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Public versus private production
A study of the cost of school cleaning in Denmark

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Abstract: The cleaning of Danish schools is produced by one of three forms of organization: decentral municipal, central municipal or private. The cost function is shown to be well estimated by a trans-log specification of scale and quality of cleaning. For small schools the organization makes little difference. For larger schools decentral municipal production is the most expensive. On average centralization reduces costs by 6%, while privatization reduces costs by 29%. These cost gaps are due to the difference in ability to exploit the economy of scale.

Keywords: *Cost function, public production, private production, scale effects, non-parametric regression, bootstrap* *JEL: C14, D78, H72, L33*

I Introduction: A cost gap

Danish municipalities own the primary schools, and they have full freedom to decide how they are cleaned. Three forms of organization are used for cleaning: Most are cleaned by decentral municipal organizations at the individual school. The rest are cleaned by central municipal units or private companies. We analyze how these forms of organization influence cleaning costs for a given cleaning quality. For larger schools we find systematic *cost gaps*. On average private cleaning is cheapest, while decentral municipal cleaning is the most expensive.

School cleaning is produced by many units of production, all using a simple technology with a low capital-labor ratio. Cleaning has a fast circulation of personnel, and new technologies are rapidly disseminated. We therefore treat our data as a set of observations of one cost function with a fixed capital-labor ratio. The cost of cleaning is estimated as a function of the form of organization, cleaning

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quality and scale.

The result is a standard translog cost function, which is our *Base-model of school cleaning*. For selected forms of organization and qualities, we compare the Base-model with alternative nonparametric regression functions and bootstrap-based confidence intervals. The Base-model is a good parametric approximation to the regression function. The advantage of the Base-model is that it pools the information for all forms of organization and cleaning qualities into a simple tool for policy analyses.

The cost gap between public and private production is found to arise from *differences in the ability to exploit economy of scale*. This finding extends and refines the standard result in the international literature: The average cost gap is almost 30% in favor of private production. See for instance the surveys by Borcherding, Pommarehne & Schneider (1984), Domberger & Jensen (1997) and Vickers & Yarow (1989). Only few studies have been made for Denmark, see Kristensen (1982), Jensen & Rasmussen (1997), and PLS Consult (1997).

Empirical studies often compare production costs of a public monopoly with private sector production on a competitive market. This has led to two explanations of the cost gap: One is *the monopoly theory* where the gap is due to the difference in competitive pressures, ie, competition reduces costs. The theory is difficult to assess empirically, as private monopolies operating without fear of entry are rare.[2)] The second is *the ownership theory*, where the gap is due to the difference in ownership. Private firms with a well-defined residual claimant (ie, owner) have a »bottom line« everybody understands. Public organizations operate under complex political pressures leading to ambiguous goals.[3)] Our explanation given in Section VI is a variant of the ownership theory.

The paper is written at two levels: Sections II, V and VI are meant to be nontechnical, while Sections III and IV are more technical. Section II looks at the data definitions and institutional factors. Section III develops the Base-model, and studies its properties against a non-parametric approach. Section IV deals with the representativity of the sample, and extends the Base-model with some municipal characteristics. Section VI presents a small (graphical) model explaining why public producers may fail to realize the potential economy of scale.

The policy analysis is conducted in Section V, where the Base-model is used to calculate the effects of policy changes. A key prediction is that if the cleaning at all schools were privatized, it could lead to savings of roughly 300 million Danish Crowns, corresponding to the salary of 1000 new schoolteachers.

2. The argument is presented in Borcherding, Pommarehne & Scheider (1984). The monopoly model is further developed into the theory of rent-seeking, where the monopoly is uphold by regulation giving barriers to entry.

3. This analysis was pioneered by a whole set of writers republished by Pejovic (1997) and developed by eg Shleifer & Vishy (1998). The basic intuition is: Any organization frequently has to make unpleasant decisions. They are more difficult to make without a hard budget constraint.

II Data and some institutional facts

The data have been collected by a questionnaire sent to all 275 Danish municipalities in the spring of 1998. After six months of monitoring and data-weeding, we managed to get a set of seemingly consistent answers from 189 municipalities covering a total of 1081 primary schools. The representativity of the sample is discussed in Section IV. The data-set contains the five types of variables listed in Table 1.

Table 1. The variables analyzed

Name	Type
i	School index, i = 1, ... , 1081
c_i	Annual cost in Danish Crowns (Kr) per school
s_i	School size in m^2
q^k	Quality: q^1, high. q^2, standard »511«. q^3, assessed
z^h	Form of organization: z^1, municipal decentral. z^2, municipal central. z^3, private.
$\mathbf{m}_i$	Vector of 24 municipality characteristics. See appendix

Note: The q's and z's are dummies, being 1 if the property is present and zero otherwise.

Subsection II.1 looks at the forms of organization and the Danish cleaning market, while II.2 discusses cleaning qualities. Subsection II.3 considers the size distribution of the schools.

II.1 Forms of organization: the ***z****-vector*

As already mentioned, municipal school cleaning is organized in three basic ways:

z^1: 66.5% of the schools use decentral municipal labor. The municipality gives each school a cleaning budget.[4)] The school then employs and monitors the cleaning personnel.

z^2: 19% of the schools are cleaned by personnel employed and monitored by a central cleaning bureau of the municipality.

z^3: 14.5% of the schools are cleaned by a private company, which has usually obtained the contract after competitive bidding.

The z's are dummy variables, where, for each i, one is 1 and two are 0, so that: $z^1_i + z^2_i + z^3_i = 1$. The z's are stacked in the vector **z**.

The private Danish cleaning market is large, and the school contracts are a small fraction only. The firm structure deviates from the competitive ideal. The market has one very large multinational company, a second large one, and many small companies. Entry costs are low, and enough consultants organize tenders and advise municipalities about current market prices. The market is therefore rather competitive.

4. The cleaning budget might be integrated in some broader budget, allowing the school some substitution between various budget accounts. In such cases, it is likely that all administrative costs are not included, also the school porter may take care of some of the functions normally done by the cleaning personnel.

The »market« for municipally organized school cleaning has many producers. Our data include 749 production units, where 719 are at individual schools and 30 are central municipal cleaning units. Each unit produces under controlled entry. Therefore, it has some degree of monopoly, but the unit knows that the municipality may decide to tender the contract. Consequently, the municipal producers of school cleaning should not be treated as true monopolies. As mentioned in the introduction the main theories of the cost gap are the monopoly theory and the ownership theory. It would appear that the ownership theory is more relevant in our case.

*II.2 Cleaning qualities: the **q**-vector*

In this paper, quality refers to the product supplied to the consumers. The quality of the workplace from the point of view of the employees is not considered. Our data are provided by the municipalities, who are the authorities responsible for the quality. The quality is specified in directives to schools, in contracts with employees (unions) and firms.

In 1977 the relevant trade unions and the Central Organization of Municipalities agreed on a joint »cleaning manual« (Kommuneinformation, 1977), defining cleaning standards. Subsequent technological developments have caused minor revisions. The manual defines a *reference standard*. It describes how often various types of facilities should be cleaned, and the intensity with which this should be done. The manual also specifies the area a cleaner should cover per hour. For schools the reference standard is termed »511«. We use it to define two more qualities.

q^1: *High*. A group of 104 schools uses higher standards than »511«. Several are in use, but each has too few observations to analyze separately. All standards above »511« are thus merged into one group, of high-standard cleaning.

q^2: *»511«*. The reference standard used in 70% of the schools.

q^3: *Assessed*. »Assessed need« is not a well-defined standard, but it is normally a lower and cheaper standard than »511«.[5)]

The q's are binary dummies. For each i, one is always 1, while two are 0. Hence, $q^1_i + q^2_i + q^3_i = 1$. The q's are stacked in a vector **q**.

The quality variable has to be controlled for in studies of the cost gap in public and private production. We therefore gave our questionnaire considerable detail about quality. Consequently, we are confident that we control for most quality differences. However, some error remains as unreported slack. It is a problem if slack differs systematically between the forms of organization.

Table 2 shows a cross tabulation of cleaning qualities and organizations that leads to 9 »boxes«. Some »boxes« in the table are shaded to show that they hold few observations. A structural model is needed to obtain good estimates for these cases. Note that for private cleaning [(22+27)/156 =] 31% of all observations are in the shaded »boxes«, so there a model structure is important.

