the following statement: *"The [transport] companies' capital costs are contingent on the transport of pupils. That is, the [bus]companies use more and larger buses than they would for ordinary passengers"* [1]. Approximately 16 per cent of all passengers in Norway on buses under the jurisdiction of public transport authorities (PTAs) are schoolchildren (Statistics Norway, 2017a). However, in rural areas, the percentage is much higher. Statements indicating that the transport of pupils is a significant constraint on public transport provision are common. Lars Engerengen,[2] the Finnmark county government's representative, has stated that approximately 85 per cent of the county's vehicle kilometres are linked to school transport. Not all of these are dedicated school transport, which he estimates to be 26 per cent of the total. The remaining vehicle kilometres produced as a result of school transport (59 per cent) are part of the ordinary public transport systems, which must be built around school transport needs (Aarhaug et al., 2017).

Major changes in the requirements for school transport are mostly the result of school closures in rural or suburban areas. When local governments determine the number of schools and regional governments provide transport, a conflict of interest between the two tiers of government is likely to arise. Closing a school and replacing it with school buses is an unpopular decision – one that is taken at the local government level. However, as regional authorities bear most of the costs associated with such changes, there is a misalignment of incentive whereby local authorities stand to benefit the most from operating fewer schools and regional authorities carry the burden of meeting the increased demand for student transport. Consequently, this may result in too few schools from a societal perspective.

In this paper, we do not analyse all the societal impacts of school structure changes; we focus on the cost developments that the regional authorities face. We also identify factors that determine the number of pupils needing ordinary school transport, as well as the impact of the number of pupils and school size on the cost of providing school transport in Norway. The data we use on costs faced by local and regional authorities is based on their purchases of such services, and as a consequence we cannot include the internal cost efficiency of the public authorities in our analyses. We contrast the costs associated with provision of school transport with those associated with running a school. This is done by estimating a cost function for school operation.

This paper shows that a school closure can increase the cost of providing public transportation both by 1) increasing the costs of providing the current level of public transport services and by 2) necessitating expansion of the current supply. The empirical results indicate that in general, municipalities' economic gains from school consolidation outweigh the corresponding cost increases related to the provision of public transport. This is contradictory to the idea of multilevel governance as an externality, whereby the municipalities' failure to internalize transport costs leads to 'too much' school transport relative to the socially optimal level. One explanation for this is that policy makers are unlikely to base their decision to close a school on economics alone. Consideration of other factors, such as the preferences of their constituencies, is also likely to play a role in their decision-making.

The rest of the paper is structured as follows. We start by describing school transport and public transport provision in Norway. This is followed by a subsection presenting a theoretical framework for analysing the conflict of interest between tiers of government. We also summarize the literature on the use of competitive tendering in public purchases, using public transport as an example. The description of the school transport market and theory together with the literature on school provision, shape our a priori expectations. Next, we present our approach to analysing these issues, as well as our data and methods. This is followed by our analyses, a discussion of these analyses considering previous studies and theory and, finally, our conclusion.

Context, Methods and Data

School transport in Norway

Children living in Norway are entitled to attend school, regardless of their economic background or their place of residence. One of the tools available to help the government to reach this objective is a school transport service. This transport service can be divided into two main groups, ordinary and special school transport. *Ordinary* school transport consists of two sub-groups: (1) pupils living 4 km (2 km for first graders) or more from their closest school; and (2) pupils who have a route to school that is considered dangerous. This is the case for all pupils regardless of whether their school is private or public. However, pupils attending after-school programmes (e.g. SFO) and voluntary tuition after school are not entitled to these ordinary services. *Special* school transport is available for pupils with disabilities or temporary disabilities or illnesses.

In this paper, we focus on *ordinary* school transport, which is funded by the regional authorities and usually provided as part of the PTA's everyday services. *Special* school transport is organized at the local level. We limit our analysis to elementary and secondary schools (*grunnskole*) and exclude upper secondary schools (*videregående*) because they are organized at the regional level. In the latter case, schooling and school transport services are administered by the same tier of government, rendering it less relevant in a study that focuses on the differences between the tiers.

Although regional authorities organize and finance ordinary school transport, local authorities pay a share of the costs, usually the retail ticket price per child. There are two exceptions to this: first, if a pupil is entitled to school transport due to having a dangerous route to school; and second, if local authorities choose to organize teaching in such a way that a pupil must attend a school that is not in the proximity of his or her home (as the crow flies). Private schools, regardless of their location, are not considered local in this sense. This typically results in greater transport needs for private school students as compared with those attending public schools.

Current efforts to consolidate and reorganize school structure have yielded mixed results. On the one hand, such changes can reduce public spending by exploiting economies of scale in the provision of education by having fewer and larger schools. On the other, they are likely to lead to cost increases by expanding the geographic coverage of school transport. Furthermore, transporting schoolchildren during peak commuting hours may exacerbate cost increases for the regional governments.

Public transport provision in Norway

Based on how it is financed, public transport in Norway can be divided into three different types. The first type, commercial public transport, includes express coach services, some boat lines and some long-distance trains. In total, these commercial services account for less than three per cent of the total number of passengers nationally. The second type consists of local and regional train services that the Norwegian Government purchases through a net service contract with the national rail transport company, NSB ("Vy" as of 24 April 2019). The exception is the Gjøvik railway line (*Gjøvikbanen*), which is operated on a competitive tendering contract. This procurement system is to be reorganized in a four-year period from 2018. The third and largest type – in terms of passenger numbers (servicing about 80 per cent of all passengers) – is organized by the regional governments through PTAs, which are either (1) an integrated part of the regional authority, as is the case in the counties of Telemark and Sogn og Fjordane; (2) a corporation fully owned by regional governments, as in the case of Oslo and Akershus (Ruter[3]) or Sør-Trøndelag (AtB); or (3) organized as a separate non-corporate entity within the regional government (*fylkeskommunalt foretak)* as in Hordaland (Skyss) and Rogaland (Kolombus). These PTAs mostly purchase local public transport services from the transport market through competitive tendering. Public transport is one of the three major public services still provided at the regional level, the others being dental services and the provision of upper secondary education.

