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Do road investments lead to economic growth?

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Road improvements lead to benefits in the form of e.g. reduced travelling time, improved traffic safety and reduced emissions. These improvements do not only benefit the actual road users, but they are also “spreading” into the local community or neighbouring communities through several types of effects e.g. enlarged labour markets. There may be “wider” benefits, meaning that the total net benefits of the project are greater than the sum of net benefits of the road users. Actually the question is not whether these “wider” benefits exist, but whether they are of any practical importance or if they might as well be ignored in ordinary economic evaluation. During several decades economists have tried to investigate the hypothesis with varying results depending on model as well as on data.

The present paper follows up our two earlier studies, where we have tried to establish whether road investments contribute to economic growth, which our earlier studies give little support for. Previously we have analysed data for industry sector or for geographical regions. This time we have sufficient data for analysing industry sector within each region. Our approaches are inspired by an article by John G. Fernald presented in 1999.

1. Introduction

Through the latest three or four decades many attempts have been made to investigate the relationship between investments in transport infrastructure and economic growth. The reason for investigating this question is among other things the widespread belief that public investment in infrastructure will generate economic growth. This belief has often been used as a justification for investment in the building of roads, railways and other transport infrastructure.

Improvements of the transport infrastructure will usually lead to travel time savings and improvements of traffic safety and comfort for the road user. Whether these improvements are sufficient to create some extra benefit is however a different question. By this we mean economic benefits beyond the benefits that the road users have themselves, also called positive externalities.

It seems clear that in some situations infrastructure improvements can give substantial contributions to the reduction of production and transportation costs due to e.g. agglomeration effects and the enlargement of markets. Effects like these are usually called allocative externalities, and they are thoroughly discussed in theoretical contributions, e.g. in Banister & Berechman (2000). There is no disagreement concerning the existence of these effects. What can be discussed is their numerical size and whether they are important or not.

There is no debate whether infrastructure investment creates economic activity. Further, there is no doubt that locally any investment will create production and secondary effects as well – even if the

investment seems totally meaningless. This is not what we are talking about here. Neither are we talking about investments that produce growth in one local community at the expense of a neighbouring community – provided the gain is not sufficient to compensate the losers. What this is about is genuine productivity gains that are not outweighed by the losses of other parties.

The discussion has mainly been about what theoretical and practical conditions that would have to be present if investments had such a productive effect. How can these effects be measured in the best possible way avoiding wrong conclusions and especially double counting?

Along with this it must be said that production function and cost function studies concerning the relation between infrastructure investment and production, have been criticised for a number of reasons, as there may be a number of explanations for observing a positive relation between infrastructure investment and economic growth. Among these are¹:

- *Reversed causality*: Some critics claim that increased production per capita may lead to a higher investment rate in public infrastructure capital. Some authors assert that this direction of causality is as likely as the one described above.
- *Common trends*: The growth in gross national product (GNP) as well as infrastructure investments has been strong in most western countries the first three or four decades after World War II. Other, but common factors may be behind the growth in both cases.
- *Left out variables*: The energy crisis in the late seventies occurred at the same time as the stagnation in the growth in GNP and infrastructure investment. Some authors have claimed that one should control for energy prices in the analyses.
- *Simultaneity*: Also unprofitable investments stimulate the local economy. As a consequence one should be very careful while estimating the relation based on data from local communities.

The analysis presented in this document is building on our preceding contributions, and the approach is similar (Eriksen & Christensen 2001 and Eriksen & Jean-Hansen 2008).

In the present document we will proceed discussing the conditions for economic growth related to transport investments in chapter 2. In chapter 3 we present the problems that we are addressing in the analysis. The model, the data and the estimation method will be reviewed in chapter 4. The results are presented in chapter 5. At last in chapter 6 the results are discussed and some conclusions are drawn.

2. Previous research

This field has been the subject of research over a very long period, but the revival of the field started when David Aschauer presented several articles. See e.g. Aschauer (1989). He found a strong relation between the growth in public infrastructure capital and productivity growth in private industry. The

¹ Mainly from Isacsson & Hultkantz (no date).

study was based on American time series data. This was the start of a strong flourishing of research in this field. Some of these contributions sought to disprove Aschauer's findings, and others in the studies modified the strong effects that Aschauer found by applying slightly different models.