5. The term in Danish is: behovsbestemt. It should also be mentioned that a few municipalities use a well-defined standard below »511«. These groups hold too few cases to analyze.

Table 2. Cross-tabulation of cleaning qualities and forms of organizations

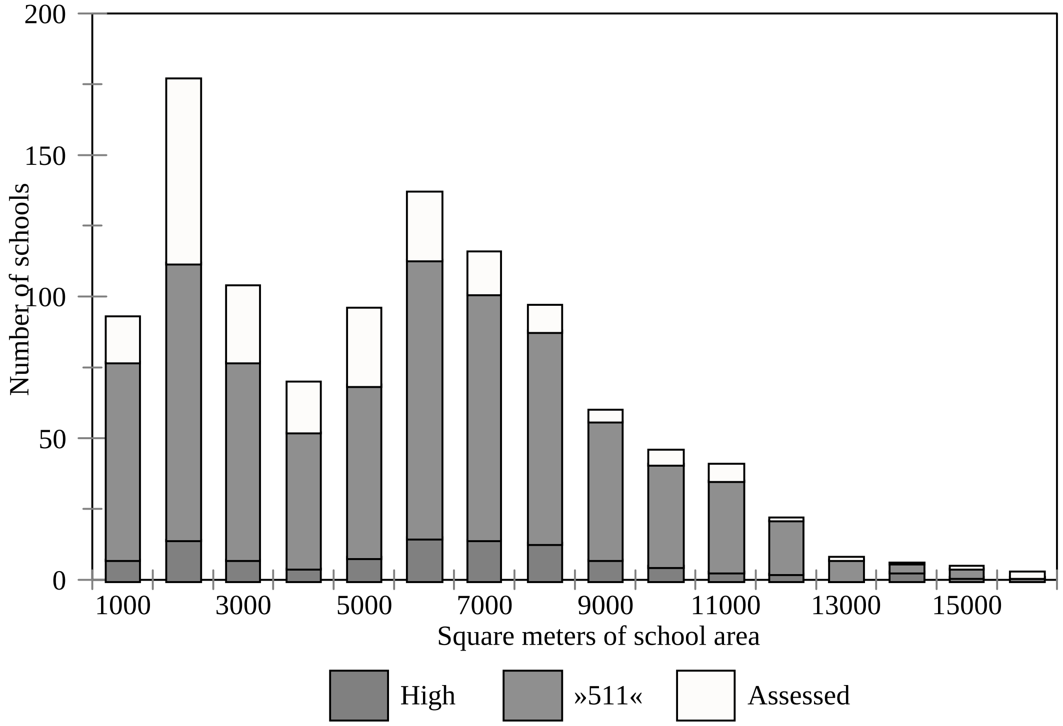
	q^1 High	q^2 »511«	q^3 »Assessed«	Sum
z^1: Decentral municipal	56	479	184	719
z^2: Central municipal	26	170	10	206
z^3: Private	22	107	27	156
Sum	104	756	221	1081

Note: The 9 entries of the table are termed »boxes« in the text. Four of those are shaded to indicate that the numbers of observations are small. The 206 schools under central municipal organizations are cleaned by 30 such units.

II.3 Size of schools

The schools differ more than fifteen times in size. Figure 1 shows the size distribution. If the schools are weighted by size, the bars shift dramatically in height to the right. The bulk of the area is in the schools from 6000 to 8000 m^2. More school area is in schools above 11000 m^2 than in schools below 3000 m^2.

Figure 1. The number of schools of different sizes and cleaning standards



The measure of school size is the area, s_i, which is used in the »cleaning manual« and apparently in all cleaning contacts. We also considered the number of classes taught at the school as an alternative measure of size. We found much the same results, but area is the better variable throughout.

One clearly relevant cost factor is the layout of the school, as is partly caused by the age of the school. Most of the schools have been renovated, reconstructed and expanded - often several times - so no meaningful statistic could be found. The school layout is thus an omitted variable: We assume that it is independent of the choice of organization.

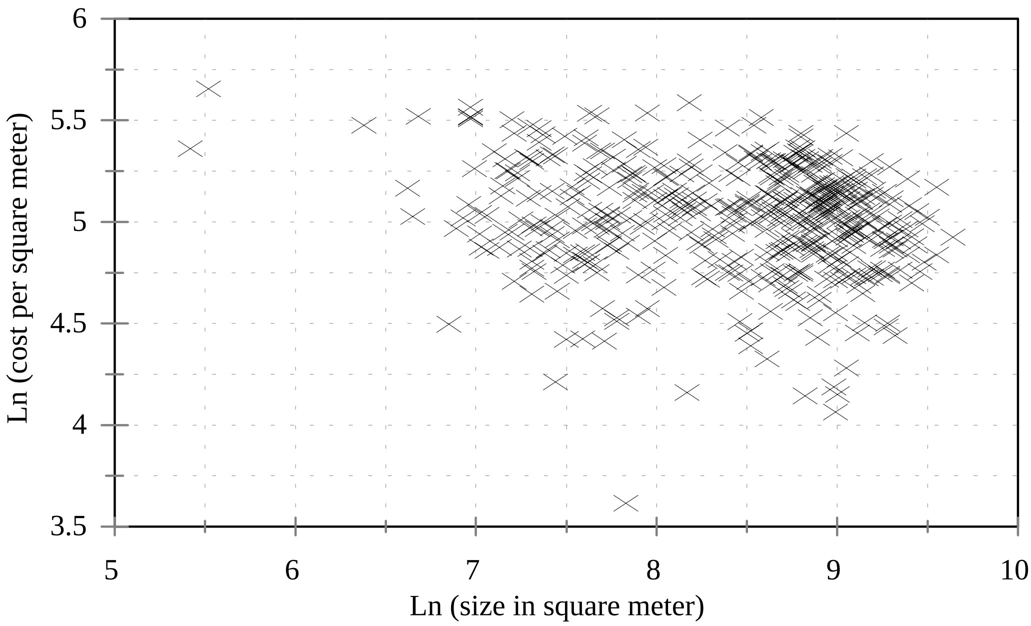
III Base-model of school cleaning

To obtain a useful tool for policy analysis we want a parametric cost function as our Base-model. Subsection III.2 presents the Base-model. Alternatively, Subsection III.3 uses nonparametric regression techniques to estimate separate cost functions for each of the »boxes« with many observations. Subsection III.4 compares the alternative cost functions, and shows that the Base-model captures the essential properties of the data.

III.1 Cost and size

A visual inspection of the data in each of the nine boxes strongly suggests a logarithmic transformation. It makes the data cluster around a straight line and eliminates strong heteroskedasticity. Also, most economic reasoning and empirical research suggest that production and cost functions are linear after a logarithmic transformation.

Figure 2. Costs (ln) and size (ln) for »511«-cleaning by decentral municipal cleaning



Figures 2, 3, and 4 show the data for quality 511 for decentral, central and private organization, respectively. The horizontal axis is the (natural) logarithm to the size of the school, while the vertical axis is the (natural) logarithm to the annual cost of cleaning per square meter. In figure 4 with private companies, the cost shows a downward trend as a function of size. Also, when the three figures are compared, it appears that the private companies have lower costs - at least for larger schools.

