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Maria Kalvarskaia and Audun Langørgen

Capital costs in municipal school buildings

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Abstract

Maria Kalvarskaia and Audun Langørgen

Capital costs in municipal school buildings

Reports 2004/9 • Statistics Norway 2004

The purpose of this report is to estimate capital and depreciation for municipal school buildings, and to analyze variation in per capita depreciation for this type of capital asset. A measure of depreciation is already reported in local government accounts. We estimate alternative measures of capital and depreciation based on the perpetual inventory method, which combines different models of depreciation with investment data for the period 1972-2001. The results demonstrate that the figures in local government accounts are too low partly due to the fact that the estimation method does not adjust for inflation, and partly due to missing and incomplete data.

In the analysis of variation of per capita depreciation in school buildings, we find that per capita depreciation tend to increase with per capita municipal incomes and with the share of population in school age, and decrease with population size and density. The short-run effect of population growth is a decrease in per capita depreciation, while higher gross migration tends to increase per capita depreciation.

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Contents

1. Introduction and summary*

The purpose of this report is to measure capital and depreciation for municipal school buildings in Norway, and to analyze variation in depreciation per capita for municipal school buildings. Moreover, one important aim is to examine how capital costs for school buildings are affected by population growth. Municipalities with high population growth claim that high growth leads to high per capita capital costs, and that these costs should be compensated in the national grant system. For a further discussion of this subject it is relevant to study the relationship between population growth and per capita depreciation.

Depreciation is reported in the local government accounts (KOSTRA). The obligation to report statistics on depreciation was introduced in 2001, meaning that local government accounts did not include measures of depreciation before this year. However, local government investments by service sector and item are available from 1972 and onwards.

Langørgen and Rønningen (2002) point out some problems with the data quality in the reported statistics on depreciation in local government accounts. One such problem is that figures for capital acquisitions in different years are not adjusted for inflation, which means that the value of older capital assets and their depreciation is underestimated in current prices. Furthermore, reported depreciation is also defective due to missing or incomplete data in many municipalities.

In order to assess the data quality of the reported statistics on depreciation, we utilize the perpetual inventory method (PIM) to compute real capital and depreciation for municipal school buildings. The results from these calculations are compared to the reported statistics on depreciation for school buildings. The perpetual inventory method is based on models of capital formation and depreciation that employ different assumptions about the lifetime or rate of depreciation for capital objects. The method utilizes historical investment data for the period 1972-2001, where investments are properly adjusted by inflation to make monetary amounts in different periods comparable.

The results suggest that the reported figures in KOSTRA underestimate depreciation for school buildings in Norway. The underestimation is partly due to the fact that inflation is not accounted for in KOSTRA, and partly due to missing and incomplete data. Moreover, depreciation in KOSTRA (and in the National Accounts) does not include the impact of maintenance expenses on the current account that may prolong the expected lifetime of assets and counteract the effect of depreciation on capital values.

A second part of this report aims at explaining variation in school building depreciation per capita as a function of community characteristics. The analysis is based on a measure derived from the perpetual inventory method (PIM), and is compared to a similar analysis by Langørgen and Rønningen (2002) on KOSTRA data for depreciation. The results for the different measures of depreciation are similar, although the marginal effect of municipal incomes is larger for PIM than for KOSTRA data. Rich municipalities are found to accumulate more capital and consequently experience higher depreciation of school buildings than poor municipalities.

Small and sparsely populated municipalities may face obstacles to exploit economies of scale in public schooling, which means that capital costs and depreciation per capita is higher than in large and densely populated municipalities. Capital costs and depreciation per capita increase with the population share in the age group 6-15 years, which is the age for attending primary schools run by municipalities. The short-run impact of population growth is a decrease in depreciation per capita, which is interpreted as the result of inertia in the adjustment of real capital. In the intermediate and longer term the effects of population growth on per capita depreciation are ambiguous and/or insignificant. However, higher per capita gross migration (defined by the sum of in- and outmigration)

* We would like to thank Ådne Cappelen, Grete Lilleschulstad and Terje Skjerpen for useful comments.

has a positive effect on capital costs when depreciation is measured by PIM. This result implies that school building capital is relatively high in municipalities with high population turnover and mobility, which may result from fiscal competition and investments to attract families with children.

The report is organized as follows. Chapter 2 is theoretical and devoted to description and formulation of the models for capital imputation. Two models are introduced. These two models differ by the form of the depreciation function, which is either linear or geometric. The models represent the Perpetual Inventory Method (PIM) for capital imputation, and implementation of different depreciation functions work as particular cases of this method.

Chapter 3 deals with description of data and calculation of capital, depreciation and investments in municipal school buildings. Data description gives information about data sources and definition of school investments. The perpetual inventory method is used for calculation of capital and depreciation based on data for 1972-2001. Data on depreciation reported in local government accounts are compared to the results based on PIM.

Capital costs include depreciation of capital and interest costs associated with the alternative return on capital in the financial market. Such interest costs are discussed and estimated in Chapter 4. Chapter 5 is devoted to the empirical analysis of depreciation in municipal school buildings. The analysis estimates effects of municipal characteristics that influence investment behavior and the accumulation of real capital in school buildings. Appendix A presents data and definitions for measuring local government investments and incomes, and a summary in Norwegian is provided in Appendix B.

2. Models for capital calculation

The common method for constructing a measure of capital in national accounting is the Perpetual Inventory Method (PIM), see e.g. Todsen (1997). This method is generally based on estimates for the value of real capital that have survived to the current period, plus the value of real capital that have been installed as a result of current investment. Valuation of assets from different periods requires that investments are adjusted by a price index.

Models for capital calculation based on PIM assume that capital in each period increases due to inflow of investments and decreases by capital depreciation. Starting from the initial period we consider three components: investments, capital and depreciation. Investments contribute to an increase in the capital stock. Depreciation is the decline in value associated with ageing and wear and tear of capital assets. At the end of every period we define capital as a stock accumulated during the previous periods, and which is reduced by depreciation and increased by investments in the current period. Net investments are defined by the change in the capital stock in a given period. For every period t the method includes operational definitions of the following components:

- gross investments in period *t*, I_t
- capital depreciation in period *t*, D_t
- capital in period *t*, K_t
- net investments in period *t*, NI_t

When gross investments It are observed over a long period of time, the PIM method shows how to derive and calculate measures for real capital, depreciation and net investments. The Perpetual Inventory Method is based on calculation of change in the capital stock in a given period

$$(2.1)\quad K_t = K_{t-1} + I_t - D_t \,.$$

The stock of capital at the end of a period is defined by the capital stock at the beginning of the period plus gross investment minus depreciation in the period. We consider a finite number of periods in the model, so we need to specify initial values of capital for the first period. If the period under consideration is sufficiently long, one may put the initial values equal to zero without serious measurement errors. The reason for this is that the value of sufficiently old capital assets is reduced approximately to zero by the process of depreciation. We assume that there is a flow of investments, by which capital is accumulated over time. The survival function defines the proportion of an investment made a certain number of periods ago that still exists as productive capital. The capital stock in period t is defined by the following expression

$$(2.2)\quad K_t = \sum_{s=0}^{\infty} B_s \cdot I_{t-s} \,,$$

where B_s denotes the share of the capacity of a capital stock invested which survives at age s = 0, 1, 2,…, and I_{t-s} is investment in period t-s measured in fixed prices. We assume that B_s is non-increasing in *s*, with $B_0 = 1$ and $B_\infty = 0$. The technical depreciation for period t is given by

$$(2.3)\quad D_t = I_t - (K_t - K_{t-1}) = \sum_{s=1}^{\infty} b_s \cdot I_{t-s} \,,$$

where

$$(2.4)\quad b_s = B_{s-1} - B_s \,,\quad s = 1, 2, \dots \,.$$

This is the common expression for depreciation in the perpetual inventory model. Linear and geometric depreciation functions, which will be considered below, introduce special cases of the model.

The last variable we need to define is net investment, which equals gross investment minus depreciation

$$(2.5)\quad NI_t = I_t - D_t \,.$$

Using (2.1) we can also estimate net investment as a change in capital between two following periods

$$(2.6)\quad NI_t = K_t - K_{t-1} \,.$$

2.1. Linear depreciation function

The first type of depreciation function considered here is the linear function. It corresponds to a straight-line depreciation pattern, which assumes equal depreciation in money terms over the lifetime of the asset. This means that depreciation equals a constant share of the initial value of the asset in every period over its lifetime. Depreciation in the linear model depends on the length of the lifetime period. Let us denote the expected lifetime by L, so we have an expression for linear depreciation in every particular period

$$(2.7) \quad D_t = \frac{1}{L} \cdot \sum_{s=1}^{L} I_{t-s} \,.$$

By comparing (2.3) and (2.7) we have $b_s = 1/L$ for any period $s \leq L$ in the linear model. This means that the survival function B_s is declining at a constant rate and is equal to 0 at s = L, at the age of the asset's retirement. Under the perpetual inventory method the lifetime period of the asset is often assumed to be given a priori, so we will consider L as given in the model.