Most of these contributions were studies of aggregated production functions or cost functions. The main reason for the debate was that Aschauer found very high elasticities of GNP with respect to public investments (output elasticities), actually as high as 0.34 and more (in special cases). This implies that a 10 percent increase in infrastructure investment leads to a 3.4 percent increase in gross production. Munnell (1990A) applied a similar approach, and she as well found strong outputs from infrastructure investments – by the same size order as found by Aschauer.

The background for the strong interest in this field in that particular period was mainly that the strong growth that was observed in the post war period stagnated in the mid nineteen-seventies, especially in the USA. Many authors saw as their mission to explain why this flourishing growth period had come to an end – at least temporarily. What Aschauer and Munnell wanted to point to was that the lack of public infrastructure capital might be an obstacle to further economic growth.

There were several reasons that other authors were criticising the results of Aschauer and Munnell. First, several authors meant that causality might as well be reversed (see chapter 1). There was made no attempt to split between cause and outcome. They were also criticised for leaving out important variables.

Some authors like Tatom (1991) performed analyses where no significant results were found. Tatom used a detailed model, specified on industry branches. He also specified other variables, like energy price. However, Munnell (1990B) performed a similar regional analysis, where she found lower coefficients at around 0.15, but still significant.

Other analyses as well show significant results, but with quite small output coefficients compared to those found by Aschauer and Munnell. Among these are Morrison & Schwartz (1992) and Nadiri & Mamuneas (1993). Other studies, like Holz-Eakin & Lovely (1996) are based on complicated models without producing more significant results, merely weak positive indications. Hulten (1996) did an analysis of data from several countries. His conclusion was that the degree of utilisation is even more important than new infrastructure investments.

Over time these studies tend to show lower or even insignificant values for output coefficients. One part of the explanation may be what Fernald (1999) points at, namely that even if investments in the transport sector may have a good effect in a certain period of history; this may not be the case at all times and under all circumstances. Fernald's findings indicated that the productivity of road investments in the US was very much reduced after the finishing of the interstate highway system around 1970. Fernald in his model assumes that high vehicle intensity in a sector will enhance the relationship between road investments and productivity change. By applying this model on data from post-war USA, he found significant and quite high output coefficients for the 50s and 60s (up till -73), but a considerably lower for the mid 70s and the 80s.

Later Kopp (2004) followed a similar approach to Fernald in his analysis for western European countries for the period 1975-2000. He found significant, but rather low productivity coefficients, about 0.05.

Eriksen & Christensen (2001) did an analysis of Norwegian data from the 1960s till 1997. The model was quite similar to the one formerly applied by Fernald on US-data. Like Fernald they applied a model where the data was divided in industry sectors. For the period 1963-1991 we find quite unexpected results: some strongly significant coefficients, but with a *negative* sign. The interpretation of this quite unexpected result being that road investments lead to reduced productivity in industry. What can be the explanation of these contra intuitive results? Is there a spurious relations involving variables that influence road investment and productivity in different directions?

Especially in the first decades after World War II road works were frequently used as remedy to reduce unemployment and also to stimulate economic activity in slimly populated regions. Both these strategies may lead to preferring socially unprofitable road project to profitable ones. These tendencies have been pointed to by Odeck (1996) and Fridstrøm & Elvik (1997). Contrary to Norway, in USA social evaluations of road projects were already frequently used in this same period, which may have influenced Fernalds results.

Eriksen & Jean-Hansen (2008) applied a model similar to Kopp's model, which means that the model had a geographical dimension instead of an industrial one. For each of the years 1997-2005 National accounting data is available on a county level. Before that county data was just available for selected year. Based on data from the Public Roads Administration road capital on a county level is estimated. Eriksen & Jean-Hansen found weak positive, but insignificant relationships in all versions of the model.