Figure 3. Costs (ln) and size (ln) for »511«-cleaning by central municipal cleaning

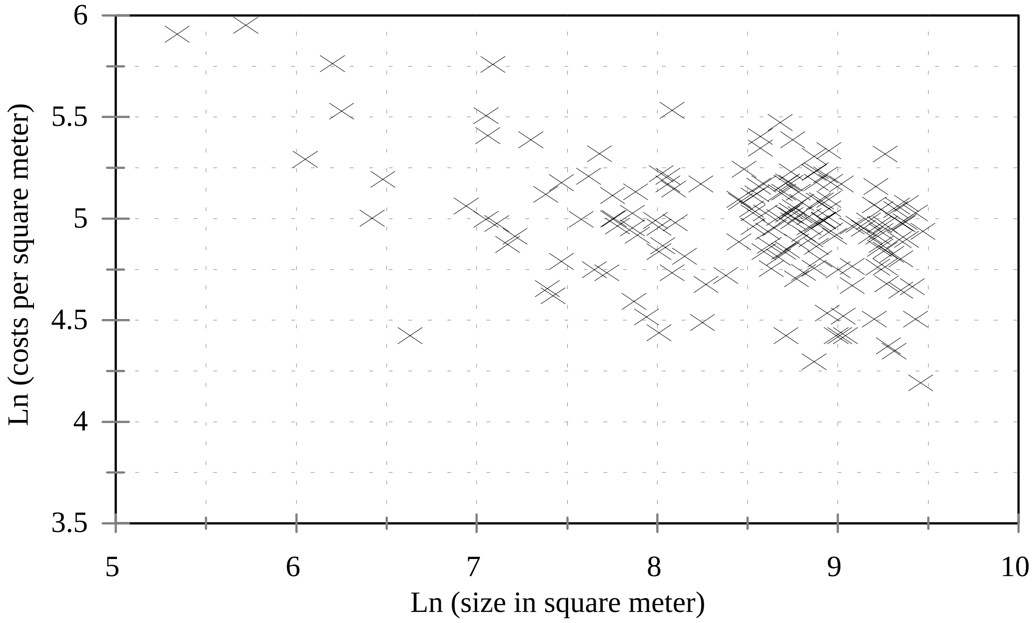


Figure 4. Costs (ln) and size (ln) for »511«-cleaning by private company

III.2 The Base-model

After a careful study of the data of all 9 »boxes« we reached the following formulation:

$$\text{Base-model:} \quad \ln(c_i/s_i) = \boldsymbol{\alpha}'\mathbf{z_i} + \boldsymbol{\beta}'\mathbf{z_i}\ln(s_i) + \boldsymbol{\gamma}'\mathbf{q_i} + \varepsilon_i \qquad (1)$$

Tables 4a and 4b report OLS-estimates of the Base-model, for all schools and for schools above 1000 m^2, respectively.

Table 4a. The estimate of the Base-model for all 1081 schools

Df = 1073		Estimate	JHC standard errors	p-values: coeff = 0
z^1, decentral	α_1	5.4380	0.1301	
z^2, central	α_2	6.1572	0.2676	
z^3, private	α_3	6.9560	0.2483	
$\ln(s_i)z^1$, slope decentral	β_1	-0.0506	0.0152	0.09%
$\ln(s_i)z^2$, slope central	β_2	-0.1402	0.0309	0.00%
$\ln(s_i)z^3$, slope private	β_3	-0.2629	0.0288	0.00%
q^1, high	γ_1	0.1111	0.0278	0.01%
q^2, »511«: set = 0	γ_2	zero	-	-
q^3, assessed	γ_3	-0.0827	0.0241	0.06%
Tests:			p-values	
Normality	$\chi^2 = 62.7$		0.00%	
Heteroskedasticity 1, x^2	$F(10, 1062) = 3.222$		0.04%	
Heteroskedasticity 2, x^2, xz	$F(21, 1051) = 2.025$		0.4%	
Reset, pr^2	$F(1,1072) = 0.498$		48.0%	
Reset, pr^2, pr^3	$F(2,1071) = 3.490$		3.1%	
Reset, pr^2, pr^3, pr^4	$F(3,1070) = 3.578$		1.4%	

Note: Equivalent representations of the model leads to (very) different R^2. For the representation in the table, $R^2 = 0.21$. If the regression is in levels, $R^2 = 0.85$.

Table 4b. The estimate of the Base-model for the1064 schools with more than 1000 m^2

Df = 1056		Estimate	JHC standard errors	p-values: coeff = 0
z^1, decentral	α_1	5.3979	0.1301	
z^2, central	α_2	5.8735	0.2736	
z^3, private	α_3	6.9159	0.3416	
$\ln(s_i)z^1$, slope decentral	β_1	-0.0459	0.0158	0.36%
$\ln(s_i)z^2$, slope central	β_2	-0.1077	0.0315	0.06%
$\ln(s_i)z^3$, slope private	β_3	-0.2584	0.0394	0.00%
q^1, high	γ_1	0.1199	0.0278	0.00%
q^2, »511«: set = 0	γ_2	zero	-	
q^3, assessed	γ_3	-0.0820	0.0242	0.07%
Tests:			p-values	
Normality	$\chi^2 = 65.2$		< 0.00%	
Heteroskedasticity 1, x^2	$F(11, 1036) = 2.476$		0.5%	
Heteroskedasticity 2, x^2, xz	$F(23, 1024) = 1.802$		1.2%	
Reset, pr^2	$F(1,1047) = 0.055$		81.4%	
Reset, pr^2, pr^3	$F(2,1046) = 5.338$		0.5%	
Reset, pr^2, pr^3, pr^4	$F(3,1045) = 3.824$		1.0%	

The log-log form of the model implies that 1+β is the elasticity of scale (m^2 of school area). School cleaning produced by form of organization z^j has economy to scale if $\beta_j < 0$, constant return to scale if $\beta_j = 0$, and diseconomy to scale if $\beta_j > 0$. The estimates of the β's are different and negative in the three cases. School cleaning has significant economy of scale, but the scale effect depends significantly upon the organization of production: For decentral the effect of scale is small. For central it is intermediary, and for private it is large. This new result will be discussed in detail in Sections V and VI.

The γ's are quality factors. To estimate the model, γ_2 is normalized to 0. The two other qualities are defined relatively to quality »511«. That is, when $\gamma_1 = 0.1111$ it means that it costs 11% more to use the high quality than quality »511«. We tried to include the interaction-term $\boldsymbol{\eta}'\mathbf{q}_i \ln(s_i)$, but it was not statistically significant. The estimates of the two γ's show that it is 8% cheaper to use the assessed standard, than »511«, and 11-12% more expensive to use the high standard. The model structure implies that these relations are the same for all three forms of organization.

The diagnostic tests point to three problems:

(a) Heteroskedasticity. To avoid inconsistent estimates of the standard errors, they have been estimated by the JHC-procedure (Jackknife Heteroskedasticity Consistent standard errors).
(b) Non-normality of residuals. By using the JHC-procedure in (a), the tests have the standard asymptotic distribution.
(c) The Reset-test show small problems with the functional form. With 1081 observations the Reset-test detects even small deviations from linearity. The next subsections deal with this problem.

III.3 Non-parametric regression analysis

The Base-model provides a regression function for each »box«. To see if these functions impose an unreasonable structure on the data, we alternatively have estimated the regression functions using kernel nonparametric mean regression, see Härdle (1990) or Yatchew (1998). This procedure can under mild conditions estimate any nonlinear continuous regression function.

The value of the regression function, for instance, at ln(s), is estimated by calculating a weighted average of the observed cost, $\ln(c_i/s_i)$, for schools with ln-size close to ln(s). The estimator, G(s), of the regression function is

$$G(s) = \sum_{i=1}^{n} w_i(s)\ \ln(c_i),$$

where $w_i(s)$ is the weight for school i. The weight for school i depends on the size s of the school for which the regression function is evaluated. The weights are determined by a kernel function,

$$w_i(s) = \frac{K\left(\dfrac{\ln(s)-\ln(s_i)}{h}\right)}{\sum_{i=1}^{n} K\left(\dfrac{\ln(s)-\ln(s_i)}{h}\right)},$$

where K(.) is the kernel and h is the bandwidth. We used the standard normal density as kernel since it has unbounded support and the data is sparse, in particular, for small schools.

The choice of kernel is less important than the choice of bandwidth. In short, a large bandwidth gives a smooth estimate of the regression function but also a high bias whereas a small bandwidth gives a wiggly estimate with a high variance. The tradeoff between bias and variance is solved by minimizing the integrated mean square error. In practice, this can be done by minimizing a cross-validation function, which mimics the behavior of the mean squared error. Hence, we used this (mechanically) way to select the bandwidth. Finally, around the largest and smallest schools, boundary problems arise. We solved this by eliminating all schools within a bandwidth of the boundary when selecting the bandwidth using cross-validation.

We also provide confidence intervals for the regression functions using the bootstrap. The usual asymptotic based symmetric 90%-confidence interval at s is constructed as $(G(s)-a_{0.95}\sqrt{v(s)}\ ,\ G(s)+a_{0.95}\sqrt{v(s)})$, where v(s) is the variance[6)] of G(s) given by

$$v(s) = \sum_{i=1}^{n} \left[\frac{K\left(\dfrac{\ln(s)-\ln(s_i)}{h}\right)}{\sum_{i=1}^{n} K\left(\dfrac{\ln(s)-\ln(s_i)}{h}\right)} \right]^2 (\ln(c_i)-G(s))^2,$$

and $a_{0.95}$ is the 0.95-quantile of the standard normal distribution. The bootstrap confidence interval is constructed by replacing the 0.95-quantile of the standard normal distribution by the 0.95-quantile of the bootstrap distribution found in the following way.