The capital stock in every period is defined by the value of capital from the previous period, capital depreciation and investments in the current period as it follows from (2.1). In the case of linear depreciation the capital stock's value is measured by the following expression

$$(2.8) \quad K_t = \sum_{s=0}^{L} \frac{L-s}{L} I_{t-s} \,.$$

Thus, the value of capital is formed by the investments that are not fully depreciated during the last L periods.

2.2. Geometric depreciation function

The second type of depreciation function we consider here is the geometric function. This function corresponds to a pattern that assumes higher depreciation in the earlier years of an asset's lifetime period than in the later years. This depreciation profile is based on the efficiency and rentals on a fixed asset declining at a constant geometric rate from period to period. However, the rate of depreciation is constant under this method. The geometric depreciation function is convex and converges asymptotically to zero.

Let us consider depreciation under the perpetual inventory method. If B_s (see (Biørn et al. (1999))) is geometrically declining with the factor $1-\delta$ ($0 \leq \delta < 1$), we have $B_s = (1-\delta)^s, s = 0,1,\ldots$, and, from (2.4), $b_s = \delta(1-\delta)^{s-1}, s = 1,2,\ldots$, so that (2.2) and (2.3) take the form

$$(2.9) \; K_t = \sum_{s=0}^{\infty} (1-\delta)^s \cdot I_{t-s} \,,$$

$$(2.10) \; D_t = \delta \cdot \sum_{s=1}^{\infty} (1-\delta)^{s-1} \cdot I_{t-s} = \delta \cdot K_{t-1} \,.$$

We can then interpret δ as the 'technical' depreciation rate, in other words, the part of the capital stock at the end of period *t-1*, which vanishes during period *t*. In this case B_s follows the only survival function, for which $D_t \,/\, K_{t-1}$ has a constant value over the time for any investment path. From equations (2.1) and (2.10) the expression for the capital stock for any period *t* is given by

$$(2.11) \; K_t = (1-\delta) \cdot K_{t-1} + I_t \,.$$

As in the case of the linear depreciation function, we can also derive expressions for capital and depreciation based on information about investments and the depreciation rate by assuming that the initial capital stock equals zero in the first period of observation, and capital in that period is equal to the first period's gross investment ($K_1 = I_1$).

2.3. Comparison of linear and geometric depreciation

The exponential depreciation function can be used as an approximation of geometric depreciation, see NOU (1989). We consider the time path of capital (in continuous time) formed by an initial investment I_0, which is subject to exponential depreciation by the rate δ. In this case real capital (K) is a function of time *t* given by the formula

$$(2.12) \; K = I_0 \cdot e^{-\delta t} \,.$$

It is possible to find the exponential depreciation rate that gives the same present value of the real capital stock over the lifetime period as in the linear depreciation profile. Thus, calculation of the present value of capital provides a basis for comparing linear and geometric models of depreciation. The question is which level of the depreciation rate yields the same discounted value of the capital stock as in the linear depreciation model with lifetime *L* years.

Let us consider the special case where the discounting factor equals zero. Thus, in the calculation of present value a unit of capital is given the same weight at different points in time. With exponential depreciation the present value of capital for each unit of initial investment is given by

$$(2.13)\ PV^E = \int_0^\infty e^{-\delta t} dt = \frac{1}{\delta},$$

where the present value (PV^E) is computed at time 0. In the case of linear depreciation, investment is depreciated over the time *L*, and the present value of capital (PV^L) for each unit of initial investment is

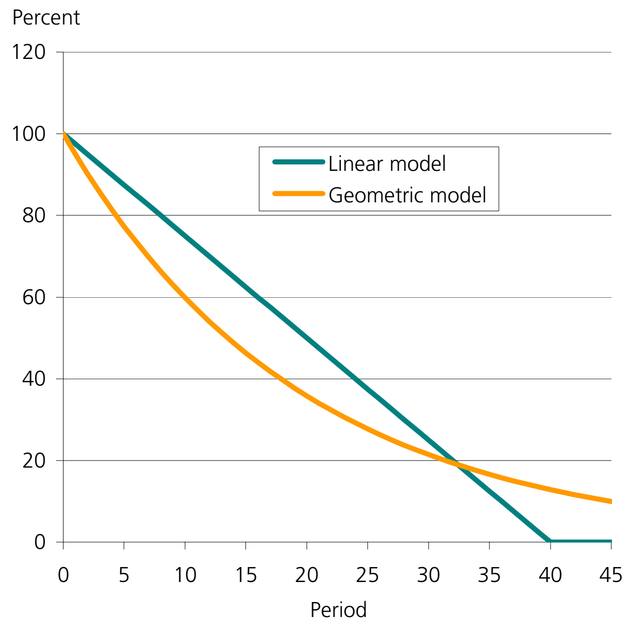
$$(2.14)\ PV^L = \int_0^L \frac{L-t}{L} dt = \frac{L}{2}.$$

By imposing the restriction that the present values in (2.13) and (2.14) are equal ($PV^E = PV^L$), one can find the exponential depreciation rate δ which gives the same present value of real capital as linear depreciation with lifetime *L*

$$(2.15)\ \delta = \frac{2}{L}.$$

The depreciation profile $\delta = \frac{2}{L}$ is called the "double-declining balance", and defines a relationship between the lifetime of the asset and its depreciation rate, as well as between linear and geometric depreciation methods.

Figure 2.1. Survival functions for linear model with lifetime 40 years and geometric model with depreciation rate 0.05



In this report we consider the lifetime period to be exogenous based on existing estimates. Local government accounts in Norway (KOSTRA) are regulated by a rule which imposes that the length of the lifetime for school buildings is equal to 40 years. However, we also estimate the effects of changes in the lifetime assumption in order to study the robustness of the results. For the geometric depreciation model the technical depreciation rate is compared to the results for different lifetime assumptions in the linear model, where the corresponding depreciation rates are derived from equation (2.15). For instance, a lifetime of 40 years in the linear model corresponds to a depreciation rate of 0.05 in the geometric model.

Figure 2.1 shows the time path of capital reduced by depreciation for linear and geometric models. The lifetime period of assets is 40 years and the depreciation rate is correspondingly 0.05. The remaining value of real capital goes down to zero in the long run. Although the capital value in the geometric model is lower during the first 32 periods, it becomes higher after that time and finally the areas under the graphs are equal, which is used as basis for comparing the linear and geometric models.

3. Capital, depreciation and investments in municipal school buildings

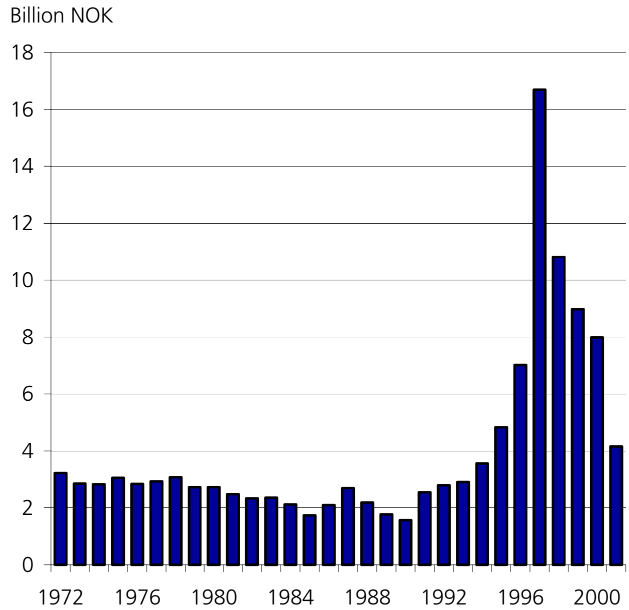
This chapter deals with the measurement of capital, depreciation and net investments, and comparison of the results from different models for capital calculation. Gross school investments are observed in the local government's accounts. Measures of depreciation are derived from the perpetual inventory method, and these measures are compared to data on depreciation in the local government accounts. The calculations are based on investment data for municipal school buildings going back to 1972, while local governments started to report depreciation in the new accounting system (KOSTRA) that was introduced in 2001.

3.1. Investment data

In order to utilize the perpetual inventory method, we consider the period of 30 years from 1972 to 2001 and gross investment data for that period. This is the period for which data from local government accounts are available. We use observations for 435 municipalities and their investments based on the structure of local units in 1994.

Investments in school buildings are defined by the following expenditure types: Construction of new buildings, maintenance of existing ones, and other expenses on the construction of new buildings. Since the aim is to analyze capital and depreciation in school buildings, we do not include expenses on purchase of land property. However, we include maintenance costs since such expenses increase the value of existing capital. Furthermore, the lifetime period of previous investments is prolonged by maintenance.[1] There were several changes in data nomenclature and its components over the time period under consideration. However, definitions were chosen to make investments comparable for the three periods from 1972 - 1990, from 1991 - 2000 and from 2001 and thereafter. For more details, see Appendix A.