3. Description of the problem

The aim of the project is to contribute to the answering of the following question:

Do investments in public infrastructure lead to higher economic productivity in the private industries?

This is the main problem, which may be widened or narrowed in different ways. Here we will limit ourselves to looking into road investments. This is due to the fact that Fernald's model is designed especially for road investments. An additional point is that road investments has for a long time been the subject of huge interest in the public debate in Norway.

As mentioned in the introduction: The fact that road investments create economic activity must not be confused with it contributing to increased productivity. From the viewpoint of a local community all projects may be welcomed since local demand and work places will be the result of this activity. From the viewpoint of society this is of course not sufficient to judge that a road investment is socially profitable. It may also be the case that it is profitable for one community at the expense of a different community or the total society. Whether this is socially profitable depends upon whether the winners can compensate the losers and still have some of the benefit left. The question remains, however: Are there any wider economic impacts? That is, are there benefits beyond the benefits of the road user? Actually this is the same as asking whether there are positive externalities.

The questions are addressed from a macro perspective. The mechanisms that lead to positive externalities are not discussed here.

However, from society's viewpoint the question may be whether the investment is acceptable from an equity perspective, either socially or geographically. This question is not treated in this analysis. We are limiting ourselves to a traditional social evaluation perspective. Although in the analysis we will look into regional differences.

4. Analytical framework

4.1 The model

By the two previous studies we have performed in this field we either have run sector-wise regressions like in Eriksen & Christensen (2001) or by county (Eriksen & Jean-Hansen 2008). In the present analysis regressions are run by county (region) as well as by industry sector within each geographical region. This has been made possible by improvement of the statistics.

Let the gross product of sector i in county j , be a function of capital (excluding vehicles), K_{ij} , labour L_{ij} and transport services, T_{ij} , which again is a function of road stock in the county, G_j and the stock of vehicles, V_{ij} . Output also depends upon neutral technical level, U_{ij} .

We assume that production in each sector within the counties may be described by:

$$(1) \quad X_{ij} = U_{ij} \cdot F_{ij}^j [K_{ij}, L_{ij}, T_{ij}(V_{ij}, G_j)] \quad \text{for all } i \text{ and } j.$$

The way transportation is represented in the model is as a transport aggregate, which says that transport service from the road infrastructure is enhanced by the number of vehicles in the sector within the region.

We assume free competition and that the scale elasticity equals unity. Then profit maximisation implies that the production elasticity for a factor equals the budget share of that factor. E.g. if we call the cost share of capital S_{Kij} , this will be equal to $F_{Kij}' \cdot K_{ij}/X_{ij}$. We will have similar expressions for labour and vehicle capital.

The production function (1) may have a general form except that the scale elasticity is supposed to be equal to unity.

The function for the transport aggregate T_{ij} in sector i is assumed to be of the Cobb-Douglas form:

$$(2) \quad T_{ij} = T(V_{ij}, G_j) = A V_{ij}^{\gamma} G_j^{\gamma}$$

Here the ratio of the elasticities with respect to V_i and G can be expressed as:

$$(3) \quad \frac{F_{G_j}'}{F_{V_{ij}}'} \frac{G_j}{V_{ij}} = \frac{T_{G_j}'}{T_{V_{ij}}'} \frac{G_j}{V_{ij}} = \frac{\gamma}{\gamma} = \phi$$

The indicators on industry branch have been omitted. As seen this ratio is constant for all sectors. This rather inflexible function form has not been chosen because this ratio needs to be constant, but for mathematical simplicity. The main point is that there probably is a high degree of co variation between vehicle intensity and road capital's contribution to productivity. More general function

forms may be applied, but the mathematically convenient Cobb-Douglas formulation is sufficient to illustrate the point.

Since we assume free competition and the scale elasticity equals unity, the production elasticity for capital $F_K' \cdot K/X$ equals the budget share of capital, S_K , and likewise for all other production factors. (The “i” for sector has been omitted).