Most *ordinary* school transport is integrated in the overall public transport system and purchased as part of it. This means that the transport used by schoolchildren is also open to the public at ordinary ticket prices. However, these services are scheduled to fit school schedules, reducing their attractiveness for other users. Typically, there would be one departure going to a school in the morning and a return journey in the afternoon, following the school schedule. *Special* school transport is usually organized as demand-responsive transport. In some cases, this is done by the local authorities; in other cases, it is contracted out to the regional PTA or another company. These companies then act on behalf of the local authorities (Leiren et al., 2014).

Theory and literature

Organizing public services on a sub-national level using the Type I and Type II frameworks of multilevel governance

There are many theoretical perspectives from which one could approach issues related to public transport provision and the provision of transport for schoolchildren. Using theories of multilevel governance, we can describe the relation between the different levels of government involved as a continuous negotiation (Bache and Flinders, 2004, Hooghe and Marks, 2003). We also recognize that the interaction between different levels of government involves economic externalities. The provision of basic education is reliant of two sub-services, teaching and transport. Basic education is supplied at the local level, whereas public transport is organized at the regional level. This can be seen as a 'natural' division of responsibilities spreading costs over output in public services, following Oakerson (1999). One could argue, with some merit, that the provision of education is more labour intensive than that of public transport. Although public transport is labour intensive compared to other industries, with labour costs amounting to more than half of the total cost, the labour cost component of education is approximately 90 per cent (Statistics Norway, 2017b, Statistics Norway, 2018). Therefore, the gains from economies of scale in providing public transport are greater than in basic education. Following the argument of Hooghe and Marks (2003), this points to education's being provided at a lower level of government than public transport. However, it is not obvious that the transport of schoolchildren should be seen as a part of public transport and not a part of education.

The current arrangement highlights the fact that the final service offered to the public depends on decisions made at different levels of government. This creates an interdependence between the different levels of government. The overall policy objectives, namely to provide both a good education to all children and a good public transport network, are the same at both the regional and local levels. However, core objectives and budgets are different, creating the possibility for sub-optimization at the societal level. When local government over-consumes transport services, it places constraints on the regional government's ability to prioritize in the provision of services. These are aspects similar to those described by Hansen (2000). According to the externality approach, efficient provision of schools at the local government level induces a negative externality at the regional government level, which reduces the regional government's ability to reach its policy objectives efficiently. A social planner would jointly consider the costs of schooling and school transport when identifying the cost-minimizing school structure. But in the current context, decisions are likely to be based solely on the costs of schooling. Externality theory tells us that when decision makers do not face the societal costs of their decisions, the outcome will be economically inefficient. In our case, this means that the number of schools will be fewer than optimal and consequently the overall cost of providing education will be higher than the minimal costs. Coase (1960) shows that in cases with well-defined property rights and low transaction costs, a socially optimal solution can be achieved by means of negotiation.

The case in question here is the efficient provision of public transport. This is a case of lacking 'budget equivalence' (Spahn, 2015) where decisions taken at one tier of government have economic consequences for a different tier.

We rely on Hooghe and Marks (2003) Type I and II governance frameworks. Type I refers to a multilevel governance system with a limited number of tiers of general-purpose jurisdictions bundling together multiple functions. This is contrasted with Type II, which consists of specialized jurisdictions providing a particular service. In the case of Norway, education is provided within a Type I framework, where different services are provided at different levels of government. Public transport can be argued to be a case of Type II, where transport services are pooled into the responsibilities of a PTA, providing a service that is not exclusively limited to a particular geographical area, as some of the services cross administrative borders at both the local and regional levels. In addition, PTAs provide transport services for different needs. In the case of education, the local and regional levels of government each provide a different set of services and the geographical scope of the local governmental jurisdiction is a sub-set of the regional government's scope.

Alternatively, education could also be organized following the principle of a Type II service, which would (probably) bundle the provision of education with the provision of related transport services. In such a system, the provision of education including the transport of schoolchildren would be provided by a special agency under a unique authority, as opposed to being part of a bundled set of services provided by two tiers of government. Public transport could also be provided within a Type I governance arrangement, with a smaller geographical scope and a new tier for transport within the geographical area of each local authority. This would limit the regional authorities' responsibility for providing public transport between local areas within the region. Such an arrangement would be similar to the current system for transport between regions, which is the responsibility of the central government and is provided either commercially or on contract from the central government.

Expectations from theory and literature related to increasing the share of school transport in public transport contracts

In a public transport system, a key element driving cost is the capacity constraint. This is typically given by peak-hour demand (Button, 2010, Jara-Díaz et al., 2017, Fearnley, 2013, Rantzien and Rude, 2014). In practical terms, this means that in order to increase supply during peak hours, new capacity has to be added to the system giving rise to higher unit costs for transport conducted at these times. The transport of schoolchildren is typically connected to the morning peak and, to a lesser extent, the afternoon peak (Leiren et al., 2014). This means that our expectation is that increasing the share of school transport in the public transport system would increase both the volume of transport – more passengers – and the costs of providing this service, as adding school transport would increase transport demand in the time period when the cost of providing these services is higher than average.

The transport of schoolchildren is bundled with other scheduled services in the public transport system. The service is commonly purchased by the regional authorities or a body acting on their behalf, namely a PTA. It is most often bought as part of a competitive tendering process using gross contracts (Aarhaug et al., 2018). These auctions typically follow a conventional first-price sealed-bid form cf. (McAfee and McMillan, 1987). The contract is awarded to the company that is willing to provide the bundled public transport service at a given quality for the for the lowest price. This means that the unit price of this service faced by the PTA is the cost of a vehicle kilometre, not a passenger. Market relations, including ticketing and other revenue-generating activities, are handled by the PTA, not the operating company.

Within this system, the expectation is that unit cost (NOK/vehicle kilometre) increase should be less than the direct cost of purchasing these services independently. This is an expectation derived from both a case study of the tenders in Sør-Trøndelag county (Tørring and Vennes, 2014), which showed that the PTA deviated from the common bundling of different public transport services into the same contract, resulting in higher prices, and from theory, as it prevents exploiting economies of scale and scope in providing the service. However, in line with the findings of Hansson and Holmgren (2018), we recognize that this is a complex relation.