Figure 3.1. Total municipal school building investments in Norway 1972-2001. Billion NOK (2001-prices)

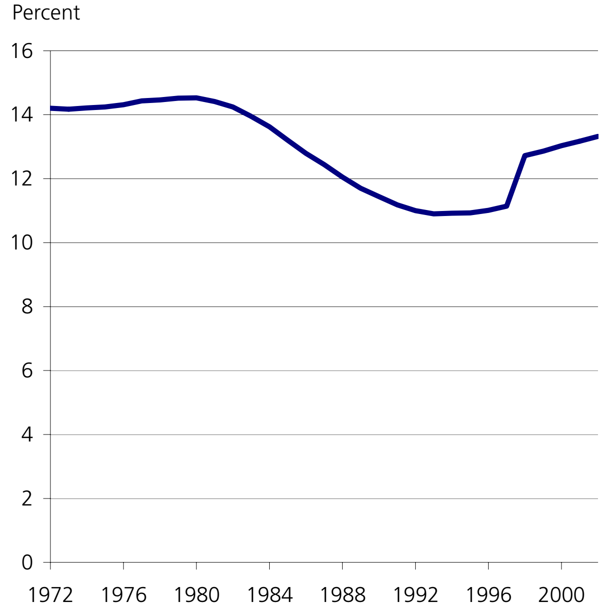


Source: Local government accounts

In order to measure investments in fixed prices, all the values of investments have been inflated with a price index for building costs of multi dwelling houses. The price index is normalized to 1 in the base year, which is 2001. Summary results for investments in fixed prices are reported if Figure 3.1. The histogram shows that school building investments in fixed prices were stable or declining through the seventies and eighties, while there was an investment boom in the late nineties. The peak was in 1997, which followed after several years of growing investments. In this year a reform was introduced in the Norwegian education system, where the age for entering primary schools was reduced from 7 to 6 years. This reform required an expansion of school building capacity. School investments were also high although declining in the years following the reform.

[1] The practice here differs from the common approach in KOSTRA and the National Accounts, since we also include maintenance on the current account in the definition of investments.

Figure 3.2. Percent of population in the age groups that attend primary schools, 1972-2002



It is likely that the aggregate time path of school investments in Figure 3.1 is affected by changes in the total number of children that are in the age for obligatory primary school. The share of children in the age groups that have been included in primary schools is shown in Figure 3.2. Due to declining fertility rates there was a reduction in the population share of children in school age through the 1980s. The sharp increase from 1997 to 1998 resulted from the inclusion of 6 year old children as pupils in primary schools.

In order to make our data comparable across municipalities we calculate investments per capita. We use the population by the end of the year to calculate investments per person in every period. Summary statistics for school building investments per capita in different municipalities is displayed in Table 3.1 for the period 1972-2001.

The time path of investments per capita is similar to that for aggregated investments. Looking at the mean values we observe stability or decline through the seventies and eighties and a boom in the late nineties. There are two negative observations for minimum values, which may indicate errors in the local government accounts. These negative values have been corrected to zero in the following analysis.

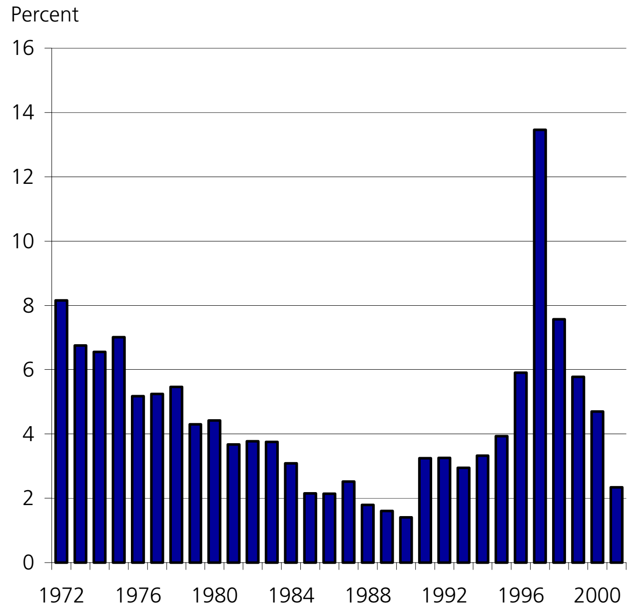
Since local governments face a budget constraint, it would be interesting to study the share of income that is invested in school buildings. The definition of total income includes tax incomes, net transfers from the central government and incomes from hydroelectric power licensing. Since we consider investments and incomes for the same periods, we report budget shares (not adjusted either by a price index or by population). The share of total income invested in school buildings is shown in Figure 3.3.

Table 3.1. Summary statistics for school investments in municipalities, NOK per capita (2001-prices), 1972-2001

Year	N Obs*	Mean	Std Dev	Minimum	Maximum
1972	414	1 108	1 890	0	16 597
1973	414	914	1 347	0	10 929
1974	414	895	1 196	17	9 319
1975	414	1 007	1 446	0	12 704
1976	418	879	1 206	34	9 228
1977	435	879	1 648	0	25 868
1978	435	906	1 814	0	31 041
1979	435	751	1 142	0	9 448
1980	435	808	1 220	0	11 760
1981	435	696	1 146	0	13 741
1982	435	774	1 385	0	15 142
1983	435	729	1 199	27	12 800
1984	435	731	1 198	27	12 514
1985	435	599	944	8	10 391
1986	435	610	812	-62	6 839
1987	435	759	1 172	0	9 241
1988	435	584	971	2	9 170
1989	435	545	1 750	0	34 297
1990	435	522	1 051	0	14 127
1991	435	986	2 508	0	42 056
1992	435	1 037	3 236	0	55 870
1993	435	848	1 421	0	15 147
1994	435	1 000	1 725	0	16 409
1995	435	1 152	2 019	0	20 872
1996	435	1 863	3 441	0	40 572
1997	435	4 032	3 367	0	22 032
1998	435	2 297	3 288	0	38 923
1999	435	1 823	2 984	0	29 154
2000	435	1 463	1 860	-33	11 603
2001	433	764	1 139	0	11.502

* The number of observations differs from 435 because of missing values on population in some of the municipalities in the earlier years. Moreover, two municipalities are omitted from the data set due to non-reported data on population in 2001. In the following analysis these two values have been replaced with data on population in 2000.

Figure 3.3. Percent of total income invested in school buildings, 1972-2001*



* There are some zero observations in the income data for 2001. Since we divide by this variable in our calculations, these observations (3 municipalities) were omitted in 2001.

Table 3.2. Correlation between investments and income per capita, 1972-2001

1972	0.234
1973	0.245
1974	0.124
1975	0.137
1976	0.270
1977	0.278
1978	0.311
1979	0.235
1980	0.182
1981	0.105
1982	0.142
1983	0.414
1984	0.427
1985	0.276
1986	0.149
1987	0.149
1988	0.157
1989	0.145
1990	0.222
1991	0.195
1992	0.442
1993	0.220
1994	0.142
1995	0.164
1996	0.380
1997	0.173
1998	-0.012
1999	0.001
2000	-0.071
2001	-0.012

Comparing this histogram with Figure 3.1 for total investments in fixed prices there is a somewhat different time path from 1972 - 1990. The share of income which was spent on investments in school buildings in 1972, constituted more than 8 percent of local government's income. By the year 1990 local governments had reduced this share to 1 percent on average. The declining investment share in the 1980s coincides with a declining share of children in school age as shown in Figure 3.2. The share of total income invested in school buildings was increasing over the following years that coincide with the education reform. Here we also observe a boom in the late nineties with a peak of 13 percent in 1997, and a gradual decrease in the following years.

The relationship between municipal income and investments per capita can be characterized by the correlation on the municipal level between these variables for every particular period, which is shown in Table 3.2. We find that incomes and investments are positively correlated in most of the years, with a notable exception for the years 1998-2001. This period corresponds to declining school investments after the national reform in 1997. Thus, in the period after the reform there was no tendency for rich municipalities to invest more in school buildings than poor municipalities. Moreover, the correlations are quite unstable throughout the period 1972-2001.

3.2. Depreciation in local government accounts

Starting from the year 2001, local governments report data on depreciation along with investments in school buildings in their accounts. Local governments use a linear depreciation function when they report the data on depreciation. They apply a financial depreciation method, which means that investments are compared and aggregated in current prices and initial values of capital are not adjusted by inflation.

This method has been discussed by Langørgen and Rønningen (2002). They argue that values reported in KOSTRA underestimate the level of depreciation due to several reasons. Utilization of the financial method of computation is the most obvious one. The comparison of investments and capital from different time periods becomes difficult to follow when investments are measured in current (historical) prices. The inflation process over a long period of time leads to underestimation of capital and depreciation of older assets as measured in 2001-prices, since the nominal value of assets are increasing over time due to inflation. The underestimation is larger for older assets and increases with increasing inflation. Moreover, the underestimation of depreciation is larger in municipalities that have a relatively small part of new school buildings and/or invest more in maintenance than in construction of new buildings. Some municipalities may also use school buildings that are older than the assumed lifetime period in KOSTRA. Local governments do not include operating expenses on maintenance as a part of investments when they estimate capital and depreciation, although these expenses may extend the lifetime period of capital assets. Another source of underestimation is the possible lack of information on investment costs for some of the assets, particularly the older ones.