By applying this and (3) for the sector “i” we get the simple relationship:

$$(4) \quad S_{Gj} = F_G^{i'} \frac{G}{X} = \phi \cdot S_{Vij}$$

The elasticity with respect to road stock is proportional to the cost share of vehicle capital. As may be seen from (4), all vehicle cost shares in each sector should be equal ($=S_{Vj}$) within each region. We will, however, take S_{Vij} as observations for S_{Vj} .

We let lower case letters denote logarithms of the main variables. By combining with (4) the relative growth of the gross product may be written:

$$(5) \quad dx_{ij} = du_{ij} + S_{Kij} \cdot dk_{ij} + S_{Lij} \cdot dl_{ij} + S_{Tij} \cdot (s_{Vij} \cdot dv_{ij} + s_{Gj} \cdot dg_j) \\ = du_{ij} + S_{Kij} \cdot dk_{ij} + S_{Lij} \cdot dl_{ij} + S_{Vij} \cdot dv_{ij} + \phi \cdot S_{Vij} \cdot dg_i$$

Here S_{Tij} is the cost share of the transport aggregate, and the lower case s-es are cost shares of the cost share for vehicle costs and road costs.

The relative productivity growth for the privately paid production factors is called Solow's productivity residual and is defined by:

$$(6) \quad dp_{ij} = dx_{ij} - S_{Kij} \cdot dk_{ij} - S_{Lij} \cdot dl_{ij} - S_{Vij} \cdot dv_{ij}$$

By inserting in (5) this becomes:

$$(7) \quad dp_{ij} = \phi \cdot S_{Vij} \cdot dg_i + du_{ij}$$

It is evident from (7) that productivity growth depends only on growth in road capital and upon technological change.

Here there is a possible danger of simultaneity bias since reversed causality cannot be ruled out. We therefore make some additional assumptions:

$$(8) \quad du_{ij} = c_{ij} + d\bar{u}_j + \varepsilon_{ij}$$

The averages of the variables are defined similar to (7):

$$(9) \quad d\bar{p}_j = \phi \cdot \bar{S}_{Vj} \cdot dg_j + d\bar{u}_j$$

By inserting (8) and (9) the expression for productivity growth may be written:

$$(10) \quad dp_{ij} = c_{ij} + \phi \cdot (S_{Vij} - \bar{S}_{Vj}) \cdot dg_j + d\bar{p}_j + \varepsilon_{ij}$$

By inserting $dp_{ij}^* = dp_{ij} - \bar{dp}_j$ and $S_{vij}^* = S_{vij} - \bar{S}_{vj}$, the regression equation may be expressed as deviations from an average:

$$(11) \quad dp_{ij}^* = c_{ij} + \phi \cdot S_{vij}^* dg_j + \varepsilon_{ij}$$

Equation (11) provides a simple linear relationship that seems suitable for statistical estimation.

4.2 The data and estimating

The data source is National Accounting data for the period 1997-2005 from Statistics Norway and data from the Norwegian Public Roads Administration concerning road investment size and geographical distribution.

The basic data is the same as for Eriksen & Jean-Hansen (2008). The difference in the present analysis is that industry sector is introduced as a new dimension. With six sectors within each county this gives six times as many observations as before. Public administration is not included. We have the following sectors:

1. Fishing, farming, forestry
2. Manufacturing and mining
3. Building and construction, production of energy and water
4. Gross and retail trade
5. Transportation and oil exploitation
6. Services, other

Some simplifications are necessary to get data on the detailed level of county and sector. We have used gross production as a proxy variable for calculating these inner distributions. Obviously, in some cases this method can produce wrong results. Hopefully, the sizes are not totally wrong. The fact that variables are expressed as relative changes probably makes them less sensitive to variations in the size of the absolute level.

For the years prior to 2003 the size of the road capital is estimated by Statistics Norway. For the following years, estimations are done by TØI (ref Eriksen & Jean-Hansen 2008). This may cause a break in the series of figures that is not accounted for in this analysis.

Solow's productivity residual is calculated by the following proxy as the growth from one year to the next:

$$(12) \quad \Delta p_{ij} = \Delta x_{ij} - S_{kij} \cdot \Delta k_{ij} - S_{lij} \cdot \Delta l_{ij} - S_{vij} \cdot \Delta v_{ij}$$

Here Δp_{ij} is the relative productivity growth from one year to the next one and similar for the other variables.