There are several studies on the efficiency of public transport provision within a system of competitive tendering indicating efficiency decline, cf. Vigren (2016) and Holmgren (2013). In this paper, we do not analyse the efficiency of the Norwegian public transport system as such. Rather, we focus on the isolated effect on unit prices achieved on contracts for public transport associated with changes in the provision of school services. We use this as a starting point for analysing the effect of closing a school on the budgets of regional and local authorities.

To the authors' knowledge, there is only one previous study combining Norwegian school data with public transport data, namely that of Iversen and Nyhus (2015), who use data on public transport cost at the regional level. They derive the cost of school transport from the total cost of public transport at the regional level and the estimated market share of pupils (out of the total number of passengers). Given the uncertainties inherent in their approach, they are cautious in their conclusions. They do, however, estimate the cost increase at the county level resulting from closing an average school to be between 300 000 and 600 000 NOK. From interview data, they show that regional government representatives perceive the cost increase to be substantial.

Methods and data

We adopt a microeconomic cost function framework to analyse how the organization of primary education – as determined by local governments – impacts on the costs of providing public transport, the latter being organized and financed by regional governments. The analysis rests on the assumption that the level of service is predetermined by regional governments and that bus operating companies minimize the costs of complying with this predetermined standard. This means that the contract is awarded to the bus company that offers to provide the given level of service for the lowest price.

The cost function for bus operations comprises bus kilometres, $y \in \Re_+$, and transportation of pupils, $e^S \in \Re_+$. The latter is proxied by the number of pupils eligible for transport. Pupils constitute an important cost driver for public transport because school transport takes place during peak hours, and because the productivity of bus routes that facilitate school transport is in many cases low. Finally, factors that are beyond the bus operators' control, $\mathbf{z^O} \in \Re_+^K$[4], including population densities and urban/rural transport, are accounted for. The cost function for bus operations – representing the minimal costs of providing the predetermined level of service and school transport determined by regional governments – is thus formally defined as follows:

$$c\left(y, e^S; \mathbf{z}^O\right) \qquad (1)$$

Empirically, we adopt a Cobb-Douglas type cost function[5]

$$\ln\left(C_{it}\right) = \beta_0 + \beta_y \ln\left(y_{it}\right) + \beta_e \ln\left(e_{it}^S\right) + \sum_{k=1}^{K} \beta_k \ln\left(z_{kit}^O\right) + \varepsilon \qquad (2)$$

where the subscripts i and t refer to the geographic region and time period, respectively.

Having considered the bus operating companies' costs of meeting the predetermined supply, we turn to the regional governments, which oversee the supply of scheduled traffic, measured in bus kilometres. Their goal is to create a public transport network (i.e. a service supply) that maximizes the number of passengers, subject to legal requirements, including providing school transport, and political requirements such as having a minimum level of service. Supply is therefore likely to be influenced by factors such as population size and density that are exogenous to the regional governments[6]. Let the vector $\mathbf{z}^C \in \Re_+^L$[7]

denote these factors. This allows us to characterize the supply of public transport by means of the function

$$y = f\left(e^S, \mathbf{z}^{\mathbf{C}}\right) \qquad (3)$$

which is estimated using a linear regression model[8]:

$$y_{it} = \beta_0 + \beta_e e_{it}^S + \sum_{l=1}^{L} \beta_l z_{lit}^C + \varepsilon \qquad (4)$$

Finally, we consider the determinants of the number of pupils eligible for school transport. As previously mentioned, the distance from a student's home to school is the key determinant of eligibility. We do not have data on the population's access to schools at the municipal level. Instead, we approximate access by including school density, namely the number of schools per square meter, defined as $(x/a) \in \Re_+$, coupled with variables that describe population densities and the share of urban population per municipality. In addition to distance between home and school, there are other important characteristics that play a part in determining eligibility for school transport: *First graders* have a lower distance requirement for eligibility compared to older children. Children who are enrolled in after-school programmes (*SFO*) are not entitled to school transport. *Private schools* may also cause an increase in the demand for school transport as they may attract pupils from all over the municipality, while public schools usually serve the local population. Finally, when pupils' route to school is classified as "dangerous", they may be entitled to transportation, even if they do not meet the distance requirements. These factors are denoted $\mathbf{z}^M \in \Re_+^I$. Consequently, we define the number of pupils entitled to school transport by the function

$$e^S = g\left(\frac{x}{a}, \mathbf{z}^{\mathbf{M}}\right) \qquad (5)$$

which is estimated based on the following functional form that passes the Ramsey RESET test:

$$\frac{e_{it}^S}{e_{it}} = \beta_0 + \beta_x \frac{x_{it}}{a_{it}} + \sum_{j=1}^{I} \beta_j z_{jit}^M + \varepsilon \qquad (6)$$

A key assumption is that the average school size is not determined by the number of pupils eligible for school transport, which would lead to a reverse causality problem from a statistical point of view. The argument is that the municipal governments, which oversee the school system, reap the financial gains from school consolidation (i.e. by exploiting economies of scale in the provision of schooling), but face only a fraction of the costs of providing school transport. The reason is that regional governments are responsible for organizing and financing school transport in most cases. Hence, municipality governments are expected to pay less attention to school transport when forming the primary school system, as they do not internalize the costs of said transport.

Inserting Eqs. 3 and 5 into Eq. 1, we find the following relationship between the average school size and the costs of bus operations:

$$c\left(f\left(g\left(\frac{x}{a}, \mathbf{z}^{\mathbf{M}}\right), \mathbf{z}^{\mathbf{C}}\right), g\left(\frac{x}{a}, \mathbf{z}^{\mathbf{M}}\right); \mathbf{z}^{\mathbf{O}}\right) \qquad (7)$$

We assume that all functions are differentiable. The impact of a marginal change in the number of schools in the area under consideration is in this case given by the following formula:

$$\frac{\partial c}{\partial x} = \underbrace{\frac{\partial c}{\partial f}\frac{\partial f}{\partial g}\frac{\partial g}{\partial \left(x/a\right)}\left(\frac{1}{a}\right)}_{\text{Volume effect}} + \underbrace{\frac{\partial c}{\partial g}\frac{\partial g}{\partial \left(x/a\right)}\left(\frac{1}{a}\right)}_{\text{Unit cost effect}} = \left(\frac{\partial c}{\partial f}\frac{\partial f}{\partial g} + \frac{\partial c}{\partial g}\right)\underbrace{\frac{\partial g}{\partial \left(x/a\right)}\left(\frac{1}{a}\right)}_{\text{Change in pupil transport}} \quad (8)$$

Eq. 8 illustrates that school transport influences the costs of providing public transport in both direct and indirect ways. First, as school transport is costly, especially during peak hours, adding more pupils to the existing public transport system (i.e. for given bus kilometres) contributes to an increase in the costs per kilometre. We dub this the *unit cost effect*, referring to the fact that the cost per passenger increases when more pupils are being transported. Second, adding more pupils to the public transport system may induce changes to the supply of public transport, e.g., by requiring the establishment of new routes or the extension of existing services to meet school transport needs. This is dubbed the *volume effect*. Together these two effects make up the total economic impact of changes to the primary school system on the counties' costs of providing public transport.