1. Make a random sample of pairs (c_i,s_i) from the (original) sample. Denote this a bootstrap sample $((c_1^*,s_1^*), (c_2^*,s_2^*),..., (c_n^*,s_n^*))$.
2. Using the bootstrap sample from 1, calculate the regression function $G^*(s)$ and the variance $v^*(s)$. Then calculate the absolute t-ratio $|t^*| = \left|\dfrac{G^*(s)-G(s)}{\sqrt{v^*(s)}}\right|$.
3. Repeat step 1 and 2 2000 times. The 1900[th] largest value of the 2000 $|t^*|$ values is the 0.95-quantile $a_{0.95}$ of the bootstrap distribution.

The bootstrap confidence interval is constructed using the t-ratio in step 2, because this method obtains an asymptotic refinement compared with the usual (first-order) asymptotic approximation, see Horowitz (1999) for details.

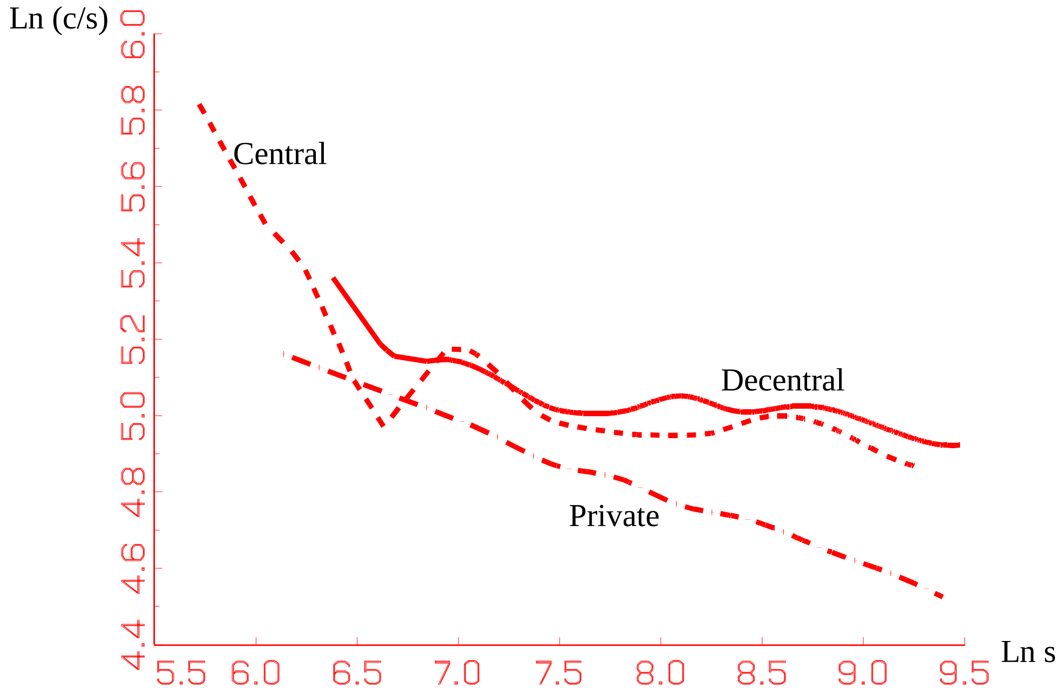
Table 2 shows that the 4 shaded »boxes« hold 26, 10, 22 and 27 schools, respectively. In these cases the confidence intervals around the kernel regression are very wide. But for the 5 »boxes« with the largest number of observations the process works well: cross-validation selects well-defined bandwidths, and the confidence intervals are rather narrow.

Figure 5 shows how the three kernel regressions look for quality »511«. Note that the regression curves have different lengths. The start and end of the curves are determined by the observations. The

6. Assuming the regression function is undersmoothed

curve for private cleaning is (almost always) below the other curves, and it looks very linear. The top curve is the one for decentral municipal cleaning - it has a small slope and it also looks reasonably linear, except perhaps for the smallest schools. The curve for central municipal cleaning starts high for the smallest schools, and it is less well behaved than the other two. The kink around 6.7 is caused by *one* isolated, extreme observation as seen on Figure 3.

Figure 5. The three kernel regressions for quality »511«



The cut off point for nonlinearity is around 1000 m^2, so that the problem affects *mini-schools only*. There are 25 such schools, and they hold 0.5% of the total school area.[7)]

III.4 Comparing kernel regressions and the Base-model

Figures 6 to 10 show the 5 kernel regressions for the »boxes« with more than 50 observations, their 90% confidence intervals, and the Base-model curve for the same »box«. The graphs are shown only for schools above 1000 m^2, because the confidence intervals are very wide for smaller schools.

The kernel regressions are nonlinear and some of them »fluctuate«. They could have been smoothed by manually selecting the bandwidth. We preferred to let the data decide. Most of the fluctuations can - and should - be given no economic explanations. The aim is that the Base-model accounts for the economically meaningful properties of the data.

The regression lines for the Base-model lie within the 90%-confidence intervals nearly everywhere. In case of the centrally organized cleaning with quality »511«, the Base-model seems slightly to overestimate the scale effects for medium to large schools. For the other four cases, the Base-model

7. The Danish school system there has a special concept of »lilleskoler« (mini-schools) pointing to the special character of very small schools. Also the »cleaning manual« points to the mini-schools as special cases.

provides a reasonable good projection of the non-linear kernel regressions onto a linear curve. The conclusion is confirmed in section V when comparing policy consequences of the Base-model and the kernel regressions. We conclude that the Base-model gives a sensible representation of the data.