As mentioned all variables are measured at current prices, not indexed.

The cost for using capital is calculated from the simplified formula:

$$(13) \quad P_K = P_J \cdot (r + \delta)$$

Here P_K is the price for the use of capital, P_J is the purchasing price for capital goods, r is the discount rate, and δ is the yearly depreciation rate.

As can be seen, data is a mix of time series and cross section. Since data is on augmentation form the regression data only comprises eight periods.

Regressions are run with lagged as well as unlagged time series. As mentioned above lagging may be a way of counteracting reversed causality, since here productivity growth will follow after infrastructure improvements and not before.

We have chosen to include time as a variable in all alternatives. In some alternatives we have also included variables for region. Some experiments with variables for industry sector were performed, but these runs offered little explanation in addition, and the results are not included here.

Due to the lagging the number of observations varies from 570 to 870. The general regression equation is:

$$(14) \quad \Delta p_{ij}^* = c_{ij} + \phi \cdot S_{vij}^* \cdot \Delta g_j + r_1 \cdot R1 + r_2 \cdot R2 + r_3 \cdot R3 + t \cdot TID + \varepsilon_{ij}$$

Here R1, R2 and R3 are dummy variables for region (seven regions), TID denotes time, starting with 1998(=1).

5. Results

5.1 Productivity in the regions

The regions (LF1²...LF7) in the model are based on the 19 counties of Norway and follow the classification used by Statistics Norway.

LF1 – Oslo and Akershus,	R1=1, R2=0, R3=0
LF2 – Hedmark and Oppland	R1=1, R2=1, R3=0
LF3 – Østfold, Buskerud, Vestfold and Telemark	R1=1, R2=1, R3=1
LF4 – Aust-Agder, Vest-Agder and Rogaland	R1=0, R2=1, R3=0
LF5 – Hordaland, Sogn og Fjordane, Møre and Romsdal	R1=0, R2=1, R3=1
LF6 – Sør-Trøndelag and Nord-Trøndelag	R1=0, R2=0, R3=1
LF7 – Nordland, Troms and Finnmark	R1=0, R2=0, R3=0

The productivity development over the years 1997-2005 is displayed in figure 1.

² Based on regions (= Landsdeler) and counties (= Fylker).

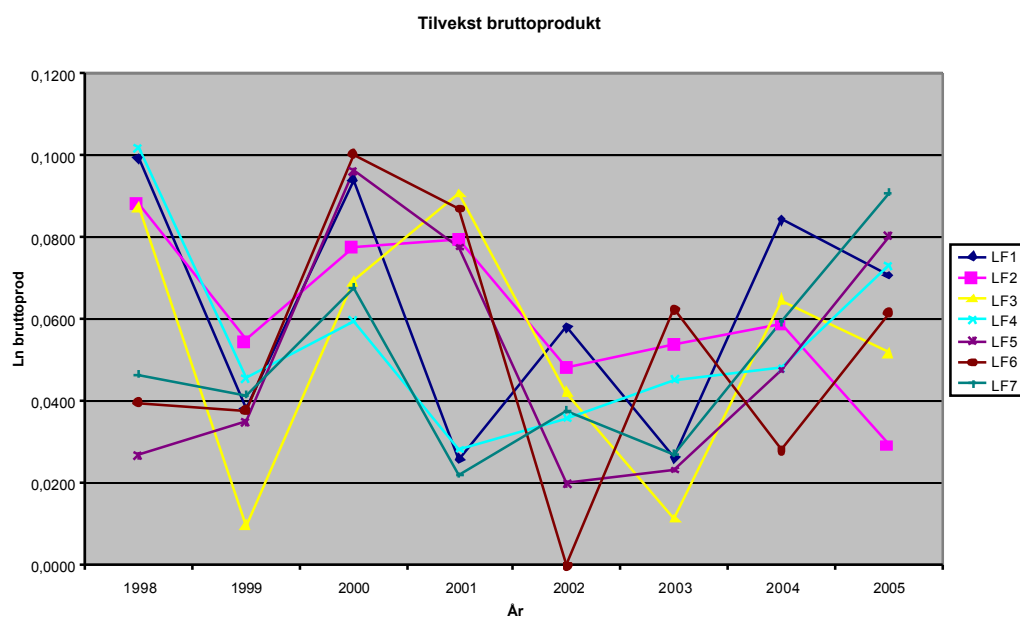


Figure 1. Logarithmic growth of gross product in private sector by region.