We apply econometric analysis to panel datasets at the municipal and regional levels to estimate the functions in Eq. 1-3. These data are available from public sources, such as the KOSTRA database at Statistics Norway and the GSI database (*Grunnskolenes informasjonssystem).*

We combine these data with transport provision data at the "package" level, which refers to the contract level for public transport with buses. Public transport is typically organized in several packages for each county, in such a way that each package covers more than one municipality. Our motivation for using this level is to look at the effects of school-related transport on costs and competition in public transport tenders. These data have been made available through the project *Cost Developments in Public Transport*, a collaboration between the Institute of Transport Economics (TØI) and Møreforskning Molde (MFM), commissioned by The Norwegian Association of Local and Regional Authorities (KS).

Cost of providing basic education

Having considered the costs of providing school transport, we turn to the costs of providing basic education. More precisely, we consider how cost savings from increasing school size (i.e. school consolidation) compare with the induced cost increases for school transport. From the point of view of minimizing the public sector's costs, these costs should be aligned. Where they deviate, we can interpret it as a manifestation of a failure of coordination among multiple levels of government.

In estimating a cost function for the provision of school services we have drawn inspiration from Falch et al. (2005), Falch et al. (2008) and Gronberg et al. (2015) in terms of variables used and functional forms. Costs are evaluated at the level of the municipality, and the cost function is assumed to take the Translog functional form. The provision of education is assumed to comprise one variable input (labour: represented by its input price, denoted w) and one quasi-fixed input (the number of schools: denoted x), and two outputs (the number of pupils with and without need for special education, denoted v_1 and v_2, respectively), the first of which acknowledges the costs of providing special education.

There may also be concerns about changes in educational quality following a school closure. For example, larger schools are likely to have more pupils per teacher than small schools, which may be considered a deterioration of quality. There are also differences in grades and other potential quality indicators among schools. However, we refrain from including such characteristics in the model as we suspect that it may do more damage than good, for example by introducing endogeneity. First, the recent study by Kirkebøen et al. (2017) shows that having more teachers per pupil has little or no effect on grades. Second, Steffensen et al. (2017) show that pupil characteristics play a major role in explaining inter-school variation in grades, and that the school's contribution to this variation may be smaller.

We impose homogeneity in factor prices. Since there is only one input, this means that wages are omitted as an explanatory variable and are instead captured in the dependent variable. The model to be fitted is assumed to take the Translog functional form:

$$\begin{aligned}\ln\left(\frac{C_{it}}{w_{it}}\right) = {} & \beta_0 + \beta_x \ln(x_{it}) + \beta_{v1}\ln(v_{1it}) + \beta_{v2}\ln(v_{2it}) \\ & +0.5\beta_{xx}\ln(x_{it})^2 + 0.5\beta_{v1v1}\ln(v_{1it})^2 + 0.5\beta_{v2v2}\ln(v_{2it})^2 \\ & +\beta_{xv1}\ln(x_{it})\ln(v_{1it}) + \beta_{xv2}\ln(x_{it})\ln(v_{2it}) \\ & +\beta_{v1v2}\ln(v_{1it})\ln(v_{2it}) + \varepsilon\end{aligned} \quad (9)$$

We estimate this function using data at the local level from (Statistics Norway, 2017b) *Pupils in primary and lower secondary school 1999–2016* (table 04684).

Analysis

In this section we present our empirical analysis.

What determines the number of pupils entitled to school transport?

The first step of our analysis is to establish which factors influence the number of pupils entitled to school transport, with emphasis on school structure, proxied by the number of pupils per school. This analysis is conducted at the municipal level, using data from Statistics Norway and GSI for the years 2007–2016.

A key assumption is that school structure is independent from the number of pupils in primary and secondary schools (*grunnskolen)* entitled to school transport as this mitigates the issue of reverse causality. Our opinion is that this assumption holds because the costs of providing schooling are substantially higher for the municipality than those associated with school transport provision. Moreover, local governments do not fully internalize the costs associated with school transport.

As previously noted, we have selected relevant explanatory variables based on the rules for eligibility for school transport. Of primary interest to us is school density (i.e. number of schools per square meter), along with population density and the share of urban population. Note that we include both urban and overall population densities in the model to accommodate school access in urban areas and in the municipality as a whole. We also include municipality characteristics such as one-person households, pupils enrolled in SFO, and metres of pedestrian and cycle paths as a proxy for non-dangerous routes to school. In addition, we include interactions among the variables in the specification. We have selected our preferred functional form based on rigorous testing using the Ramsey RESET test, and have calculated the model using ordinary least squares, fixed and random effects estimators, and first differences. Testing shows that the panel data estimators are preferred over pooled OLS. The null hypothesis of the Hausman test is soundly rejected, which leads us to conclude that the fixed effects model is the preferred model specification. Hence, we use this model for predicting how marginal changes in the number of schools influence the number of pupils eligible for school transport.

