# Why do costs of civil engineering grow faster than prices in general?

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## Abstract

In recent years infrastructure ownership has been privatised. New public infrastructure is being built according to different public-private cooperation models. Despite the privatisation, the public sector – local and central government – finances a major share of new infrastructure. The international financial crisis and its impacts on the public economy make infrastructure maintenance considerably more difficult and cut investment in civil engineering. Along with scarce financial resources, the problem is exacerbated by the rising costs of civil engineering. Several input prices of civil engineering have increased clearly more than prices in general.

The issue is examined on two levels: the international and national levels. The used material consists of statistics compiled by Eurostat and the national statistical office as well as material acquired from clients. The aim of the two-level examination is to first determine whether the increased cost level of civil engineering is a global, a national or a cyclical phenomenon. Another aim is to discover the reasons for the runaway costs of civil engineering and whether their rise can be brought under control. The study will use primarily statistical methods.

The main reasons for the rise in the cost level are the increase in the prices of fuels and taxation. Changes in the content of infrastructure projects also tend to raise the cost level. Whatever the reasons, the situation forces the public sector to try and choose the most beneficial projects. The rapid rise of costs increases the pressure to improve productivity.

**Keywords: cost, price, civil engineering, time series**

## 1. Background

Civil engineering projects typically have a long lead time from planning to completion. The majority are financed by the public sector. Decisions are made at several stages in all civil engineering projects, especially in public ones. The costs of a project must be estimated at

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the same time. The first cost estimates are prepared already at a very early stage based on rough plans by comparing alternative solutions.

As planning proceeds, the content of projects becomes more precise and their scope tends to widen. In projects of long duration, even amendments to laws, e.g. on safety requirements or tax solutions, manage to increase costs. It has been noted that used cost calculation methods do not work on pricing of risks, pricing of projects implemented in difficult conditions (e.g. in a dense urban structure), or pricing of demanding types of work like tunnels. (Haapamäki, 2007)

Cost overruns are also caused by the failure to take a rise in cost level into account. That is more pronounced when the input costs of civil engineering increase significantly more than costs in general. If allowance for an increase in cost level is not made in comprehensive contracts, the profitability of contractors suffers. Clients, on the other hand, must know how to prepare for higher input costs both in traditional procurement models with an index clause and new procurements based on an alliance contract. (Hurskainen, 2009)

There are deficiencies in the cost management of civil engineering projects. It has been suggested that better understanding of the operating environment and monitoring of business cycles and markets can also improve cost management. Scheduling of projects so that unintended over-demand is not created by projects involving the same types of work or selection of the appropriate procurement model and contract form for each economic situation are suggested as means of managing costs. (Hurskainen, 2009)

This paper delves into the cost formation and cost level changes of civil engineering. The goal is to determine the factors influencing the sector’s cost level, which would allow looking for ways to forecast cost developments. The target is member states of the European Union, one of which is examined in more detail.

## 2. Material and methods

The study consists of two parts. The first part identifies the factors influencing the cost developments in one country (Finland) and compares the results with changes in the levels of civil engineering costs in other European countries.

The second phase of the project involved searching for variables that would allow forecasting cost changes. For that, the correlations between variables describing civil engineering and its operating environment and cost developments were analysed.

Used research material consisted of public official statistics on civil engineering and its operating environment. The source of national data is Statistics Finland and that of European data Eurostat.

## 3. Civil engineering cost development in Finland

In Finland, the development of civil engineering costs is measured by an input cost-type cost index of civil engineering works as in most European and OECD countries. The input price index or input factor price index measures the weighted, combined price development of factors of production consumed in construction (labour, construction materials and components, services, machine work, etc.). The impact of each factor of production on the index corresponds to its share of the construction budget. The input price index describes the change in the construction costs of a construction lot, unchanged in terms of production technology and input cost breakdown, from the base year to the period under review. A construction lot or input structure is a combination of 40 different type contracts. Input price developments are based on market prices compiled either specifically for the cost index of civil engineering works or its parallel indices. (Official Statistics of Finland, 2005)

Based on this cost index of civil engineering works, sector costs have increased twice as much as the general price level since 2000 (figure 1). The inputs in civil engineering with the biggest impact on the development indicated by the index are fossil (fuel point figure 195 and bitumen point figure 385). The general price level increase is based on the cost-of-living index (2000=100). Costs of civil engineering works have also developed differently from those of building construction.