As may be seen, the regions to some extent show a parallel development the first part of the period up till 2000-2001. After that the picture gets more blurred, and fewer common features are seen. From 2002 gross product grow at an increased rate in all regions.

Returning to Solow's residual, which is defined as productivity growth minus the weighted sum of the three production factors, we see a quite parallel development, as depicted in figure 2. This is also described in chapter 4.1.

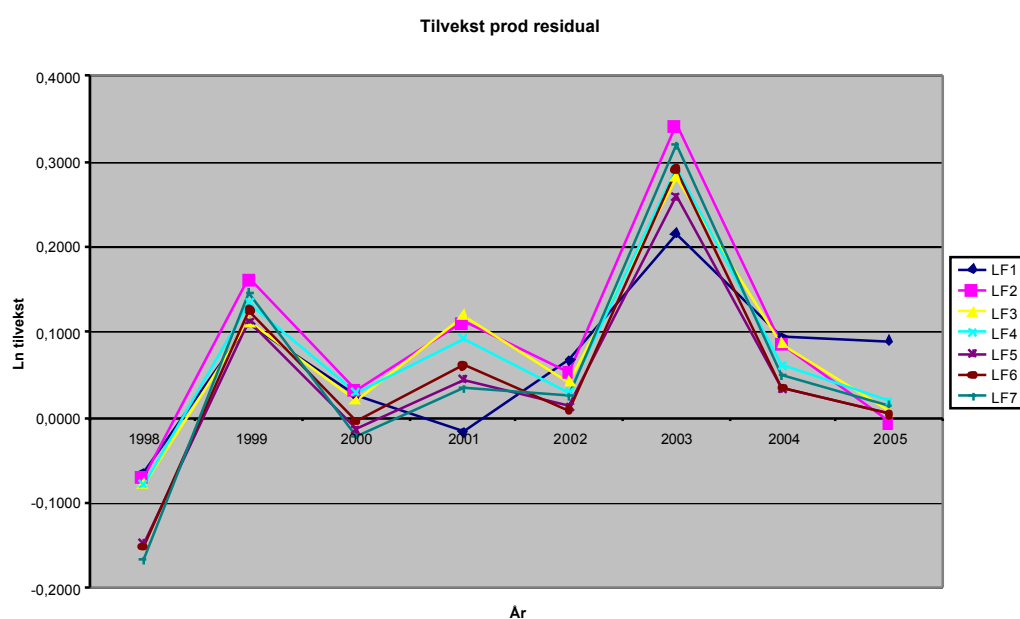


Figure 2. Logarithmic growth in Solow's productivity residual by region.

Over time most regions have a positive development. The direction of change is the same in all cases, but one. The change rates, however, varies a bit, which may be seen from figure 3. This figure depicts deviation from the average values. Here it shown that development in some regions varies a lot, while it in other regions is quite stable.