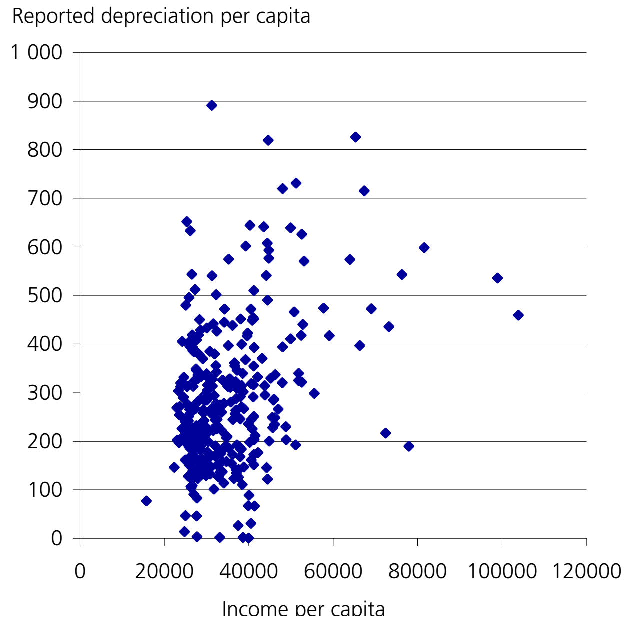
There are many missing values on depreciation in KOSTRA for 2001, which means that 86 observations are excluded. Moreover, two observations are omitted due to values that are not within a reasonable range. The final set includes 347 municipalities for which statistics on depreciation are summarized in Table 3.3.

The minimum value of depreciation per capita corresponds to Båtsfjord, the maximum to Lenvik. Since we found a positive correlation between municipal investments and incomes, we also expect that per capita capital and depreciation are positively correlated with per capita incomes across municipalities. Thus, a diagram of school building depreciation plotted versus income per capita is displayed in Figure 3.4. The correlation between per capita income and depreciation is 0.375, which confirms that the correlation is positive. This may imply that municipalities with higher incomes tend to accumulate more capital and consequently are reporting more depreciation.

Table 3.3. Summary statistics for depreciation in school buildings reported in KOSTRA. NOK per capita, 2001

Mean	Std Dev	Minimum	Maximum
282	145	1	891

Figure 3.4. School building depreciation in KOSTRA and local government income. NOK per capita, 2001



3.3. Capital model with linear depreciation function

To estimate capital in the linear model, we use a standard assumption about the lifetime period of school buildings. In the municipal accounts (KOSTRA) it is assumed that school buildings have a lifetime equal to 40 years. To study the sensitivity of results to this assumption we also calculate measures of capital based on lifetimes of 30 and 50 years.

Since we only have investment data for 30 years, a measurement error is introduced, which derives from capital inherited from the period before 1972. Since we have no estimate of the initial stock of capital in 1972, this initial stock is not included in the calculations. Consequently, the imputed capital and depreciation in 2001 is underestimated if the lifetime period exceeds 30 years, although the initial capital stock has certainly been subject to severe depreciation during the 30-year period.

In the following analysis we will concentrate on capital and depreciation in the year 2001, since this allows utilization of all the years in the panel data set. In order to compare figures across municipalities, the estimated capital and depreciation are normalized by the population in each municipality. Summary statistics for capital and depreciation in 435 municipalities are displayed in table 3.4 and 3.5.

Table 3.4. Summary statistics for capital in school buildings with linear depreciation function and different assumptions about the lifetime, 2001

	NOK per capita				Billion NOK
	Mean	Std Dev	Mini-mum	Maxi-mum	Sum
Lifetime 30 years	19 190	9 872	5 650	121 620	76.7
Lifetime 40 years	22 406	11 193	6 489	137 469	87.3
Lifetime 50 years	24 336	12 079	6 992	146 978	93.6

Table 3.5. Summary statistics for depreciation in school buildings with linear depreciation function and different assumptions about the lifetime, 2001

	NOK per capita				Billion NOK
	Mean	Std Dev	Mini-mum	Maxi-mum	Sum
Lifetime 30 years	1 043	535	296	6 154	3.8
Lifetime 40 years	782	401	222	4 616	2.9
Lifetime 50 years	626	321	177	3 693	2.3

The highest values both for capital and depreciation per capita correspond to Bykle, the lowest values to Eidsberg. Different assumptions about the lifetime of school buildings result in different levels of the capital stock and depreciation. Thus, the estimated capital stock is increasing with the length of the assumed lifetime period, since the existing assets are depreciated more slowly. Depreciation is decreasing with the assumed lifetime period for exactly the same reason, while taking into account that investments, which are more than 30 years old in 2001, are not included in the measures of depreciation. Thus, one should keep in mind that the underestimation of capital and depreciation is increasing with the assumed lifetime period. If the lifetime is 30 years the number of years in the data set is sufficient. However, if the lifetime is 40 or 50 years there is underestimation, since we exclude from the consideration a period of 10 or 20 years before 1972.

Although the estimated levels are different, the estimates for different lifetime assumptions are highly correlated across municipalities. Correlation coefficients are displayed in Table 3.6 (the right upper triangle shows correlation for capital, the left lower triangle contains estimates of correlation for depreciation). There is a high positive correlation between estimates both for capital and depreciation with different assumptions about the lifetime period of assets. The levels of capital and depreciation per capita are closely related as suggested by the correlation coefficients, which are displayed in Table 3.7. Correlation coefficients are positive and high. Correlation between capital and depreciation increases with the assumed lifetime of the assets, which is a result of the linear depreciation function and missing data before 1972.

Table 3.6. Correlation coefficients for capital and depreciation in school buildings with linear depreciation function and different lifetime assumptions, 2001

	Capital (30)	Capital (40)	Capital (50)
Depreciation (30)	Capital (30) Depr (30)	0.989	0.977
Depreciation (40)	1.000	Capital (40) Depr (40)	0.997
Depreciation (50)	1.000	1.000	Capital (50) Depr (50)

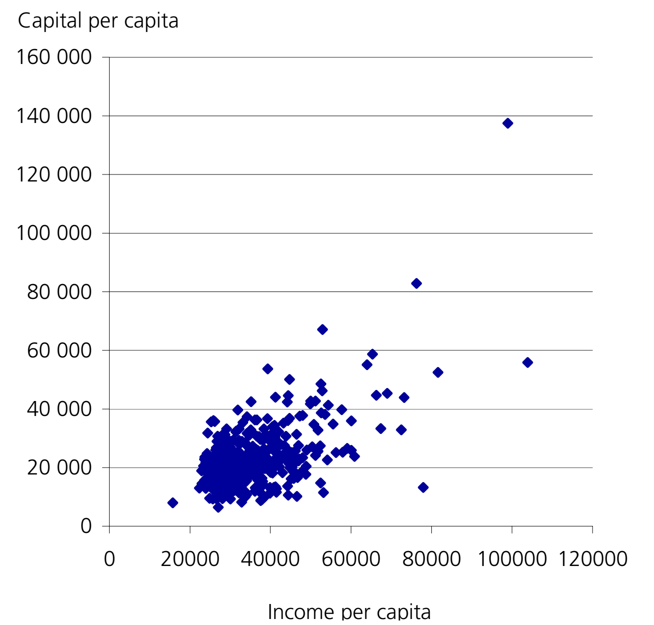
Table 3.7. Correlation coefficients between capital and depreciation in school buildings with linear depreciation function and different lifetime assumptions, 2001

Lifetime 30 years	0.908
Lifetime 40 years	0.958
Lifetime 50 years	0.976

Table 3.8. Summary statistics for net investments with linear depreciation and lifetime 40 years. NOK per capita, 2001

N Obs	Mean	Std Dev	Minimum	Maximum
435	-18	1 218	-4 233	10 949

Figure 3.5. Income and capital with linear depreciation function and lifetime 40 years. NOK per capita, 2001*



* Three observations are omitted from the data set since incomes are missing in the municipal accounts.

Since investments are positively correlated with income in most of the years, we expect to find a positive relationship between capital and income per capita. The relationship is displayed in Figure 3.5. The figure shows a positive relationship between capital and municipal income per capita, which is confirmed by the correlation coefficient being equal to 0.601. The highest value of per capita capital in school buildings corresponds to Bykle, and the highest per capita income is reported in Modalen.

The last variable we derive from the model is net investments. Using expression (2.5) and values of depreciation calculated from the capital imputation model with the linear depreciation function, the estimates for net investments in school buildings are displayed in Table 3.8. Since net investments equal change in capital during a year, we can conclude that the average capital stock was slightly reduced in 2001. There are 293 negative values of net investments in this period, which means that depreciation exceeded gross investments in 67 percent of the municipalities. However, this conclusion depends crucially on the assumption that the lifetime is 40 years. We should also recall that depreciation is underestimated in the model due to initial values of capital that were set to zero in 1972. This implies that net investments are overestimated in Table 3.8, provided that the lifetime of school buildings is 40 years.