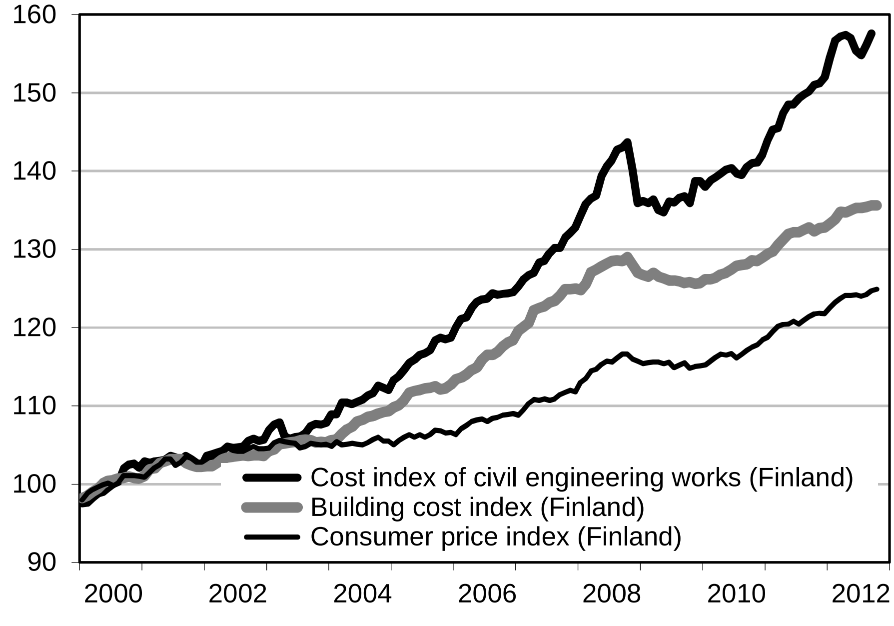


***Figure 1: Costs of civil engineering works have increased twice as much as consumer prices in Finland. Index 2000=100. Source: Statistic Finland.***

The cost level of Finnish civil engineering works measured by the national index and adjusted to the European cost level (EU=27) rose at the same rate from 2002 to 2005. In 2006−2007 the Finnish cost level rose at an accelerated rate compared to the general European cost level. National statistics indicate that the Finnish cost level has continued to rise at an alarming rate since 2007. Yet, the Finnish price level has fallen compared to the

European price level (figure 2). This allows drawing the conclusion that European costs have increased even more.

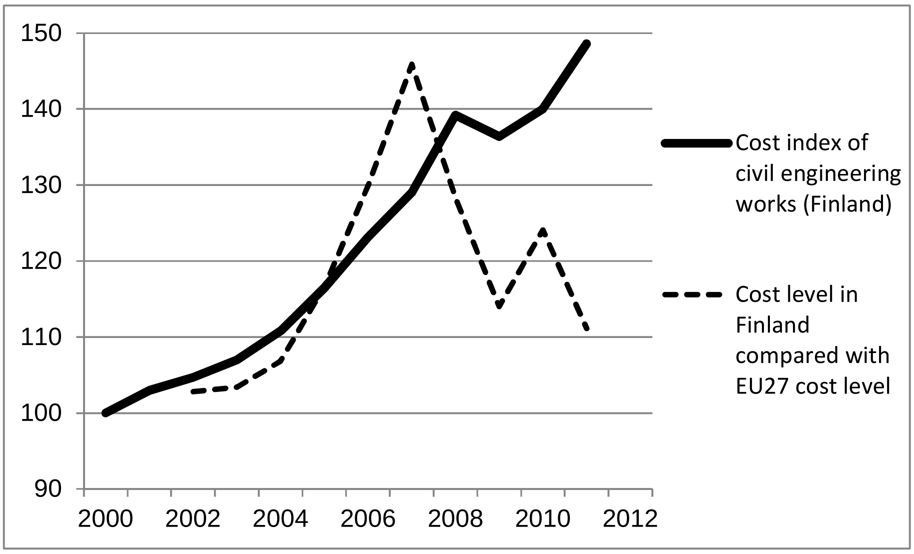


***Figure 2: Costs of civil engineering works (Finland) have increased but price level has depreciated against EU27 price level. Sources: Statistic Finland and Eurostat.***

Since 1993 construction clients have been asked to give their views on the level of civil engineering tender prices. According to them (figure 3), the tender prices of contractors, which had been considered high, collapsed back to normal in 2008. Clients find that tender prices have remained normal until autumn 2012.