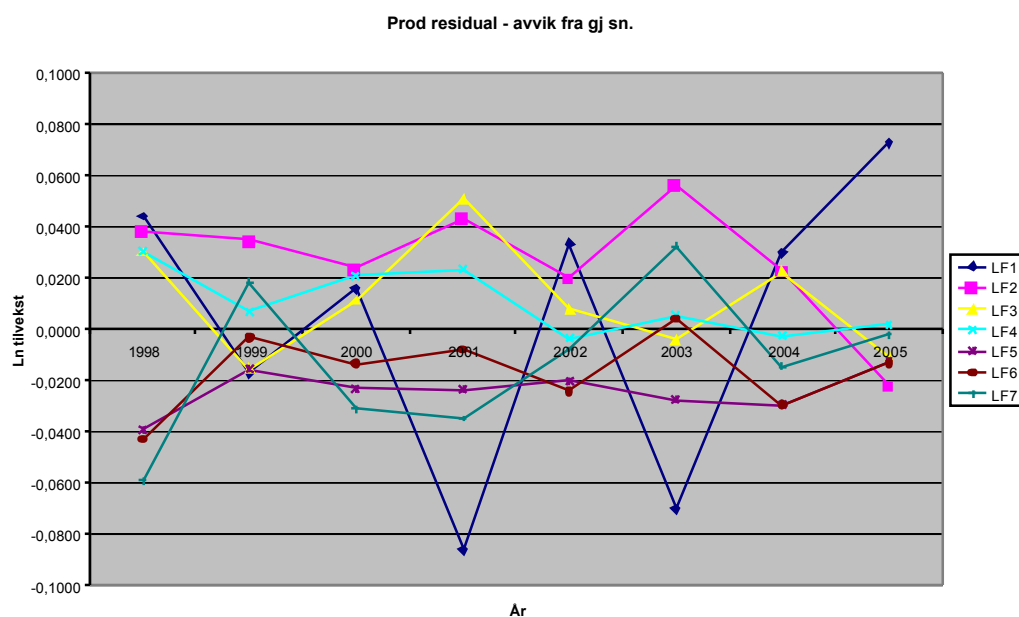


Figure 3. Logarithmic growth in Solow's productivity residual by region.

5.2 Regressions

The statistical estimations are all based on equation (14) or lagged versions of it. There are four main models, unlagged (L0) and lagged by 1 (L1), 2 (L2) or 3 (L3) years.

As mentioned above other varieties are tested –with little success so far.

The model L0 describes the relation between the productivity residual and growth in road capital weighted by vehicle intensity in accompanying county and sector and for the same year. Two varieties of the model are included, Regr 1 with just weighted road capital and time as variables and Regr 2 with weighted road capital and time and including three dummy variables for region as well.

Results of the runs with Model L0 may be seen from table 5.1.

Table 5.1. Model L0, unlagged: Productivity growth and growth in weighted road capital

		Coefficient	t-stat	P-value
Regr 1	Constant	-0,029	-2,868	0,004
	Weighted road capital	1,230	1,352	0,177
	Time	0,021	10,174	4,8E- 23
Regr 2	Constant	-0,1074	-7,8335	1,4E- 14
	Weighted road capital	0,852	0,9723	0,331
	Time	0,029	13,038	1,3E- 35
	R1	0,038	3,756	0,000
	R2	0,060	5,551	3,8E- 08
	R3	0,008	0,741	0,459

As mentioned, L1, L2 and L3 are similar models lagged with 1, 2 and 3 years. The results may be seen in tables 5.2, 5.3 and 5.4.

In all these runs, we can see, the constant term and the time term are clearly significant in all runs. A significant time parameter indicates that the closer we get to 2005 the bigger effect from transport investments.

The most important findings are that coefficient for weighted road capital is significant for the Model L2, but not for the other alternatives. This means that a lag of two years seems optimal for road investments to bear fruits in the form of benefits for private industries. No lagging or lagging by one or three years, however, produces insignificant or even inconsistent results. No lagging and lagging by three years give positive, but insignificant coefficients, while lagging by one year produces *negative* insignificant coefficients.

Returning to Model L2 (Table 5.3) we find the coefficient for weighted road capital to be 3.35. From equation (4) we can deduct an output elasticity of just below 0.02 provided an average cost share of 0.005. This implies that an increased road capital of 10 percent would produce an increment in productivity by 0.2 percents. Compared to the effects found e.g. by Aschauer (1989) the effect is very modest.

The Regr 2 runs show that the difference between regions is quite stable and partially significant. Table 5.3 shows that R1 is significant on 10 % level, while R2 is also significant on a 5 %. R3 has negative sign and is not significant. Leaving the question of significance, and adding the effects, it seems that the difference between regions is quite modest. Southern inland Norway and southern

coastal Norway have the highest effect of road investments. The lowest effects can be seen for middle and northern Norway.