3.4. Capital model with geometric depreciation function

As shown in equation (2.15), a given lifetime period can be 'translated' to a depreciation rate by assuming that the present value of real capital over the whole lifetime period is equal for the linear and geometric depreciation functions. Thus, from the assumption of a lifetime of 40 years for school buildings, it follows that the depreciation rate in the geometric model is equal to 0.05. Lifetimes of 30 and 50 years are 'translated' to depreciation rates of 0.067 and 0.04, respectively. Since the initial value of the capital is set to zero, there is a measurement error that decreases over time. Thus, like before we focus on the last year of calculation, which is 2001. The results for 435 municipalities are summarized in Tables 3.9 and 3.10.

The geometric model yields estimates of capital that decrease with the depreciation rate, while the level of depreciation increases with the depreciation rate. These results are similar to the linear model. Extreme values correspond to the same municipalities as in the case with linear depreciation. The highest capital and depreciation are found for Bykle and the lowest for Eidsberg.

Table 3.9. Summary statistics for capital in school buildings with geometric depreciation function and different assumptions about the depreciation rate, 2001

	NOK per capita				Billion NOK
	Mean	Std Dev	Mini-mum	Maxi-mum	Sum
Depreciation rate 0.067	16 639	8 351	5 042	98 322	67.4
Depreciation rate 0.05	19 118	9 496	5 670	114 179	75.9
Depreciation rate 0.04	20 930	10 354	6 132	125 184	82.0

Table 3.10. Summary statistics for depreciation in school buildings with geometric depreciation function and different assumptions about the depreciation rate, 2001

	NOK per capita				Billion NOK
	Mean	Std Dev	Mini-mum	Maxi-mum	Sum
Depreciation, rate 0.067	1 134	592	348	6 999	4.5
Depreciation, rate 0.05	966	497	291	5 989	3.8
Depreciation, rate 0.04	840	430	250	5 200	3.2

Table 3.11. Correlation coefficients for capital and depreciation in school buildings with geometric depreciation function and different assumptions about the depreciation rate, 2001

	Capital (0.067)	Capital (0.05)	Capital (0.04)
	Capital (0.067)	0.996	0.988
Depreciation (0.067)	Depr (0.067)		
		Capital (0.05)	0.998
Depreciation (0.05)	0.996	Depr (0.05)	
			Capital (0.04)
Depreciation (0.04)	0.988	0.998	Depr (0.04)

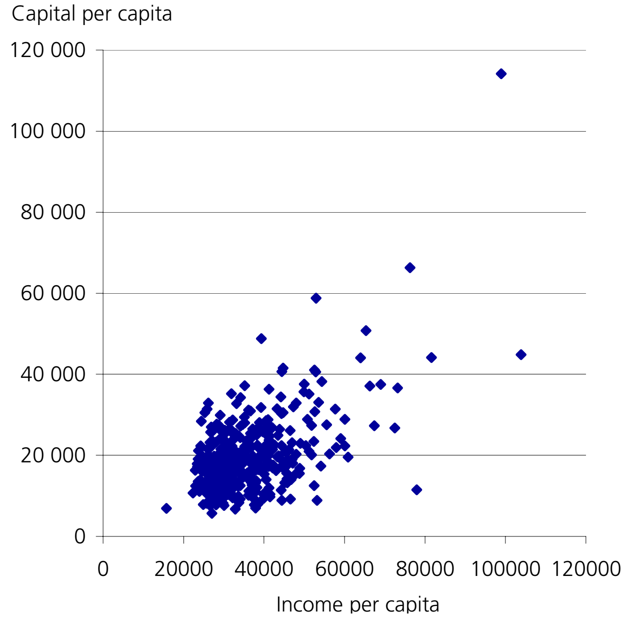
Table 3.12. Correlation coefficients between capital and depreciation in school buildings with geometric depreciation function and different assumptions about the depreciation rate, 2001

Depreciation rate 0.067	0.991
Depreciation rate 0.05	0.993
Depreciation rate 0.04	0.994

Correlation coefficients between different depreciation rates are displayed in Table 3.11 (the right upper triangle contains coefficients for capital, the left lower triangle for depreciation). The results show that estimates both for capital and depreciation calculated with different assumptions about the depreciation rate are highly correlated. Recall however, that this result is affected by the lack of investment data before 1972. Correlation coefficients between capital and depreciation for different assumptions about the depreciation rate are displayed in Table 3.12. As in the case with the linear method, estimates of correlation between capital and depreciation are positive and high.

Figure 3.6 displays the relationship between capital and income per capita based on a geometric depreciation function. This graph shows a similar relationship between capital and income as in the case with linear depreciation. There is a tendency that capital per capita increases with income per capita. This result is confirmed by the estimated correlation coefficient between these two variables, which is equal to 0.570.

Figure 3.6. Income and capital with geometric depreciation function and depreciation rate 0.05. NOK per capita, 2001*



* Municipalities with non-reported values of income in 2001 were omitted from the data set.

Table 3.13. Summary statistics for net investments with depreciation rate 0.05. NOK per capita, 2001

N Obs	Mean	Std Dev	Minimum	Maximum
435	-201	1 249	-5 607	10 797

Summary statistics for per capita net investment with geometric depreciation function is reported in Table 3.13. In 2001 net investment is negative in 324 municipalities, which include 74.5 percent of the municipalities. Furthermore, net investments are likely to be overestimated due to the assumption of zero initial capital in 1972.

3.5. Comparison of different methods

In this section the calculated depreciation based on linear and geometric methods are compared to the statistics on depreciation reported by local governments. Missing observations, which correspond to observations with zero values on depreciation in KOSTRA, and outliers, are omitted from the comparison. The final set consists of 347 observations, which are supposed to be valid for all three methods (linear, geometric and reported depreciation). Since municipalities use a linear method of depreciation in their accounts and report depreciation in current prices, we also include here a non-inflated linear depreciation, which is calculated from the data on investment in current prices for every period. These estimates are supposed to reproduce the method for reporting depreciation in KOSTRA, although there is a difference in the treatment of maintenance costs. The PIM calculation of non-inflated linear depreciation includes maintenance, which is not included when depreciation is reported in KOSTRA.

Table 3.14. Summary statistics for depreciation calculated by different methods. NOK per capita, 2001

Variable	Mean	Std Dev	Minimum	Maximum
Linear depreciation, lifetime 40 years	767	415	221	4 616
Non-inflated linear depreciation, lifetime 40 years	498	275	150	3 178
Geometric depreciation, depreciation rate 0.05	948	512	291	5 989
Depreciation in KOSTRA	282	145	1	891

The results show a difference in the level of reported and calculated depreciation. This difference is partly due to the method in KOSTRA, which disregards inflation. Since reported values are not adjusted by a price index they underestimate the values in 2001. Also, the lack of investment data before 1972 means that the figures based on the perpetual inventory method underestimate the level of capital and depreciation. Nevertheless, the average level of depreciation in KOSTRA is only 57 percent of non-inflated linear depreciation, which means that there are other reasons for underestimation in KOSTRA in addition to the underestimation that is due to non-inflated investment figures. Thus, the data in KOSTRA could be too low because of incomplete data for older capital assets, or because of the fact that maintenance investments in school buildings are not included in depreciation as measured in KOSTRA.

Table 3.15 displays correlation coefficients for the four different measures of depreciation (the same measures as in Table 3.14). Linear and geometric depreciation methods yield measures that are highly correlated both for non-inflated values and adjusted by inflation. Correlation between the perpetual inventory method and KOSTRA is lower even for non-adjusted linear depreciation. The correlation between depreciation measures based on PIM methods and depreciation reported in KOSTRA is equal to 0.546. Another interesting result is that non-inflated linear depreciation is highly correlated with geometric depreciation.

Table 3.15. Correlation coefficients for four types of depreciation in 2001 (lifetime 40 years)

Variable	Reported depreciation	Linear depreciation	Non-inflated linear depreciation	Geometric depreciation
Reported depreciation	1.000			
Linear depreciation	0.546	1.000		
Non-inflated linear depreciation	0.546	0.956	1.000	
Geometric depreciation	0.546	0.953	0.996	1.000

The comparison shows significant differences between the perpetual inventory method and the accounting practice in local governments. Some reasons for such differences were discussed above, but there could as well be other undetected explanations. However, to obtain more information on this issue, a deeper look into the practice of local government accounting is required.

4. Interest costs of real capital

The user cost of capital is the cost of using one unit of real capital as input in the production process during one period. This cost includes depreciation, changes in the valuation of real capital, and the real opportunity cost of holding the wealth in the form of physical capital. Measures of depreciation in school buildings have already been derived in previous chapters. By adjusting investments for inflation, the valuation changes that owe to changes in the general price level are reflected in the measurement of capital and depreciation. However, since there barely exists a second-hand market for school buildings, it is difficult to observe valuation changes that are specific to school buildings. Such valuation changes could arise due to demand and supply factors in the market for existing school buildings.