Table 1: Explaining the number of pupils entitled to school transport

	(OLS)	(FE)	(RE)	(FD)
	Eligible pupils, share	Eligible pupils, share	Eligible pupils, share	Eligible pupils, share
Schools per m^2	-1.666^{***}	-3.477^{***}	-3.772^{***}	-2.597^{**}
	(0.282)	(0.766)	(0.491)	(1.182)
Private Schools (share)	0.083^{***}	0.087^{***}	0.097^{***}	0.081
	(0.021)	(0.027)	(0.025)	(0.050)
Urban Pop (share)	-0.626^{***}	-0.268^{***}	-0.559^{***}	-0.052
	(0.015)	(0.050)	(0.026)	(0.077)
Urban Pop. Dens	-0.000^{***}	-0.000^{**}	-0.000^{***}	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Pop. Dens.	0.000^{***}	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)
One-person HH. (share)	2.454^{***}	0.491	0.136	0.311
	(0.540)	(0.621)	(0.568)	(0.949)
SFO (Share)	-0.001^{***}	-0.001^{***}	-0.001^{***}	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Pedestrian street (Km)	0.001^{**}	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Schools/m^2*Urb.pop.sh	0.605	3.498^{***}	3.529^{***}	1.951
	(0.397)	(0.941)	(0.645)	(1.434)
Urb.pop.sh*Pedestr. st.	-0.001^{**}	0.000	0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.000)
Constant	0.774^{***}	0.593^{***}	0.772^{***}	-0.002
	(0.010)	(0.035)	(0.017)	(0.002)
Observations	3269	3269	3269	2456
Adjusted R^2	0.697			0.000
Ramsey test (P-value)	0.138			0.070

OLS = Ordinary least squares; FE = Fixed effects estimator; RE = Random effects estimator; FD = First differences
Standard errors in parentheses,
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our results are in line with our expectations: The number of pupils entitled to transport services declines in school density, the number of pupils attending SFO, and the proportion of the population living in urban areas. Private schools contribute to an increase in the number of pupils eligible for school transport.

From the fixed effects model, we extrapolate that the opening of a new school would, on average, correspond to 4 fewer pupils being entitled to transport services. Our FE estimates vary between 1 and 38 pupils per municipality. As a comparison, the average number of pupils entitled to transport services per school per municipality observed in the data is 55.

How does school transport affect the volume of public transport provided?

We analyse the volume effect on route package level. In this regression, we seek to describe how the number of pupils entitled to public transport to school affects the level of public transport services, measured in bus kilometres. The assumption is that the regional authorities take the number of pupils they have to service as given, which is taken into account when designing the public transport system.

Table 2 presents the results from different model specifications for the regression model. (1) and (2) Oslo are without county dummies, while the specifications used in (3) and (4) include county dummies. (1) and (3) are without scale effects (squared term), while (2) and (4) include scale effects with respect to the number of pupils entitled to school transport. We have also analysed the geographical size of the route package, but this is not reported as it has no significant effect on the length of the route network provided. Moreover, the regional dummies are not emphasized in the current analysis. Hence, they are reported in the Appendix.

Table 2: Explaining the extent of the public transport network[9, 10].

	(1) Route kms (1000)	(2) Route kms (1000)	(3) Route kms (1000)	(4) Route kms (1000)
Population	-0.001 (0.006)	-0.002 (0.006)	-0.003 (0.007)	-0.005 (0.007)
Nr. eligible pupils	1.037^{***} (0.270)	2.011^{***} (0.598)	1.036^{***} (0.326)	2.249^{***} (0.711)
Pop dens	-0.644 (2.164)	0.230 (2.194)	0.086 (2.593)	1.270 (2.630)
Urban pop sh.	3863.117^{***} (905.203)	3762.240^{***} (897.317)	3258.170^{***} (967.536)	3328.716^{***} (954.438)
0.5*(Nr. eligible pupils)^2		-0.001^{*} (0.000)		-0.001^{*} (0.000)
Constant	-1720.850^{***} (635.676)	-2206.974^{***} (683.097)	-1781.030^{*} (1011.724)	-2428.211^{**} (1053.172)
Observations	113	113	114	114
Adjusted R^2	0.318	0.332	0.371	0.389
Ramsey test (P-value)	0.412	0.079	0.397	0.000

Standard errors in parentheses,
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.0$

The effect of the number of pupils on the provision of public transport is robust with respect to the inclusion of county dummy variables, but it is affected when including the square of pupils entitled to school transport. This model indicates that an extra pupil entitled to school transport increases the annual production of public transport by about 1040 bus kilometres. The estimates vary between zero and 2 000 annual kilometres for the different route packages and the number of extra kilometres decrease with increasing population density. Hence, the effect is largest in the rural areas, in line with expectations.

How does a change in school structure affect the price level of public transport?

The unit cost effect is identified by analysing how the total cost of a route package is influenced by school transport. This is an indicator of how an operator allocates its resources in response to the criteria set by the regional authorities and an expression of the regional governments' costs of buying an extra unit of public transport.

Table 3 shows the results from our preferred model, a Cobb-Douglas cost function. We tested the robustness of this function using county dummies as an indicator for unobserved county level variations as well as a more flexible specification including squared and interaction terms. The Cobb-Douglas function is preferred because it contains few parameters (to be fitted for a small sample) and because it satisfies the Ramsey RESET test.

Table 3: A cost function for tendered bus operations[11, 12]

	(1) ln(Cost)	(2) ln(Cost)	(3) ln(Cost)	(4) ln(Cost)
ln(Pop.Dens.)	0.099***	0.089***	0.031	0.012
	(0.022)	(0.022)	(0.026)	(0.025)
ln(Urban.Pop.Share)	-0.225*	-0.261**	-0.116	-0.156
	(0.122)	(0.124)	(0.122)	(0.120)
ln(Route.Kms)	0.888***	0.799**	0.895***	0.322
	(0.030)	(0.386)	(0.029)	(0.392)
ln(Nr.Pupils)	0.091**	-0.512	0.076*	-1.370**
	(0.041)	(0.541)	(0.045)	(0.537)
0.5*ln(Pop Dens)^2		0.034		0.043
		(0.025)		(0.026)
0.5*ln(Nr.Pupils)^2		0.195**		0.213**
		(0.096)		(0.094)
ln(Pop Dens)*ln(Nr. Pupils)		-0.051		0.001
		(0.037)		(0.037)
Constant	3.974***	6.318*	4.396***	12.941***
	(0.395)	(3.260)	(0.406)	(3.284)
Observations	113	113	113	113
Adjusted R^2	0.934	0.936	0.947	0.952
Ramset test (P-value)	0.380	0. 975	0.302	0.07