Table 5.2. Model L1, lagged 1 year: Productivity growth and growth in weighted road capital

		Coefficient	t-stat	P-value
Regr 1	Constant	-0,062	-5,886	5,8E- 09
	Weighted road capital	-0,951	-1,045	0,296
	Time	0,033	14,04	3,7E- 40
Regr 2	Constant	-0,123	-9,127	5,7E- 19
	Weighted road capital	-1,126	-1,276	0,202
	Time	0,038	15,918	1,0E- 49
	R1	0,003	3,322	0,001
	R2	0,052	4,968	8,3E- 07
	R3	0,002	0,225	0,822

Table 5.3 Model L2, lagged 2 years: Productivity growth and growth in weighted road capital

		Coefficient	t-stat	P-value
Regr 1	Constant	-0,120	-10,875	1,64E-25
	Weighted road capital	3,356	3,339	0,001
	Time	0,0532	18,835	5,0E- 64
Regr 2	Constant	-0,135	-10,214	7,0E- 23
	Weighted road capital	3,212	3,208	0,001
	Time	0,053	18,937	1,6E- 64
	R1	0,017	1,713	0,086
	R2	0,024	2,227	0,0263
	R3	-0,014	-1,362	0,173

Table 5.4 Model L3, lagged 3 years: Productivity growth and growth in weighted road capital

		Coefficient	t-stat	P-value

Regr 1	Constant	-0,051	-4,437	1,0E- 05
	Weighted road capital	0,560	0,532	0,595
	Time	0,0246	7,151	2,7E- 12
Regr 2	Constant	-0,107	-7,808	1,7E- 14
	Weighted road capital	0,339	0,343	0,731
	Time	0,029	13,032	1,4E- 35
	R1	0,038	3,744	0,000
	R2	0,060	5,606	2,8E- 08
	R3	0,001	0,740	0,460

6. Conclusions and further work

Just in one of the four tested models there is a clear connection between road infrastructure improvements and the productivity of private industry. A time lag of two years, however, provides a significant relationship between the two. This is maybe reasonable considering the time it usually takes from an investment is made until the improved road infrastructure will come into use. Models with other lags or no lags offer no significant relations.

Over time, if we look at our three studies, Eriksen & Christensen (2001), Eriksen & Jean-Hansen (2008) and the present study, the results have changed from strongly negative and significant coefficients, via vaguely positive, but insignificant relations to positive significant coefficients, at least for one of the models. One thing that speaks for the present analysis is that it is based on a larger data material than the previous ones.

If we were to draw some conclusions from this, it might be that road investments after all *may* have had a productivity enhancing effect. It seems that earlier this tendency earlier may have been influenced by a propensity to invest in a traditional sense socially unprofitable road projects.

The grounds for this may be regional policies as well as contra business cycle policies. This is supported by the findings of Odeck (1996) and Fridstrøm & Elvik (1997). Both articles find a lack of correspondence between calculated the *ex ante* profitability of projects and what projects that are actually carried through *ex post*.

The findings of the present analysis indicate that this very political way of using road investments have decreased in later years. Cost-benefit analyses have long been compulsory in Norway, however compulsory to prepare but not compulsory to follow. As we have seen, quite frequently CBAs are overturned in favour of political judgments. There are, however, signs that social profitability has come more into focus over time. More toll-road projects over time may have contributed to that, since social profitability is usually weighted for these projects. Thus it is therefore possible that

different road investment policies in earlier years might have led to better profitability concerning industry productivity.

What has not been treated is the ordinary consumer benefits from better roads in the form of reduced travelling times and/or improved comfort. For consumers the result is saved costs or higher utility. In the next round this may lead to an increased demand for goods and services. See e.g. Banister & Berechman (2000). Only the materialised sides, like consumption or labour supply may be caught in an econometric model. How to catch the non materialised benefits is still a considerable challenge.

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