Since local governments almost monopolize the production of primary education within each jurisdiction, school buildings can only be sold to buyers who want to use the buildings for other purposes than schooling. In regions with net out-migration it is likely that the demand for used school buildings is low, while municipalities may want to sell out vacant capacity. However, due to low demand, the market price is expected to be low or even zero. In regions with net in-migration it is likely that the demand for used school buildings is higher, but the buildings are not sold because the local governments need to increase the capacity to serve an increasing number of pupils. Thus, we have to rely on investment costs to estimate the value of real capital in school buildings, although this is insufficient to capture the regional variation in market values. Moreover, this assigned value is likely to overestimate the market value of school buildings, since a transition of usage from schooling to business or housing purposes would require reconstruction of the buildings. The transfer of a school building into another type of real estate implies that extra costs are incurred.

Nevertheless, estimates of opportunity cost for real capital as measured by the perpetual inventory method (PIM) are provided in this chapter. To the extent that market values are overestimated by PIM, the opportunity cost is also overestimated. When money is invested in physical capital the opportunity cost is determined by the normal rate of return on financial investments. The real interest rate that is earned by investing money in a bank or in the financial market indicates the per unit opportunity cost for holding real capital. When the real capital is debt-financed, it is relevant to use the interest rate on bank loans, while the opportunity cost for real capital that is financed by internal funds is given by the interest rate on bank deposits. The average real interest rates for bank loans and bank deposits in 2001 were 5.7 and 2.7 percent, respectively. This indicates the relevant interval for the opportunity cost per unit of real capital value in 2001. We will consider the imputed value of the capital stock in 2001 as an amount of money that can be used to reduce loans or increase bank deposits.

The estimates of opportunity cost of school buildings in 2001 are based on three different cases, which differ by the interest rate used in the calculations. The highest rate is 5.7 percent, and corresponds to the average real interest rate on bank loans in 2001. The lowest rate is 2.7 percent, and corresponds to the average real interest rate on bank deposits in 2001. Then we also consider an intermediate annual real interest rate, which is 4 percent. This rate corresponds to the expected long-term rate of return from the Norwegian Petroleum Fund. This means that money can alternatively be invested in the Norwegian Petroleum Fund and provide 4 percent expected real rate of return. This rate of return has also been used in the cost-benefit analysis of investment projects in the public sector. Consequently, 4 percent is the officially required rate of return in Norway. The calculated interest costs are displayed in Tables 4.1 and 4.2. The opportunity cost is calculated on the basis of a linear model with a lifetime of 40 years and a geometric model with depreciation rate 0.05, and the tables build on 435 municipalities.

Table 4.1. Interest costs for capital in school buildings with linear depreciation, 2001

	NOK per capita				Billion NOK
	Mean	Std Dev	Minimum	Maximum	Sum
Interest rate 0.027	603	297	176	3578	2.4
Interest rate 0.04	894	440	261	5300	3.5
Interest rate 0.057	1274	627	372	7553	5.0

Table 4.2. Interest costs for capital in school buildings with geometric depreciation, 2001

	NOK per capita				Billion NOK
	Mean	Std Dev	Minimum	Maximum	Sum
Interest rate 0.027	515	252	154	2971	2.1
Interest rate 0.04	763	374	228	4402	3.1
Interest rate 0.057	1087	533	325	6273	4.4

Due to missing investment data for the period before 1972, accumulated real capital is underestimated by the perpetual inventory method when the value of school buildings is defined by the replacement cost. This underestimation contributes to the underestimation of interest costs in Tables 4.1 and 4.2. The underestimation is probably larger for the geometric method than for the linear method, since the geometric method put relatively higher weight on the older assets. Recall however, that PIM may overestimate the opportunity cost due to low demand and high reconstruction costs in the market for existing school buildings.

5. Empirical analysis of depreciation in school buildings

This chapter is based on the empirical analysis of depreciation by Langørgen and Rønningen (2002). They utilize KOSTRA-data for depreciation in school buildings. In this chapter the analysis is reproduced for depreciation as measured by the Perpetual Inventory Method (PIM). The aim of the analysis is to identify how depreciation is influenced by different factors, such as income in municipalities, the size of municipalities, demographic changes, age structure of the population and settlement pattern.

An important aim is to examine the impact of population growth on per capita depreciation. The analysis allows us to study whether municipalities with increasing or decreasing population have higher depreciation than municipalities with stable population. The dependent variable is school building depreciation per capita (in 1000 NOK) calculated with a linear depreciation function where the lifetime of the assets are assumed to equal 40 years. As different depreciation functions yield highly correlated depreciation measures, the estimation results that are based on PIM are robust to the choice of depreciation function. For this reason we only present estimation results for depreciation calculated from the linear model with lifetime 40 years.

5.1. Explanatory variables

A relevant method is to analyze the dynamic process of capital formation by the use of panel data. The analysis by Langørgen and Rønningen uses data for only one year (2001), since municipalities started to report data on depreciation in KOSTRA in 2001. We consider the same year in order to reproduce the analysis and compare the results. Moreover, as it was argued above, calculated depreciation for the year 2001 is less influenced by measurement errors than earlier years, since we only have observations for school building investments from 1972 and onwards.

Local governments have to finance their investments from current incomes or borrowing, which means that the capacity to finance investments depends on current and expected incomes. Since the income distribution across municipalities is rather stable, the distribution of future incomes is likely to be highly correlated with the distribution of current incomes. Therefore, current per capita free incomes are included in the analysis to capture cross-sectional variation in the capacity to finance investments, and the accumulated capital and depreciation is expected to increase with the income level. Free incomes are defined by the sum of municipal tax incomes and central government block grants.

While income is constraining the supply of municipal services, there are also influences from need and cost factors. Characteristics like size and demographic structure of municipalities are examples of such factors. Inverse population size is introduced by the ratio 1000 / population to capture extra capital costs for municipalities of a small size. Such costs are assumed to derive from economies of scale. Moreover, we include an indicator for small municipalities which is positive for municipalities with population below 10000, and is calculated as (10000 - population) / 10000. For municipalities with population from 10000 and above the indicator is equal to zero. We also include a dummy variable for large municipalities with population above 110000, in order to test whether investments are more expensive in large municipalities.

Another factor that may affect the investment behavior of local governments is the age structure of the local population. A high share of children and youth may increase the demand for investments in school buildings. By contrast, a high share of elderly may increase expenditures and investments in health care services and care for the elderly, which may reduce the priority of school investments. In the analysis these effects are captured by the share of population between 6 and 15 years (corresponding to the age group in compulsory primary schools), and the population share 80 years and above.

Population growth in municipalities may affect investment behavior and depreciation. Population growth implies that more capital is needed to provide a given service standard. However, inertia in the dynamic process may introduce time lags in the response of real capital to population change. Thus, we consider changes in population over the last two years (1999 - 2001) and several previous periods during the last twenty years before 2001. In the short term we expect that depreciation per capita decreases with growth in the total population due to adjustment inertia for capital. Thus, there is a period of transition with high investments and low capital stock, as argued by Langørgen and Rønningen (2001). The relationship between population growth rates in different periods is displayed in Table 5.1. For most periods the correlations are positive and rather high. The high correlations in Table 5.1 are a reason why the lag-structure for population growth has been restricted to five time periods. These correlations suggest that the composition of declining, stable and growing municipalities is not changing at a high rate.

Table 5.1. Correlation coefficients for population growth in different periods

Period	1981-1986	1986-1991	1991-1996	1996-1999	1999-2001
1981-1986	1				
1986-1991	0.687	1			
1991-1996	0.491	0.594	1		
1996-1999	0.603	0.675	0.560	1	
1999-2001	0.485	0.534	0.476	0.566	1

In the long run we expect zero or a positive effect of population growth on the use of real capital inputs per pupil in the production of school services. No effect means that the variation in capital per capita is explained by other factors like municipal incomes and the population share in the age group 6-15 years. The alternative hypothesis of a positive effect may arise from a standard on school buildings that is increasing over time, which may imply that stable and declining municipalities using old school buildings provide a lower standard of the physical environment in public schools. In this case, population growth encourages local governments to upgrade their capital stock to a higher level.

To account for the allocation on different service sectors, we include changes in the shares of population of particular age groups like youth between 6 and 15 years and elderly 80 years and above. These variables are included to tests whether or not the hypothesized impact of population growth is also related to changes in the age structure of the population.

The model includes a measure of gross migration of the population in each municipality. First we calculate the sum of in- and out-migrants in each year as a share of the population in each municipality, and then the average percent of gross migration over a ten-year period is included in the analysis. This variable is included in the model to test the hypothesis that higher population turnover and mobility leads to a higher priority of school building investments. Carlsen et. al. (2004) argue that fiscal competition induce local governments to give a high priority to services like kindergartens and primary education in order to attract the mobile households, which mainly include younger adults and families with children. Thus, school spending and investments are expected to account for a relatively high budget share in municipalities with high mobility.