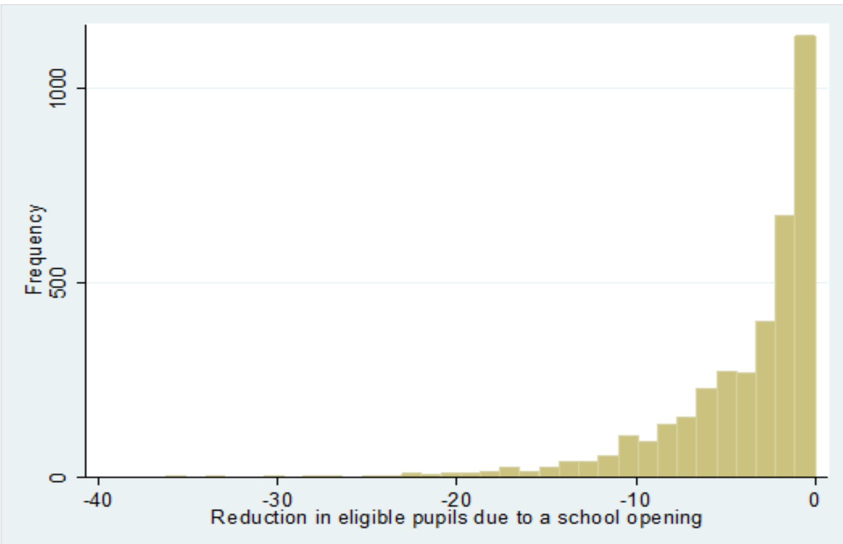
Standard errors in parentheses
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

The results show that the majority of the cost is explained by factors such as vehicle kilometres and population density, which is in line with expectations. However, the results also indicate that each extra pupil, on average, increases the price level on each contract. In other words, the transport of schoolchildren is more expensive per unit compared to other transport.

Estimating the transport cost increase resulting from a school closure

Based on the results from the previous three sections, we can now estimate the contribution of a school closure to annual transport costs. We start by presenting a frequency plot of the estimated reduction in the number of pupils eligible for school transport due to a school opening. This is the mirror image of increases in school transport due to a school closure.

Figure 1. Frequency plot of reduction in eligible pupils due to a school opening based on the FE estimator



Our results indicate that most municipalities will experience a small change in school transport due to a school opening. On average, a marginal school opening results in 4 fewer pupils entitled to ordinary school transport. Based on the FE estimates, the maximum number is 38 pupils. Using these estimates, we identify the volume and unit cost effects according to Eq. 8.

Table 4: Estimating average and maximal increase in transport cost per school closure

For pupils = 4 (mean)

	Obs	Mean	Std. Dev	Min	Max
Volume effect	114	117 268.5	201 07.3	75 414.3	202 191.0
Unit cost effect	114	22 045.7	198 06.3	97.3	114 820.7
Total effect	114	139 314.2	249 62.9	96 005.05	222 934.3

For pupils = 38 (max)

	Obs	Mean	Std. Dev	Min	Max
Volume effect	114	1 114 051.0	191 018.8	716 436.7	1 920 814.0
Unit cost effect	114	209 434.1	188 159.9	924.9	1 090 797.0
Total effect	114	1 323 485.0	2 371 47.9	912 047.9	2 117 876.0

Table 4 shows that the volume effect is the most important in terms of estimating the total cost effect of closing a school. Our finding is that the effect is between

NOK 96 000 and 223 000 per school, with an average of NOK 139 314. This is below the estimate of Iversen and Nyhus (2015), which ranges from NOK 300 000 to 600 000. However, our results show that in cases where many pupils are involved, the additional transportation costs may be substantial, ranging from NOK 900 000 to 2 000 000. This highlights that there is substantial variation, and that the consequences of closing a school can be very significant in some locations.

Local cost savings resulting from a school closure

We have estimated the cost function (9) using data on pupils in primary and lower secondary schools in Norway for the period 1999–2016, using both OLS and the fixed effects estimator (Table 5). Testing shows that the panel data estimator is preferable to pooled OLS. We have also considered the random effects panel data estimator, but it is not supported by the Hausman test. For comparison, we also report the first difference estimator.

Note that the model implicitly considers the average school size (i.e. the number of pupils per school) by controlling for both the number of schools and pupils. Thus, a ceteris paribus change in the number of schools implies that the average school size is altered. We have also considered a specification where the number of small schools (up to 100 pupils) and the number of large schools are treated as separate capital indicators but have dismissed it because the majority of the parameter estimates do not pass the t-test.

Table 5. A cost function for school operations

	(OLS) Ln(cost/wage)	(FE) Ln(cost/wage)	(FD) Ln(cost/wage)
Ln(Schools, nr)	0.667^{***} (0.056)	0.778^{***} (0.083)	0.654^{***} (0.110)
Ln(Pupils wo special training , nr)	-0.148^{***} (0.056)	-0.180^{*} (0.097)	-0.043 (0.161)
Ln(Pupils w special training , nr)	0.367^{***} (0.044)	0.179^{***} (0.045)	0.204^{***} (0.059)
$0.5\text{Ln(Schools, nr)}^2$	0.145^{***} (0.018)	0.103^{***} (0.024)	0.110^{***} (0.029)
$0.5\text{Ln(Pupils wo special training, nr)}^2$	0.186^{***} 0.032	0.184^{***} 0.085^{***}	0.126^{***} 0.036^{**}
Ln(Schools) Ln(Pupils wo)	-0.133^{***} (0.017)	-0.122^{***} (0.019)	-0.115^{***} (0.023)
Ln(Schools) Ln(Pupils w)	0.040^{**} (0.016)	-0.011 (0.013)	0.007 (0.014)
Ln(Pupils wo) Ln(Pupils w)	-0.064^{***} (0.016)	-0.067^{***} (0.013)	-0.042^{***} (0.016)
Constant	7.627^{***} (0.112)	8.444^{***} (0.308)	0.003^{**} (0.001)
Observations	3154	3154	2643
Adjusted R^2	0.989	0.257	0.126

OLS = Ordinary least squares; FE = Fixed effects estimator; FD = First difference estimator

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Using these regressions to estimate cost changes from a marginal school opening we get costs in thousands of NOK.