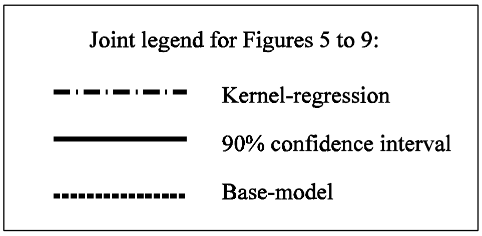


Figure 6. The kernel regression and Base-model for decentral and high quality

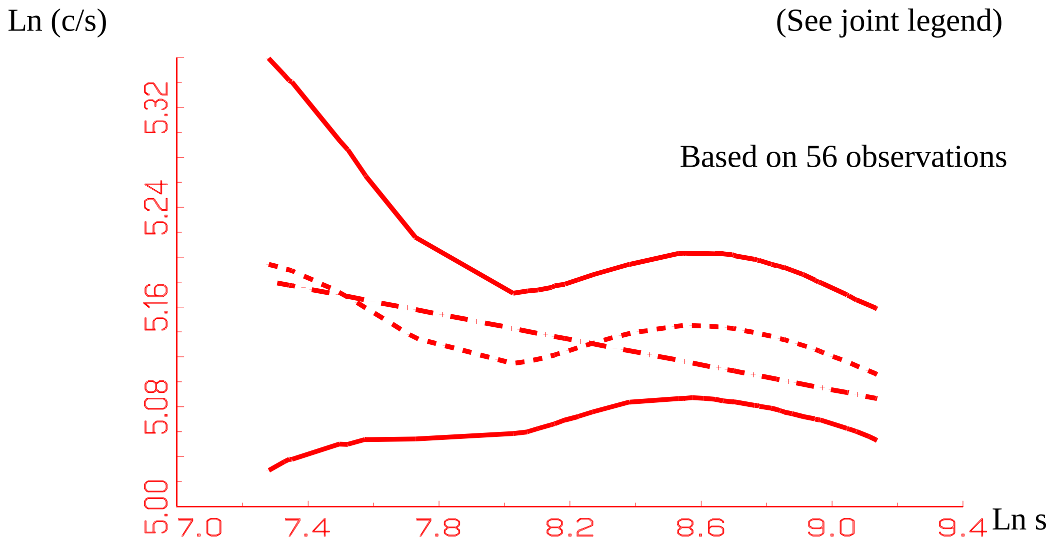


Figure 7. The kernel regression and Base-model for decentral and quality »511«

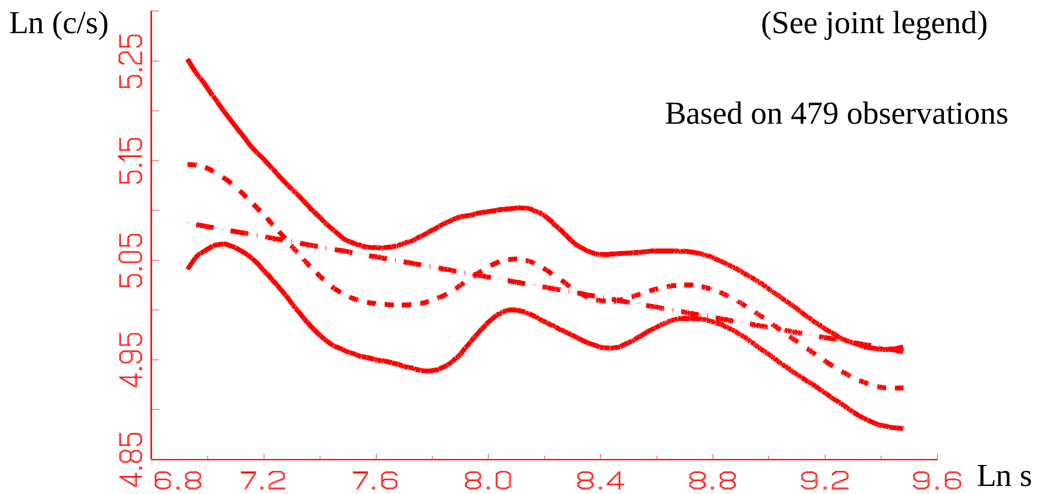


Figure 8. The kernel regression and Base-model for decentral and assessed quality

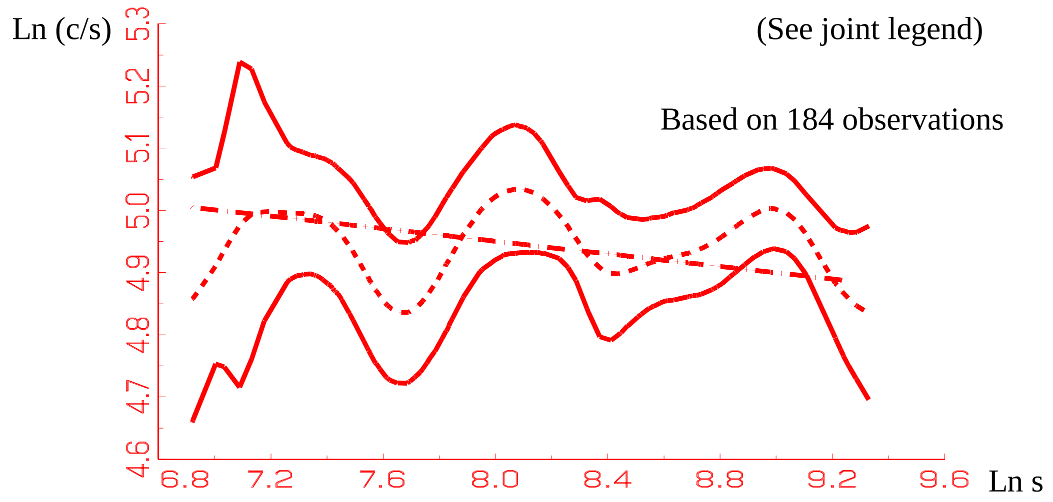


Figure 9. The kernel regression and Base-model for central and quality »511«

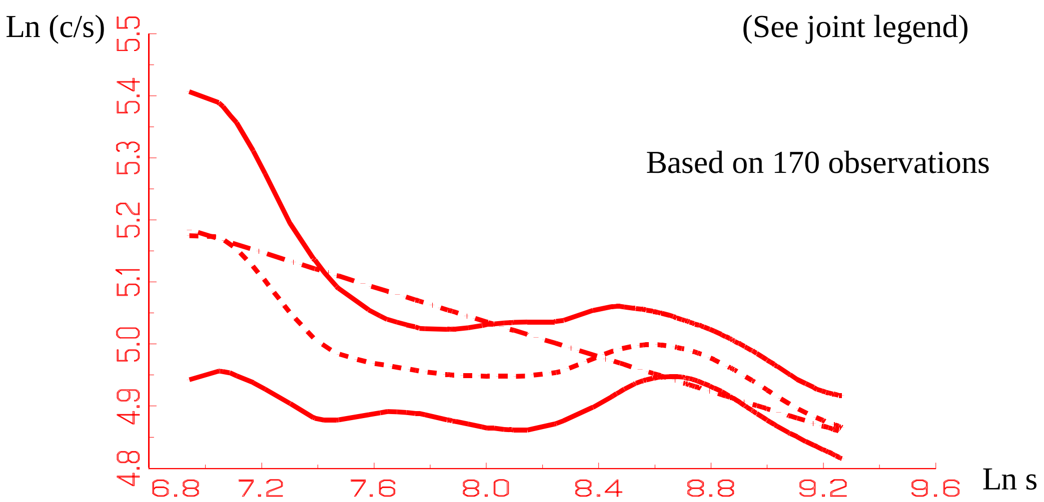
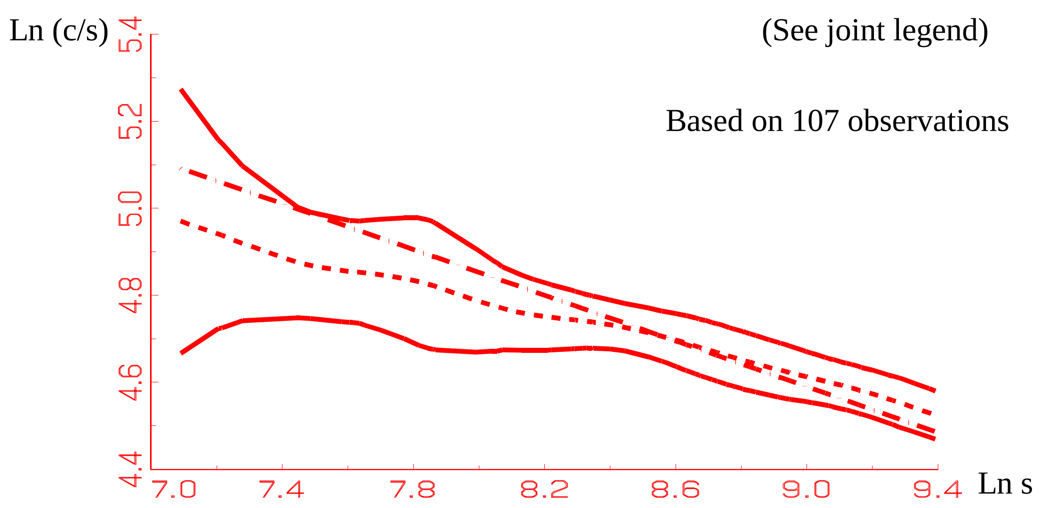


Figure 10. The kernel regression and Base-model for private and quality »511«



IV Extending the Base-model by municipal characteristics

We now turn to the differences between municipalities, and investigate if municipal characteristics can explain part of the residuals from the Base-model. Equation (2) augments the Base-model with a new term $\varphi^j m^j_i$ to estimate the effects of the municipal characteristics m^j.

Extended model: $$\ln (c_i/s_i) = \boldsymbol{\alpha' z_i} + \boldsymbol{\beta' z_i}\ln(s_i)\mathbf{z_i} + \boldsymbol{\gamma' q_i} + \varphi^j m^j_i + \varepsilon_i \qquad (2)$$

The model can be extended with one or more m^j-terms. Subsection IV.1 analyzes if the sample is representative with respect to municipalities, while Subsection IV.2 looks at the effects of various extensions.

IV.1 Sample skewness and skewness relevance

Our data are missing the schools for 31% of the municipalities, who decided not to return the questionnaires. The municipality decide the form of organization, construction of schools (and hence school size), and cleaning quality. If these decisions are related, the sample may be skewed.