Table 5.2. Summary statistics for variables in the model for depreciation

Variable	N Obs	Mean	Std Dev	Minimum	Maximum
Depreciation reported in KOSTRA, NOK per capita	347	282	145	1	891
Depreciation calculated by PIM, NOK per capita	435	782	401	222	4616
Free incomes, NOK per capita	435	26964	12943	0	109994
Inverse population size	435	0.354	0.405	0.002	4.292
Indicator for small municipalities	435	0.480	0.336	0	0.977
Indicator for large municipalities (more than 110000 people)	435	0.007	0.083	0	1.000
Average distance to the nearest basic spatial unit (10 km)	435	0.372	0.268	0	2.242
Average distance to subdistrict's center (10 km)	435	0.834	0.715	0	6.188
Percent of population 6-15 years old	435	13.630	1.504	9.521	19.077
Percent of population 80 years and above	435	5.193	1.576	1.681	12.457
Population growth 1999-2001, percent	435	0.353	2.320	-15.795	10.109
Population growth 1996-1999, percent	435	-0.391	3.536	-15.664	14.953
Population growth 1991-1996, percent	435	0.088	4.477	-21.171	21.856
Population growth 1986-1991, percent	435	-0.299	5.122	-14.653	19.926
Population growth 1981-1986, percent	435	0.399	4.205	-20.862	18.949
Gross migration, annual average 1992-2001, percent	435	9.084	2.662	4.593	18.532
Change in the share of population 6-15 years of age 1991-2001, percent	435	3.687	11.314	-30.196	50.064
Change in the share of population 80 years and above 1991-2001, percent	435	6.454	116.855	-2.272	2438.00

Table 5.3. Results of regression analysis for calculated and reported depreciation per capita in school buildings

Variable	PIM (OLS)	PIM (robust regression)	KOSTRA (robust regression)
Intercept	-0.904*	-0.834*	-0.059
	(-3.33)	(-3.92)	(0.54)
Free incomes, 1000 NOK per capita	0.007*	0.012*	0.001
	(4.86)	(8.49)	(1.72)
Inverse population size	0.140*	0.195*	0.111*
	(2.20)	(2.98)	(2.95)
Indicator for small municipalities	0.048	-0.101	-0.002
	(0.59)	(-1.51)	(0.05)
Indicator for large municipalities (more than 110 000 citizens)	0.113	0.129	0.074
	(0.61)	(0.92)	(0.65)
Average distance to the nearest basic spatial unit (10 km)	0.234*	0.036	-0.041
	(2.59)	(0.48)	(0.83)
Average distance to subdistrict's center (10 km)	0.112*	0.129*	0.072*
	(3.50)	(4.98)	(4.97)
Percent of population 6 - 15 years old	0.063*	0.066*	0.015*
	(4.05)	(5.5)	(2.33)
Percent of population over 80 years and above	0.030	0.010	-0.005
	(1.82)	(0.76)	(0.65)
Population growth 1999-2001, percent	-0.014	-0.023*	-0.009*
	(-1.57)	(-3.33)	(2.55)
Population growth 1996-1999, percent	0.013	-0.003	0.002
	(-1.82)	(-0.47)	(0.72)
Population growth 1991-1996, percent	0.010*	0.0002	-0.0001
	(2.18)	(0.04)	(0.05)
Population growth 1986-1991, percent	0.012*	0.003	0.007*
	(2.28)	(0.66)	(3.17)
Population growth 1981-1986, percent	-0.007	-0.0003	-0.0001
	(-1.17)	(-0.06)	(0.06)
Gross migration, annual average 1992-2001, percent	0.027*	0.02*	0.003
	(3.63)	(3.42)	(0.86)
Change in the share of population 6-15 years of age 1991-2001, percent	0.0008	-0.001	0.001
	(0.48)	(-1.08)	(1.27)
Change in the share of population 80 years and above 1991-2001, percent	0.0003*	-0.001	0.015
	(2.32)	(-0.04)	(1.6)
R^2 adjusted	0.40	0.40	0.52
Number of observations	435	413	347

* The endogenous variable is depreciation per capita in 1000 NOK. Coefficients that are significant on the 5 percent level are marked with an asterisk. T-statistics in parentheses.

The population settlement pattern is assumed to affect capital and investments in school buildings. Local governments are expected to provide services at a decentralized level, and the traveling distances for private or public transportation of pupils in primary schools is regulated by a national norm. Since school and class sizes are smaller in sparsely populated areas, we expect that capital costs tend to increase with traveling distances. Thus, municipalities have better opportunities to exploit economies of scale in densely populated areas. In order to describe the settlement pattern in different municipalities, each municipality is divided into subdistricts with at least 2000 citizens. Each subdistrict is assumed to be able to form a sufficiently large unit for providing effective service production, especially in education and care for the elderly. Distances to the centers of the subdistricts yield information about population density within different municipalities. Another indicator of population density is a measure of distances to the nearest Basic Spatial Unit ("grunnkrets"). Shorter distances are expected to imply lower capital costs. The unit of measurement for these two variables is Norwegian miles, which equal 10 kilometers. Table 5.2 displays statistics for variables included in the analysis.

5.2. Empirical analysis

The empirical analysis in this section reproduces the regression model introduced by Langørgen and Rønningen (2002). The purpose is to compare estimation results for different measures of the endogenous variable, which is depreciation per capita. The measures of depreciation are either based on KOSTRA for 2001, or on the alternative perpetual inventory method that utilizes investment data for the period 1972-2001.

There are 435 observations in the data set. There are no evident outliers in the data on depreciation that are derived from the perpetual inventory method. As one would expect the highest values of depreciation per capita correspond to rich municipalities with high incomes. The ordinary least squares (OLS) method is applied in the analysis of depreciation derived from PIM. However, there are many missing values and outliers in the data on depreciation in KOSTRA. Langørgen and Rønningen (2002) use robust regression to deal with these outliers.

In addition to the OLS method of estimation we also use robust regression, which allows control for outliers in the data set. Robust regression analysis provides an alternative to the least squares regression model when fundamental assumptions are not fulfilled by the nature of the data. There is a family of robust regression methods that replaces the sum of squared errors as the criterion to be minimized with a criterion less influenced by outliers. Here we apply the reweighted least squares method, which treat observations differently with regard to the values of residuals in the model, see Li (1985). Observations with small residuals get higher weights than observations with larger residuals. The least squares method is applied to the reweighted observations. Due to outliers, estimates from the robust regression method are considered more reliable than estimates based on the ordinary least squares method, especially for depreciation reported in KOSTRA. The estimation results from ordinary least squares and robust regression methods for PIM and KOSTRA-data on depreciation are displayed in Table 5.3.

The estimation results show that free incomes per capita have a significant effect on depreciation in school buildings, given that depreciation is measured by PIM. This means that local governments with higher municipal incomes tend to accumulate more capital by investing in school buildings. An increase of one thousand NOK in income gives an increase in depreciation by 7 or 12 NOK in the two regressions based on PIM-data for depreciation. This effect is smaller and insignificant in the regression model based on KOSTRA-data for depreciation. Thus the effect of municipal incomes depends on how depreciation is measured.

Inverse population size has a positive effect, which is statistically significant in all three models. This means that small municipalities have higher depreciation per capita. The coefficient for the indicator for small municipalities is not significant in any of the models. The same applies to the dummy variable for large municipalities; estimates are positive but insignificant. The coefficient for average distance to the nearest basic spatial unit is not significant for depreciation reported in the local governments accounts, but it is significant for the model where depreciation is derived from PIM and estimated by OLS. The coefficient for average distance to the subdistrict's center is positive and significant in all models. Thus municipalities with larger distances tend to invest more in school buildings, which implies that they accumulate more capital and higher depreciation per capita.

The share of youth in primary school age (between 6 and 15 years) has significant coefficients in both regressions for PIM depreciation and in the regression for KOSTRA depreciation. Thus the results support the hypothesis that the demand for school buildings increases with the share of children in school age. The estimate for the share of elderly is insignificant in all three regressions. Estimates for the change of population in school age (i.e. from 6 to 15 years) over the last ten years is also insignificant irrespective of how depreciation is measured. The coefficient for change in the share of population 80 years and above is signifycant in the OLS regression on PIM-data, but insignificant in the robust regressions.

Population growth in municipalities has different effects for different periods. Population growth during the last two years has a negative effect, which is significant in the robust regressions. This implies that there is inertia in the adjustment of real capital to population changes. Thus, the short-run impact of population growth is a reduction in the capital stock per capita, and depreciation per capita is also reduced. Estimates for the previous years are insignificant in the robust regression based on PIM-data for depreciation, while some of the effects are positive and significant in the other two regressions. Thus, we find little support for the hypothesis that per capita depreciation is higher in municipalities with higher population growth. However, the effect of gross migration is positive in all three regressions and significantly so when depreciation is derived from PIM. This result may imply that municipalities with high mobility give a high priority to school buildings due to fiscal competition.

The conclusion from the analysis is that some of our main hypotheses are supported by the regression results, while some of the results are ambiguous for different measures of depreciation and estimation methods. The model based on KOSTRA-data yields higher explanatory power than the models where depreciation is calculated by PIM. Nevertheless, we rely more on the results from the robust regression on PIM values due to missing observations and measurement errors in KOSTRA data on depreciation.

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Appendix A

Calculation of municipal investments and incomes

Rules for calculation of different types of investments

Investment data have been reported by local governments for the period 1972-2001. We decided to include two components in the definition of gross investments in school buildings.