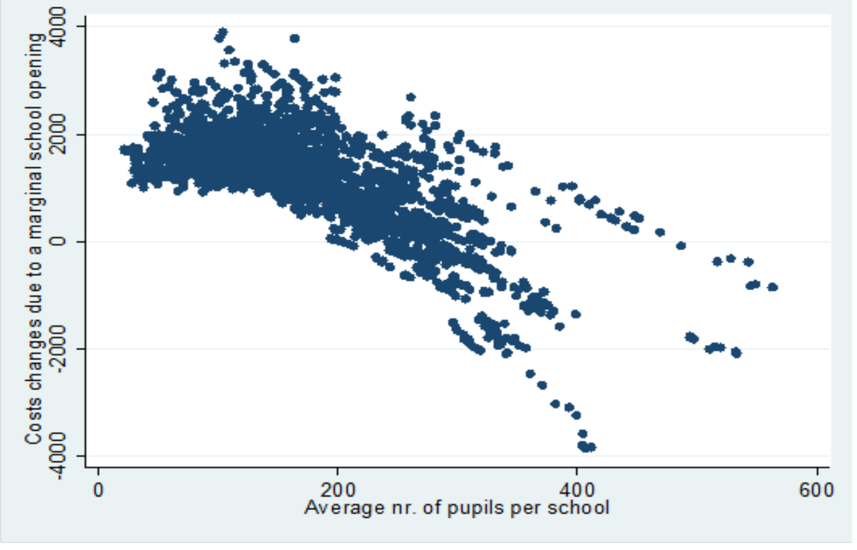
Table 6. Changes in costs (1000 NOK) from a ceteris paribus school opening.

Variable	*Obs*	*Mean*	*Dev.*	*Min*	*Max*
Cost change (OLS)	3,154	3,085.9	1,055.9	475.1	1,2224.3
Cost change (FE)	3,154	1,153.2	866.6	-3,857.6	3,900.4

We find that the estimates are positive over the entire range of data for the OLS specification. This means that adding a new school while keeping the number of pupils the same will only lead to cost increases (NOK 3 million on average). The corresponding estimates of our preferred model – the fixed effects model – are much lower, averaging NOK 1.1 million.

For the fixed effects model, some of the marginal cost changes are found to be negative; in other words, increasing school capacity will lead to cost savings. Intuitively, this happens when schools are 'too large' from an economic point of view, namely when there are decreasing returns for school size. This is illustrated by Figure 2, which displays the relationship between the average number of pupils per school (per municipality) and changes in costs due to a ceteris paribus school opening.

Figure 2. Plotting cost changes for the local government from opening a school



Note that because the derivatives are symmetric, sign reversal of the above estimates will provide predictions of the cost changes of a school closure. That is, as most cost changes are found to be positive, closing a school will reduce municipal spending on schools overall, except in municipalities where schools already are quite large. Our estimates indicate that in general the savings from closing a school surpass the corresponding costs of transporting additional pupils.

Discussion

Our quantitative analysis shows that the transport of schoolchildren increases the volume and price of public transport and that closing rural schools results in more pupils' needing transport. At the same time, closing schools and increasing the average school size increases cost efficiency in the provision of school services. This is in line with expectations from the literature (Falch et al., 2008). It is cheaper to teach a pupil in a larger school than in a smaller one, as larger schools will have more equally sized classes and therefore fewer pupils per employee at the school (both teachers and other staff). This is because even small classes need at least one teacher and there is a minimum staff requirement for running a school. Falch et al. (2005) found that there are economies of scale for schools between 10 and 300 pupils, while there are limited economic benefits from having schools larger than this. Falch et al. (2005) measured this using teacher density (teacher hours per pupil). Our analysis has not explicitly addressed changes in the quality of education as schools get larger. However, in line with newer studies (Steffensen et al., 2017, Kirkebøen et al., 2017), Bonesrønning and Iversen (2007) indicate that school size has a very limited effect on learning outcomes, operationalized by results from national tests. The direction, size and significance of the effect varies between different model specifications. In bivariate analysis, the effect of school size is positive. However, it turns negative (but is very small) when parent education levels are controlled for. In their subsequent report, Bonesrønning and Iversen (2010) find no significant effect of school size.

Comparing the cost savings achieved at the local level with the cost increases at the regional level, we find that the cost savings are larger on average. Still, there is important local variation. Our analysis thus indicates that this policy of school closures would also be pursued if schools and the ordinary transport of schoolchildren were integrated in a Type II arrangement, using the Hooghe and Marks (2003) framework and assuming that school authorities can achieve the same price for school transport as regional PTAs. Using these assumptions, integrating these services shifts the tipping point towards more and smaller schools. However, it can be argued that the tender prices cannot be assumed to be similar; cf. Hansson and Holmgren (2018) and Aarhaug et al. (2018). Experience points to smaller tenders and PTAs achieving higher prices, which is an argument against integrating school transport with school provision.

From the perspective of regional authorities, school transport is a cost that limits their ability to offer the services they want, as the related cost increases are not fully compensated for by local authorities. Still, the increase in cost at the regional level is, on average, less than the cost savings at the local level. This raises at least two questions: Should local authorities provide more compensation for the induced costs at the regional level? And does this simple way of comparing the costs of two different services allow us to make statements about the distribution between local and regional authorities?

From a multilevel government perspective, this situation with savings at the local level and increased costs at the regional level points to an increasing transfer of power from regional to local authorities, thus limiting regional authorities' ability to operate independently of local policy decisions. In practical terms, our results highlight how local government decisions, in the form of school closures, place constraints on regional authorities. Closing a school also has the consequence of reducing the regional authority's degrees of freedom in providing public transport services. Therefore, although the cost savings at the local level and the cost increases at the regional level result in a total combined cost savings, closing schools undermines regional authorities' ability to reach their policy objectives. These issues could be addressed either by integrating the cost of school transport into the provision of schools in a Type II arrangement or by reallocating the responsibilities for public transport from the regional to the local level in a Type I arrangement.

The experience of tendering school contracts separately (Tørring and Vennes, 2014) indicates that including school transport in the provision of schools would be cost increasing. Keeping school transport as part of local public transport but transferring the responsibility for providing this transport from regional to local authorities remains an option. However, as indicated in Aarhaug et al. (2018), the benefit of such an arrangement must be seen in the context of the size of the municipality. There is a cost-minimizing bus contract size, which is already larger than the average tendered bus contract. From this we deduce that neither the Type I arrangement, aligning the cost of school transport and public transport, nor the Type II arrangement, transferring the responsibility for school transport from the realm of public transport to school service provision, is clearly better than the current arrangement. In other words, while the current arrangement is problematic in that it appears to incentivize an undersupply of schools, it is not clear that the alternatives are better, as they both point to higher prices for school transport.