Much official data are available on municipalities. This permits us to assess the representativity of the sample with regard to many municipal characteristics. The Appendix contains a list of the 24 municipal characteristics (m^j, for j = 1, ..., 24) we thought of as potentially most relevant.[8)] They ere divided in five groups (G1) to (G5), each trying to catch an underlying, latent trait:

(G1) One variable measures the market orientation of the municipality.
(G2) Eight variables try to catch the structure of production and employment as well as urbanization and distance to major towns.
(G3) Three variables give the size of the social sector and public employment in the municipality. They measure the fraction of the population that depends upon the public sector. It is termed the »welfare coalition« variables in Christoffersen & Paldam (1998).
(G4) Seven variables measure the political orientation and political stability of the municipality.
(G5) Five variables cover the municipal financial situation. The variables within each group are related, to find the best representation of the latent structure.[9)]

Our estimators can be inconsistent if the sample is *skewed* in a certain direction and that direction is *relevant*.[10)] The two problems are defined for a variable m^j:

Sample skewness: large values of m^j appear too often or too rarely in the sample. The technique is explained in the Appendix.

Skewness relevance: m^j is a significant variable explaining cleaning costs. This is done by estimating if φ^j in Model (2) is significant.

8. These data are documented in Christoffersen & Paldam (1998).
9. Especially the political variables of (G4) are closely related, as we tried (in vain) to find a political factor in this public-versus-private issue, that appears heavily politicized in the media.
10. In principle the two problems might interact, so that because of the skewness one cannot analyze the relevance. The interaction problem would occur if x clustered in groups and some of these groups failed to appear in the sample, and at the same time precisely these groups were the »relevant« ones.

The Appendix gives the results for the two potential problems calculated for the 24 municipal characteristics. Table 5 summarizes the findings. Each row gives a summary of the results for the variables of one of the groups. For (G2) the sample has a significant skewness for 5 of the 8 variables, and 6 of the variables are significant when included in the Base-model, so they are relevant. It is further indicated that 5 of the variables have both problems at the same time. We therefore have five potential problems. They are caused by an underrepresentation of small, rural municipalities.

Table 5. A summary of the Appendix: Sample skewnesses and skewness relevance

Group	Type of variable	Numbers from appendix				Direction of skewness	Solution
		Total	Skn	Rel	Both		
G1	Market orientation of municipality	1	0	1	0	None	Not needed
G2	Structure of production, urbanization and distance to major town	8	5	6	5	Too few small rural	Estimation of effect [a)]
G3	The size of the social sector and public employment in municipality	3	2	3	2	Too large public sector	Estimation of effect [a)]
G4	Political orientation and political stability of municipality	7	2	5	2	Too left - probably due to (2) - too few rural	Estimation of effect [a)]
G5	Municipal financial situation	5	1	2	0	None	Not needed

Note: The groups (G1) to (G5) refer to text. »Skn« is skewness of municipalities, »rel« is relevance of skewness.
a. The estimation is done by augmenting the Base-model with the most significant of the variables in these groups.

Altogether (5+2+2 =) 9 of the 24 variables point to potential problems. A closer inspection show that most are part of the same skewness: An overrepresentation of the larger, industrial and urban municipalities. They are also the municipalities where the Social Democratic party tends to rule.

We have looked at each of the variables with both problems and found no case where we are unable to calculate the effect of the sample skewness. Consider, for example, the sample skewness against small rural municipalities. Its effect can be calculated since we have enough small rural municipalities.

IV.2 Effect of municipal characteristics

The 24 regressions calculated for the »relevance«-column in the Appendix are very similar and therefore not reported. The Base-model part of the regression changes little. The effects found to each of the municipal characteristics are not independent, due to the correlations between the variables. Therefore, the following process was used to find the »best« set of characteristics:

The variables in groups (G2), (G3) and (G4) have the largest effects. We included the variable with the largest effect for each group. However, for group (G2) we found two variables with independent effects. For groups (G1) and (G5) no independent effects appeared.

Table 6 shows the results when these four extension-variables are added to the Bases-model. The first point to note is the stability of the estimate of the Base-model. The calculations reported in Table 12 of Section V show that the extension-variables have a substantial effect on the cleaning costs.

Table 6. The estimate of the Base-model with municipal characteristics included

All 1081 schools	Base-model		Extended Base-model	
	Estimate	JHCSE	Estimate	JHCSE
Average net income			0.0027	0.0007
Log population			0.0220	0.0090
Political orient. of mayor			-0.0057	0.0187
Welfare coalition			0.0074	0.0011
z^1, decentral	5.438	0.130	4.762	0.154
z^2, central	6.157	0.260	5.213	0.284
z^3, private	6.956	0.248	6.226	0.256
$\ln(s_i)z^1$, slope decentral	-0.051	0.015	-0.086	0.016
$\ln(s_i)z^2$, slope central	-0.140	0.031	-0.145	0.031
$\ln(s_i)z^3$, slope private	-0.263	0.029	-0.290	0.031
q^1, high	0.111	0.028	0.107	0.028
q^2, »511«: set = 0	zero	-	zero	-
q^3, assessed	-0.083	0.024	-0.045	0.025

Note: The test-statistics given in Table 4 remains virtually unchanged for the regressions reported.

In the end only three municipal characteristics mattered statistically: wealth and size of the population (from G2) and the share of the »welfare coalition« (from G3). These three variables squeezed out the political variables. Large municipalities with many voters, who depend upon the public sector, are Social Democratic as well, but the political orientation has no independent effect.

Richer and larger municipalities have higher cleaning costs. The effects of size and wealth can be separately estimated, as shown in the table. A main reason for the cost effect is that wages are higher in the larger and richer municipalities, notably in the Copenhagen Metropolitan Area.

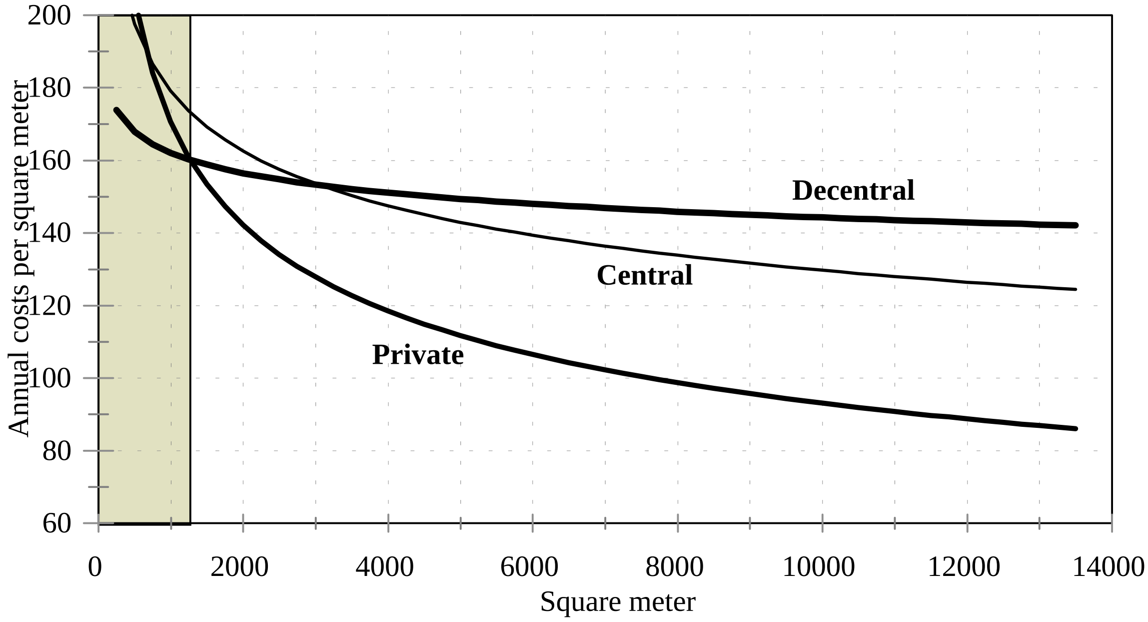
The »welfare coalition« variable measures the fraction of the population (of voting age) that depends upon the public sector - either for a job or as recipients of an income-replacing social payment (including the old age pension).[11)] The idea is, that the larger this fraction, the harder it is for elected politicians to pursue cost-saving policies in the public sector. This turns out to be a significant effect.

V Policy analysis

In this section, we use the Base-model to compare different scenarios. In particular, we predict the potential gain of using the cheapest form of organization. Subsection V.1 gives direct cost comparisons, and demonstrates that the deviations from the Base-model are small. Subsection V.2 looks at the pattern of cost changes when the cleaning quality and the form of organizational are changed. Finally, Subsection V.3 looks at the effects of the municipal characteristics.