1. Expenses on the construction of new buildings
2. Expenses on maintenance of buildings and constructions

The first component is the value of the initial investment, while the second component adds to the value of assets by counteracting the effect of depreciation, and thereby increasing the lifetime period of school buildings. Expenses on the acquisition of ground are not included in the definition, since the value of the ground is not considered as part of the capital in school buildings. This definition of gross investments has been adapted to three different accounting systems for local governments in Norway that were in use in different periods.

Period 1972-1990:
Chapter 1.21 The nine-year school (Current account and capital account is not separated)

- **Item 150** Maintenance of buildings and constructions
- **Item 151** Maintenance and other expenses (until the year 1978)
- **Item 152** Maintenance of buildings and constructions (for the year 1978)
- **Item 400** Total expenses on new buildings and constructions
- **Item 401** Other expenses in new buildings and new constructions
- **Item 402** Wage costs, new buildings and constructions
- **Item 403** Acquisition of the ground

Item 400 = Item 401 + Item 402 + Item 403
Formulas for calculation of investments:
Period **1972-1977**: Item 151 + Item 400 - Item 403
Period **1978**: Item 152 + Item 400 - Item 403
Period **1979-1990**: Item 150 + Item 400 - Item 403

Period 1991-2000:
Chapter 0.210-229 The nine-year school (Capital account)

- **Item 150** Maintenance of buildings and constructions
- **Item 410** New buildings and constructions
- **Item 480** Purchase of existing buildings and constructions

Chapter 1.21 The nine-year school (Current account)

- **Item 150** Maintenance of buildings and constructions

Formula for calculation of investments:
Item 150 (capital and current accounts) + Item 410 + Item 480

Period 2001-…
(Data from KOSTRA)
Function 0.222 School buildings and transportation (Investment and current accounts)

- **Item 070** Maintenance wage costs
- **Item 200** Furniture and equipment
- **Item 230** Expenses on building and maintenance
- **Item 250** Materials for new buildings and maintenance
- **Item 285** Purchase of existing buildings and constructions

Formula for calculation of investments:
Item 070 + Item 200 + Item 230 + Item 250 + Item 285

Rules for calculation of incomes in municipalities

Period 1972-1990:
Tax incomes
Chapter 1.90 Item 601 minus Item 001 (for years 1972 - 1977)
Chapter 1.900 plus 1.901 Item 601 minus Item 001 (for years 1978 - 1990)

Net transfers from the central government
Chapter 1 minus 10 Item 710 minus Item 310 (for years 1972 - 1979)
Chapter 1 minus 10 sum (from Item 700 to Item 710) minus (Item 300 + Item 310) (for years 1980 - 1990)
Chapter 1.91 Item 601 minus Item 001

Incomes from hydroelectric power licensing
(Included in tax-incomes for this period)

Period 1991-2000:
Tax incomes
Chapter 1.800 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)
Chapter 1.810 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)
Chapter 1.820 sum (from Item 60 to Item 79) minus sum (form Item 01 to Item 39)

Net transfers from the central government
Chapter 1.1 - 1.7 sum (from Item 70 to Item 71) minus sum (from Item 30 to Item 31)
Chapter 1.840 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)

Chapter 1.845 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)
Chapter 1.850 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)
Chapter 1.855 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)

Incomes from hydroelectric power licensing
Chapter 1.439 sum (from Item 60 to Item 79) minus sum (from Item 01 to Item 39)

Period 2001 - …
Tax incomes
Function 800 Items 870, 874 and 877

Net transfers from the central government
Function 100 - 393 sum (Items 700, 710, 800, 810) minus Item 400
Function 840 sum (from Item 600 to Item 890) minus sum (from Item 010 to Item 480)
Function 850 sum (from Item 600 to Item 890) minus sum (from Item 010 to Item 480)

Incomes from hydroelectric power licensing
Function 320 Item 890

Appendix B

Sammendrag

Formålet med denne rapporten er å måle kapital og avskrivninger i kommunale skolebygninger, samt å analysere variasjoner i avskrivninger per innbygger mellom kommuner. Spesielt ønsker vi å undersøke om det er noen sammenheng mellom befolkningsvekst og avskrivninger per innbygger. Bakgrunnen for dette er at kommuner med høy befolkningsvekst hevder at veksten bidrar til økte avskrivninger. I så fall kan det være behov for å gi ekstra kompensasjon til vekstkommunene for at disse skal kunne tilby et like godt tjenestetilbud som andre kommuner.

Kapittel 2 og 3 i rapporten omhandler definisjon og måling av kapital og avskrivninger. Avskrivninger blir fra og med 2001 rapportert inn gjennom KOSTRA, der beregningene bygger på anskaffelseskostnader som blir avskrevet etter en lineær avskrivningsfunksjon. For skolebygninger er levetiden antatt å være lik 40 år i KOSTRA. Statistikken for avskrivninger som baserer seg på KOSTRA kan imidlertid inneholde målefeil og underrapportering. Ved bruk av historisk anskaffelseskostnad kan verdien av kapitalen og avskrivningene bli undervurdert i løpende priser, siden inflasjon med denne målemetoden vil bidra til økt depresiering av kapitalen. Underrapporteringen i KOSTRA kan også skyldes at det mangler dokumentasjon for anskaffelseskostnad, særlig for eldre kapitalobjekter. Dessuten vil vedlikehold og mindre påkostninger vanligvis ikke inngå i definisjonen av kapital og avskrivninger, selv om slikt vedlikehold vil bidra til å forlenge kapitalens levetid.

For å studere betydningen av målemetode og eventuelle målefeil i KOSTRA, har vi utført beregninger av kapital og avskrivninger basert på data for investeringer i kommunale skolebygninger for perioden 1972-2002. Vi benytter flere forskjellige modeller for beregning av kapital og avskrivninger, der det blir gjort ulike antakelser om avskrivningsfunksjon (lineær eller geometrisk) og henholdsvis levetid eller avskrivningsrate for skolebygninger. Resultater fra disse beregningene viser at avskrivninger og inntekter per innbygger er positivt korrelert, slik at kommuner med høye inntekter har en tendens til å ha høye avskrivninger i kommunale skolebygninger. Dette kan skyldes at kommuner med god økonomi har bedre evne til å finansiere kapital og avskrivninger. Resultatene bekrefter også antakelsen om at avskrivningene i KOSTRA er undervurdert.

Kapitalkostnader omfatter avskrivninger pluss rentekostnader som tilsvarer den alternative avkastningen som kan oppnås ved å plassere kapitalen i finansmarkedet. Mens avskrivninger er beregnet i kapittel 3, blir rentekostnader anslått i kapittel 4. Rentekostnadene er anslått for ulike rentesatser som enten er bestemt av forventet realavkastning i oljefondet, eller av renten på banklån eller bankinnskudd i 2001.

Kapittel 5 gir en analyse av variasjoner i avskrivninger per innbygger for kommunale skolebygninger. Analysen benytter både tall fra KOSTRA og egne beregninger av avskrivninger som er omtalt i kapittel 3. Resultater fra analysen tyder på at økte inntekter bidrar til økte avskrivninger for kommunale skolebygninger. Avskrivningene har også en tendens til å øke med andelen av befolkningen som er i skolepliktig alder. Dette skyldes at flere skolebarn gir økt behov for klasserom og skolebygninger.

Små kommuner og kommuner med lange reiseavstander har en tendens til å ha høyere avskrivninger per innbygger enn større kommuner og kommuner med kortere reiseavstander. Dette kan skyldes at små kommuner med lange reiseavstander vanligvis har færre barn per klasse, noe som bidrar til mer kapital og avskrivninger i skolebygninger målt per elev. Det er med andre ord smådriftsulemper og desentraliseringskostnader i tilknytning til skolebygninger.

Befolkningsvekst bidrar til lavere avskrivninger per innbygger på kort sikt. Dette kan skyldes tilpasningstregheter som medfører at det tar tid å bygge opp kapitalen til et høyere nivå som kreves for å betjene en voksende befolkning. På mellomlang og lengre sikt er effektene av befolkningsvekst svakere og mer usikre. Resultatene gir dermed i liten grad støtte til hypotesen om at befolkningsvekst bidrar til økte kapitalkostnader. Vi finner imidlertid at høyere bruttoflytting per innbygger bidrar til høyere avskrivninger per innbygger. Dette kan tyde på at kommuner med høy gjennomtrekk av personer (høy inn- og utflytting) har forholdsvis høye kapitalkostnader. En mulig forklaring på dette er at høy mobilitet fører til fiskal konkurranse mellom kommuner. Slik konkurranse innebærer at kommunene konkurrerer om å tiltrekke seg mobile husholdninger for å styrke skattegrunnlaget. Yngre personer og barnefamilier er overrepresentert blant mobile husholdninger, samtidig som en høy andel yngre innbyggere i kommunen kan bidra til å sikre bosetting og skattegrunnlag på lengre sikt. Vi forventer derfor at kommuner med høy mobilitet vil prioritere tjenester som barnehager og grunnskole. En høy standard på skolebygninger kan med andre ord være et virkemiddel for å tiltrekke seg barnefamilier i kommuner som er eksponert for fiskal konkurranse.

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