Our analysis does not take changes in utility for pupils into account. The Norwegian value of time study (Ramjerdi et al., 2010) does not calculate values for the time of persons under 18 years of age. Therefore, we have no reference value for the change in time use for pupils. Moreover, we do not know how the total amount of time used for transport between home and school is changed by a school closure. On the one hand, this points to longer commutes in kilometres, but on the other hand it points to increased use of motorized transport and therefore higher average speeds. Changes in school structure will probably influence pupil welfare, but this is a topic for future study. Constituencies' resistance to large schools and to changes in school structure is a likely explanation for why cost savings from larger schools appear to outweigh cost increases from associated school transport.

Conclusion

Closing schools increases both the cost and transport volume of public transport. However, the increased costs incurred at the regional level are, on average, less than the savings made at local level.

Interview data, as described by Aarhaug et al. (2017) and Iversen and Nyhus (2015), suggest this has a significant impact on which public transport services can be provided given the limited resources available at the regional level. However, there is much local variation. Not all school closures result in cost savings for local authorities or in increased costs for regional authorities. Local geography plays an important role in this respect. Using a less aggregate dataset than do Iversen and Nyhus (2015), this study supports their finding that there are cost increases on the regional level related to reducing the number of schools.

We further find that this has both a price and volume effect for regional authorities when they purchase transport services: When there are fewer schools, a PTA must purchase more transport services, but the price per kilometre of transport also increases. In other words, increasing the share of school transport in a contract has an independent effect on prices in a public transport tender. Both these findings are in line with expectations from theory and the literature.

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Appendix

Table A1: Supplement to Table 2: Explaining the extent of the public transport network

	(1) Route kms (1000)	(2) Route kms (1000)	(3) Route kms (1000)	(4) Route kms (1000)
Regional dummies (Akershus as base):				
Aust-Agder			800.053 (1159.659)	635.203 (1146.353)
Buskerud			228.494 (889.741)	121.438 (878.826)
Finnmark			1478.311 (1288.729)	1455.385 (1270.389)
Hedmark			-130.400 (988.571)	-363.421 (982.052)
Hordaland			1061.014 (837.027)	1274.212 (832.581)
Møre og Romsdal			986.495 (900.439)	733.965 (897.360)
Nordland			-5.750 (796.816)	86.708 (786.929)
Oppland			-47.086 (929.724)	-241.368 (922.069)
Oslo			-43.869 (1832.714)	-273.569 (1810.543)
Oslo and Akershus			162.517 (830.044)	-69.851 (827.174)
Rogaland			2741.054*** (914.086)	2418.445*** (916.703)
Sogn og Fjordane			1239.261 (1285.182)	902.940 (1278.993)
Sør-Trøndelag			-13.331 (827.436)	-318.242 (831.072)
Telemark			632.127 (942.812)	703.337 (930.099)
Troms			665.797 (1138.026)	361.234 (1133.036)
Vest-Agder			-381.050 (1014.147)	-484.726 (1001.140)
Vestfold			1341.367 (957.260)	913.250 (969.804)
Østfold			245.805 (1299.692)	296.672 (1281.415)

Table A2: Supplement to Table 3: A cost function for tendered bus operations

	(1)	(2)	(3)	(4)
	ln(Cost)	ln(Cost)	ln(Cost)	ln(Cost)
	Regional dummies (Akershus as base):			
Aust-Agder			-0.231 (0.197)	-0.291 (0.193)
Buskerud			0.025 (0.153)	0.045 (0.152)
Finnmark			-0.837*** (0.247)	-0.954*** (0.241)
Hedmark			-0.321* (0.172)	-0.355** (0.165)
Hordaland			-0.087 (0.142)	-0.204 (0.145)
Møre og Romsdal			-0.164 (0.160)	-0.166 (0.157)
Nordland			-0.356** (0.139)	-0.412*** (0.142)
Oppland			-0.107 (0.165)	-0.085 (0.161)
Oslo and Akershus			0.072 (0.138)	0.076 (0.132)
Rogaland			-0.013 (0.154)	-0.002 (0.157)
Sogn og Fjordane			-0.019 (0.229)	-0.084 (0.222)
Sør-Trøndelag			0.037 (0.149)	0.029 (0.143)
Telemark			-0.450*** (0.161)	-0.484*** (0.161)
Troms			0.052 (0.204)	-0.093 (0.215)
Vest-Agder			-0.298 (0.182)	-0.283 (0.178)
Vestfold			-0.151 (0.171)	-0.127 (0.170)
Østfold			0.008 (0.222)	-0.058 (0.216)

Endnotes

[1] Quote from Tore Fjelland Storhaug, Telemark county government, from Aarhaug et al 2017 p. 81, author's translation.
[2] Quote from Lars Engerengen, Finnmark county government, from Aarhaug et al. 2017 p.81.
[3] The names of the PTAs are reported in the brackets.
[4] K denotes the number of contextual variables.
[5] There are two reasons why we prefer the more parsimonious Cobb-Douglas specification over a flexible functional form. First, the cost function is fitted to a small sample. Functional forms that require the estimation of a high number of parameters (e.g., the Translog functional form) are less desirable in this setting. Second, the Cobb-Douglas specification passes the Ramsey RESET test, which suggests that including higher-order terms in the model will not improve its explanatory power.
[6] While these are factors that could be influenced by political decisions in the long term, our model has a short-run perspective.
[7] L denotes the number of variables that influence the supply.
[8] We prefer this parsimonious model because empirical testing shows that it satisfies the Ramsey RESET test while more complex model specifications fail the test.
[9] The Ramsey RESET test supports the specification that does not include a square term.
[10] Regional dummies are described in appendix A1.
[11] First differences cannot be calculated because our dataset is not a genuine panel. In fact, within each county, there are several contracts which first year coincide (i.e. there is no unique time indicator within each county). However, we estimate the models with and without county dummies, which takes care of county fixed effects.
[12] Regional dummies are presented in appendix A2.