11. This variable has considerable variation, with a range from 40% to 90%. It is discussed in Christoffersen & Paldam (1998). This variable has a low correlation to the other variables included.

Figure 11. Cost average functions for the three types of organization, for quality »511«



Note: The shaded area is the one of the mini-schools where the variance is very large. The vertical axis gives the costs in 1998 Danish Crowns (Dkr). The exchange rate is fixed to the DM at ap. 3.9 Dkr/DM. To the US $ the rate fluctuates around 7 Dkr/$.

V.1 The costs of cleaning typical schools

The regression lines are transformed to area (m^2) and cost in Danish Crowns in Figure 11. Parts of the same information are also given in Table 7, for selected school sizes. The range covered by the table is ap. 90% of the schools.

Table 7. The costs in Dkr per year according to the Base-model

	q^1: High quality			q^2: Quality »511«			q^3: »assessed« quality		
School size, m^2	2000	6000	10000	2000	6000	10000	2000	6000	10000
z^1: Mnp decen	174.95	165.49	161.27	156.55	148.09	144.31	144.23	136.43	132.94
z^2: Mnp centr	181.75	155.81	145.04	162.64	139.43	129.79	149.84	128.45	119.57
z^3: Private	158.99	119.1	104.14	142.27	106.58	93.19	131.07	98.19	85.85

Note: The exchange rate of the Danish Crown has oscillated around 7 to the US $ for the last decade.

Table 8 shows the deviations - measured in % - if the kernel regressions are used instead of the Base-model. We have shaded the »boxes«, where the kernel regressions are based on so few observations that the uncertainty is large.

Table 8. Deviations between kernels and Base-model measured in %

	q^1: High quality			q^2: Quality »511«			q^3: »assessed« quality		
School size, m^2	2000	6000	10000	2000	6000	10000	2000	6000	10000
z^1: Mnp decen	0.9%	-3.3%	-1.4%	4.6%	-2.8%	2.5%	11.0%	-1.7%	0.6%
z^2: Mnp centr	-12.6%	-12.6%	1.1%	-11.5%	-5.7%	-0.9%	19.4%	2.2%	-3.2%
z^3: Private	11.5%	5.3%	-2.6%	9.7%	-0.6%	-3.7%	-9.5%	-19.0%	-15.4%

Note: The numbers given as a deviation from the Base-model in percent of the Base-model estimates.

The table shows that the non-parametric estimates mainly differ from the parametric ones for the smallest schools, and when the numbers of observations are very small, ie, for the shaded »boxes«. They are precisely the ones, where using the Base-model is preferable if we can trust the structure imposed by the model. The conclusion is that the Base-model is a good approximation, both in terms of costs and interpretation. With this we leave the non-parametric results.

V.2 The pattern of cost savings from changing form of organization and quality

The cost changes from changing cleaning quality are given in Table 9. The effect of changing between high quality and »511« is well determined, while the Base-model may marginally exaggerate the difference between »511« and the assessed quality.

Table 9. The effect of quality changes - calculated from Base-model

		To		
		High	»511«	Assessed
From	High		-10.0%	-17.4%
	»511«	11.1%		-8.3%
	Assessed	21.1%	9.0%	

Table 10. The average cost savings in % by changing type of organization for the same standard

From / To:	central municipal 2000	central municipal 6000	central municipal 10000	decentral municipal 2000	decentral municipal 6000	decentral municipal 10000
decentral	3.7%	-6.2%	-11.2%	-	-	-
central	-	-	-	-3.9%	5.8%	10.1%
Private	12.5%	23.6%	28.2%	9.1%	28.0%	35.4%

The second policy decision is the choice of organizational form. Here the picture is more complex as it interacts with the scale effect, as shown in Table 10. It shows that municipalities on average save about 6½% by centralizing the cleaning function. They lose about 4% on the small schools, but they gain about 10% on the big. The break-even point is around 3000 m^2. A much larger gain results from using the market. The break-even point is around 1000 m^2. For small schools (with 2000 m^2) the savings is 9%, and then it rises to 35% for the largest schools. As seen on Figure 11 it even rises to 40% on average for the very largest schools.

The average municipality has a size distribution of its schools as shown on Figure 1 - that is, schools have a frequency distribution as the top curve on the figure. From these data we have calculated a standardized size distribution and we have then calculated a relative school cleaning budget assuming the same quality throughout.

$RB = \sum(c_k s_k f_k)$, where k is an index over all school sizes and f is their frequency

By calculating such »average normalized budgets» we get a pattern of cost changes for the average municipality when changing type of organization as given in Table 11.

Table 11. Cost differences in average municipality of different forms of organization

		Change for all schools		
	To	decentral	central	private
From	decentral		-6.4%	-28.9%
	central	6.9%		-24.0%
	private	40.6%	31.5%	

It is obvious from Table 10 that the small schools have a small weight in the average municipal school cleaning budget. Even if there is no savings here, it matters little for the total budget. Also, the effect of changing from a decentral to a central organization is small. What matters is whether the market is used or not used.

We also know (see Table 2) that approximately 66.5% of municipalities use decentral and 19.1% use central municipal cleaning. If they all privatized their cleaning, while keeping quality constant, the savings would be 29.9*x*0.665 + 24.0*x*0.191 = 25% of the present cleaning costs. This corresponds to about 300 million Dkr.

V.3 Cost differences across municipalities

Finally, Table 12 shows the effect of the municipal characteristics. Table 6 showed that three characteristics give significant results:

The rich municipalities North of Copenhagen have average incomes more than 50000 Dkr higher than the rest of the country. However, apart from this extreme case, 50000 is a large difference. It gives 13.5% difference in cleaning costs.

The difference between the typical town-municipality and the typical rural municipalities in population is less than 10 times. Copenhagen has 100 times more inhabitants than the smallest rural municipality and this should give a difference of no less than 10% in cleaning costs (cp). When the effect of the difference in income is added, a result rises to approximately 20% results. This is in accordance with casual impressions.

Table 12. The effects of the three most important municipal characteristics

Variable	Unit	Change	Effect
Income per capita	1000 Dkr	50000 Dkr higher	13.5%
Population size	Ln pop	10 times larger	5.0%
Welfare coalition	% of population	25% (of pop) higher	14.6%

Finally, it is interesting to see that municipalities dominated by voters, who depend upon the public sector, have substantially higher cleaning costs. These voters form an implicit »welfare coalition«, which may defend the status quo. In addition Christoffersen & Paldam (1998) show that the market orientation - that is the use of private companies and competitive bidding - is smaller in municipalities with a large welfare coalition.

VI Conclusions on scale effects and the organization of public production

Our data have considerable variance, but the average results show a clear pattern at a high level of significance: No clear cost gap appears for small schools. However, the production of cleaning has strong economy of scale. The use of the market allows the municipalities to reap the full gain from economy of scale, while the two municipal ways of organizing the production find only a modest fraction of the gain. Though everybody in the cleaning profession knows the techniques, a cost gap of almost 30% emerges due to non-exploitation of the economy of scale by the public sector.

These findings raise the questions: Why does the public sector on average fail to find the economy of scale effects found by the market?

