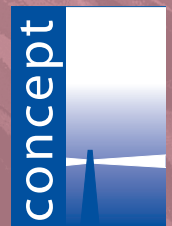


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Efficiency and Productivity in Norwegian Road Construction 2007-2016

Concept report no. 57



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Productivity is a measure of how much we get out of the resources that are used for a production purpose, that is, the relationship between total production and resource use. The ratio between a company's or organization's actual productivity and the best practice norm (e.g., the highest observed productivity in the industry) is referred to as efficiency.

Productivity growth plays a key role in cutting production costs, enhancing competitiveness, and fostering economic growth and prosperity. The Norwegian Productivity Commission (NOU 2015: 1) points out that there has been sevenfold increase in Norway's value creation in real value since 1930, while the productivity growth in mainland Norway in the period 1970-2004 was higher than in other countries. Productivity growth has since then slowed down.

The building and construction sector plays a significant role in Norway by providing infrastructure, and for employment and value creation. According to the National Accounts, the building and construction industry employed 227 400 persons and had a gross product of NOK 182.2 billion in 2016. With this, the industry constitutes Norway's second largest mainland industry according when the public sector is not considered. In the period 2001 to 2016, the total factor productivity of the industry declined by 1.3 percent annually while total factor productivity increased by 1.1 percent annually for mainland Norway in general. This development is of concern both to the authorities and the industry.

However, there are several reasons why the productivity development may be underestimated in analyzes based on public statistics from Statistics Norway. Among others, this may involve intertemporal changes in contextual factors such as technical requirements, and conditions such as challenging ground conditions and increased construction in urban areas that are not given special emphasis. In this project we have tried to shed light on the industry's productivity development and the importance of contextual factors by means of undertaking two comprehensive productivity analyzes:

- i. **Industry analysis:** A study of the industry's productivity development based on the national accounts
- ii. **Micro study:** A productivity and efficiency analysis of road construction

In the industry analysis, we assess the importance of the industry's price deflators, delimitation, and heterogeneity in input factors for productivity measurement. The analysis and results are reproduced in their entirety in Holmen (2019a), but the main conclusions from this analysis are given in chapter 3. The main emphasis in this report is on the micro study. In the summary in chapter 7 we compile the lesson from both studies: Both studies find a weak productivity development, even when contextual factors are considered.

The micro study deals with the development of efficiency and productivity in road construction, and analyzes 137 road projects that were completed in the period from 2007 to 2016. The data were collected by the Norwegian Public Roads Administration in collaboration with the Institute of Transport Economics and the project group. Compared to previous studies of the building and construction sector, which typically look at average trends in productivity, our study examines a more homogeneous sub-sector of the construction industry. We calculate the efficiencies of the projects using best practice projects as references, and estimate productivity change as a relative change in efficiency from one year to another.

A key challenge in empirical productivity and efficiency analysis is to establish a set of variables that give a sound description of the use of resources and what is being produced, as well as contextual factors that affect productivity. This applies to this micro-study, which in particular handicapped by the fact that input data including labor and capital are not available. We have consequently used total costs as the only resource variable. However, our model gives a broad description of outputs and output quality. The main output of the road construction projects is the meters of road constructed, but the lengths of bridges and tunnels and the road width are included to make the projects more comparable. The latter variable is an established measure of road quality and increases in line with the traffic.

The costs will be affected by environmental variables or contextual variables that a contractor cannot influence. We have used indicators for urban areas, ground conditions, water crossings, and topography. These variables have been selected in consultation with experts within the Norwegian Public Roads Administration, and allow an overall assessment of how construction in urban areas, challenging ground conditions, water, and topography affects the costs of road construction.

We have used three methods while implementing the micro study: non-parametric Data Envelopment Analysis (DEA) as the main tool, Stochastic Frontier Analysis (SFA) and a hybrid method combining non-parametric and parametric analyses (StoNED). Method triangulation is useful for robustness testing of the results. We see this clearly in the micro study, where the results differ between the methods.

The main conclusion is that productivity development of road construction projects has been weak. Other key findings include:

- Small projects are more productive and cost effective than large projects (scale disadvantage)
- There are differences in productivity between regions, where the eastern region exhibits the highest cost level but also undertakes the largest projects
- Conditions such as topography, ground conditions, and population density affect the costs, although the methods and model specifications used do not give a clear answer to which variables are most important

The micro study's most important and surprising finding is that small projects are more productive than large projects. This discovery appears to be robust with regards to the methods and model specifications considered.

Figure S1 reports productivities (using DEA analysis) of each road project in the data set, grouped according to region and economic size. The latter variable is indicated by the width of the bars, i.e., wide bars indicate large projects, while narrow bars indicate small projects (relative to the overall portfolio of projects). A productivity score of 1 implies that the project represents best practice, while a score of less than 1 indicates inefficiency.

Figure S1 clearly shows that the smallest projects (here indicated by the narrowest bars) have the highest productivity scores. At the same time, the figure shows that large projects typically exhibit narrow confidence intervals, which means that low productivity scores for large projects is a robust finding.

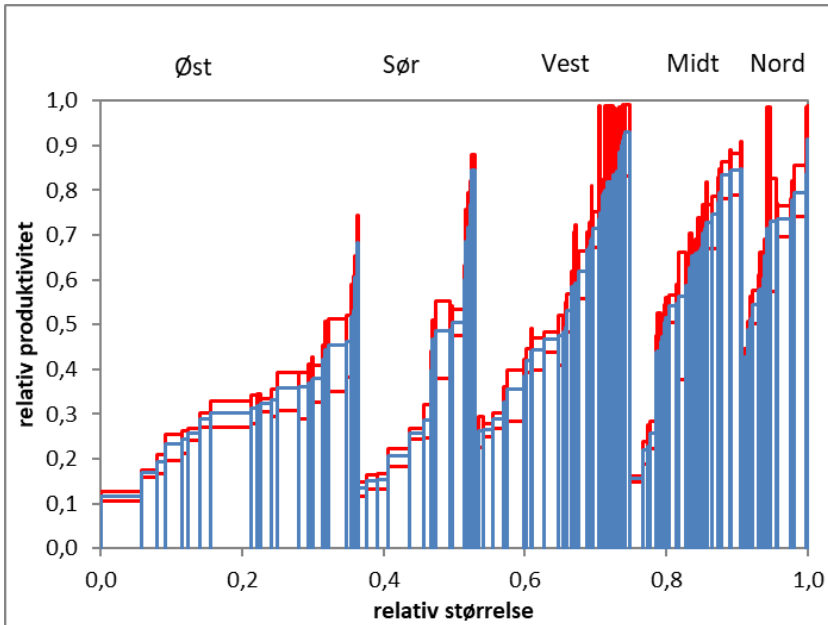


Figure S1. DEA bootstrap corrected productivity targets sorted by road region (M1). The width of the histograms corresponds to the project's share of total costs. 95% confidence interval

Our findings point towards that well-informed choices of project sizes and locations, as well as mapping and dissemination of the regions' routines for management of road construction projects could improve productivity. We encourage robustness testing of these conclusions in further research.

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