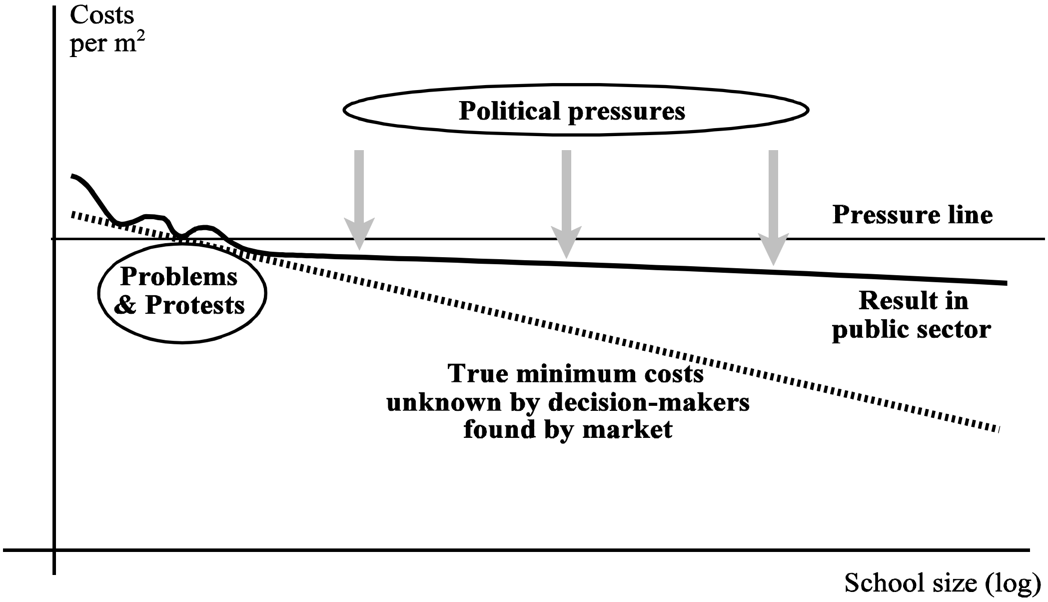
The cost gap could be explained by the model on Figure 12. It depicts a political system managed by general cost norms and standards. The cleaning norms are given in the »cleaning manual« as linear: A cleaner should cover a norm of a certain number of square meters per hour. A special section deals with mini-schools, but apart from that everything is linear.

Municipalities know that productivity advances occur in many fields: Therefore they frequently apply pressure to reduce costs. This is shown as the *pressure line* on the figure. The typical process of savings is to cut everybody by the *same* percentage. This is generally taken as fair. The equality of treatment also follows from the use of norms and standards. The pressures are typically applied till somebody »screams«.The authority then investigates if the »screamer« is seriously hurt.

The municipal authorities do not know the true cost curve, but as they apply pressures, the small schools get problems and protest. This stops the pressures. Unfortunately, there are few small schools, so the saving pressures stop before they really start to bite into the costs. In contrast, when the market is used, costs are determined by competitive bidding. This process is likely to reveal the true costs.[12)]

12. See the classical survey on competitive bidding by McAfee & McMillan (1987).

Figure 12. A model the public savings process



The introduction mentioned that the literature ascribes the cost gap to either monopoly versus competition or public versus private ownership. Our model does not rely on the monopoly power of public producers. It relies on typical public sector decision processes. It is consequently an ownership type model.

School cleaning is an unusually simple and well-known production. Nevertheless, we replicate the standard cost gap of almost 30% from many other studies from a wide range of countries.[13)] This inevitably raises the suspicion that the reason for the cost gap goes deeper than management rules and procedures. Apparently public decision-makers have designed decision-processes that make it difficult to find economy of scale. Is it not possible to redesign the public decision-process so that it can find the economy of scale, when private managers can? If it is, why has it not happened?

13. It should be mentioned that even when the cost gap has an average size of almost 30% in the approximate 300 studies made, it has considerable variation.

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Appendix: Tests for sample skewness and skewness relevance using 24 municipal characteristics

Our sample of 189 municipalities is »drawn« from the whole population of 275 municipalities. As explained in the main text we make two sets of calculations to study the representativity of the sample:

A.1. Test for sample skewness using the mean.

These variables can be used to investigate if the sample represents the population.

Let X_i be a background variable, i = 1,..,275. The population mean is $\mu = \frac{1}{275}\sum_{i=1}^{275} x_i$.

The sample is a draw of 189 of the X_i values without replacement. Denote the sample (X_1^*, X_2^*,..,X_{189}^*). The sample average is $\bar{X} = \frac{1}{189}\sum_{i=1}^{189} X_i^*$. The exact distribution of $\bar{X}$ can be found as the solution to a combinatorial problem.

Each (possible) sample gives a value of $\bar{X}$. The number of different samples is $\binom{275}{189} = \frac{275!}{189!(275-189)!}$.

The probability of a sample is not 1 over the number of different samples because each municipality does not have an equal probability of being drawn. Municipalities with many schools have a higher probability of being in a sample. If it is assumed that each school has the same probability, p_s, of not responding, and the schools respond independent of each other, then the probability of a municipality being in the sample is $(1 - p_s^{n_i})$, where n_i is the number of schools in municipality i. These probabilities are used as weights for the municipalities.

The average calculated from the actual sample can be compared with the distribution of the average, and a p-value can be found. The p-value gives the probability of obtaining an average further away from the population mean.

In practice, evaluating all the possible samples to get the distribution of the average, even for moderate sample sizes, is not plausible. Instead, the distribution can be found with arbitrary accuracy using Monte Carlo simulations. The following describes the algorithm.

a) Draw a weighed sample of 189 x_i's without replacement. Calculate the average.
b) Repeat step a) MC=2000 times. Calculate the empirical distribution function F^* of the MC number of averages calculated.
c) Calculate the p-value by $P(|\bar{X}-\mu| > |\bar{x}-\mu|) = p^*$, where $\bar{x}$ is the actual value obtained from the sample. In other words, p^* is the number of averages obtained in step a) larger than $\bar{x}$ over MC.

A.2. Tests for skewness relevance

To see if the characteristics are relevant for the cleaning costs we have made a set of 24 regressions using the ekstended model (2). They contain the base-model plus one extra variable for a municipal characteristic. The column termed »relevance« in Table A1 give the p-value for the t-test (disregarding the heteroskedasticity) for each extra variable.

In addition the table show the direction of the skewness and finally the last column gives a summary of each row. A few examples will show how the table should be read. Row 1 deals with the variable measuring the degree of market orientation of the municipality. It shows that the sample has no skewness for this variable. So even if it is relevant for the costs, it gives no sample problem. Row 2 show that the municipalities with rich citizens are overrepresented in our sample, and that this matters for cleaning costs. Wealth is thus a »problematic« municipal characteristic. It is consequently dealt with in Section IV.

Table A1. Tests for sample skewness and skewness relevance for 25 municipal characteristics

No	Name	Content	Skewness (p-values in %)			Rele-vance	Both
			Plain	Size	Direction		
1	Mo	Market orientation of municipality [a)]	14.8	11		0.8	No
2	Mtb	Tax base. Average net income per capita.	0	0.3	rich +	0	Yes
3	Mpr	Share of agriculture and fishing in employment	0	0	share -	0	Yes
4	Mpub	Share of public sector in employment [b)]	5.5	9	(share +)	0	No
5	Mtra	Share of tradables sector in employment	0	0	share -	0	Yes
6	Mpop	Logarithm of 1996 population size	0.1	2.6	large +	0	Yes
7	Murb	Urban share of population	0	0.1	urban +	0	Yes
8	Dkm	Distance to closest of 4 largest towns	3	7.9	(close +)	68	No
9	Dnab	Market orientation of neighboring municipalities [a)]	10.1	15		15	No
10	Ilp	Number of election periods lord mayor has ruled	12.4	15		0	No
11	Ipp	Number of election periods same party has ruled	85.3	92		9.2	No
12	Pm	Political party of mayor at binary left/right scale	1.2	1.4	left +	0	Yes
13	Ppm	Political party of mayor on 6-point scale	1.2	1.5	left +	0	Yes
14	Pco	Left/right orientation of majority on binary scale	6.4	11	(left +)	0	No
15	Pmaj	Relative size of majority	6.4	7.8	(small +)	29	No
16	Prw	Proportion of seats held by right wing politicians	18.4	26		0	No
17	Wpub	Public sector employees in percent of voters [b)]	3.2	5.5	(large +)	0	Yes
18	Wtra	Share welfare recipients in percent of voters [c)]	7.9	9.1	(large +)	0	No
19	Wal	Sum of Wpub and Wtra	0.8	0.8	large +	0	Yes
20	Rt	Level of municipal tax rate 1995	24	29		0	No
21	Rct	Change in Rt, 1990-95	79.9	71		8.6	No
22	Rmo	Municipal monetary assets per capita	68.4	64		62	No
23	Rcmo	Change in Rmo, 1990-95	28	23		1.3	No
24	Rpop	Relative net change in population	1	1.9	large +	20	No

Notes: The skewness test are done in two versions »plain« is the unweighted test, while »size« is weighted with the numbers of schools in the municipality.

a. Measure for the number (of 12 possible) services the municipality has outsourced.

b. Same nominator, but different denominator.

c. A person is registered as »welfare recipient« if he/she receives an income compensating social payment at one time during the year