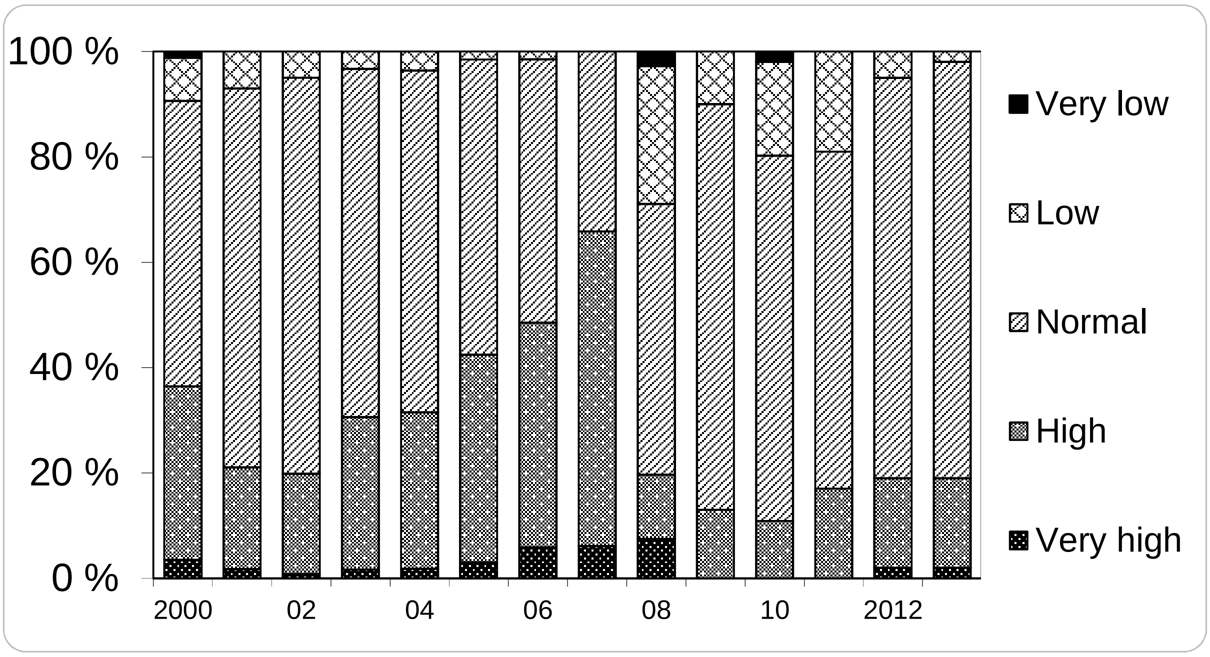

***Figure 3: According clients quoted prices for civil engineering works collapsed 2008 and have stayed normal until 2012. The normal contractor's bidding price: the same level than client's own cost estimate. Source: Nippala, 2012.***

The cost index of civil engineering works reflects the development of input prices. Tender prices consist of items such as risk provisions and a margin in addition to them. Analysis of the financial statements of civil engineering companies explains the steep increase in input prices while tender prices have remained normal (figure 4). Companies have compromised their margins. The traditional theory of supply and demand assumes that prices should fall when demand decreases, but that did not happen.

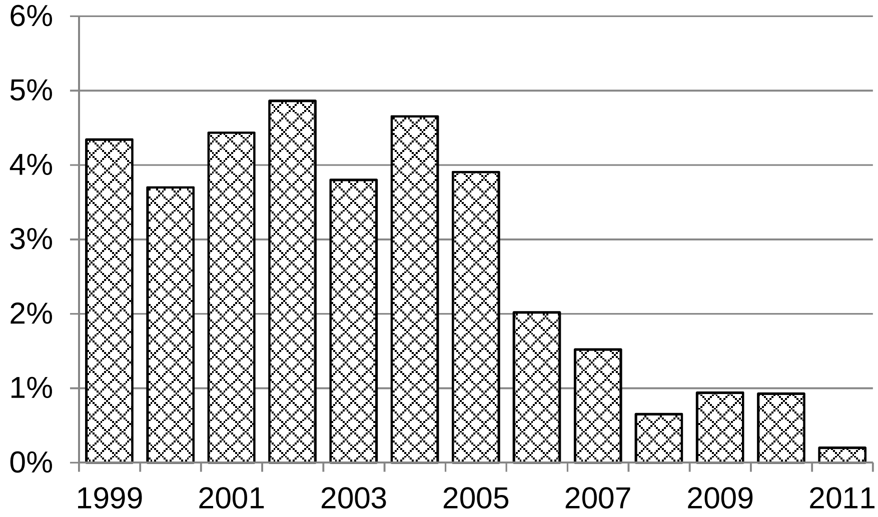


***Figure 4: Net profit of civil engineering companies. Source: Statistic Finland.***

## 3. Development of civil engineering cost level in European Union member states

Statistics on EU member states' civil engineering cost levels have been compiled since 2002. A common reference level (EU27=100) is calculated annually for the EU area as well as an index adjusted to the reference level for the member states and three other EU countries (Eurostat database, referred 29.10.2012). This analysis sought out those among the 27 countries when this index had been the highest or the lowest. These values were compared to the countries' civil engineering volume, economic development and fluctuations in the world market price of oil.

In 2007 the relative cost level of civil engineering works rose in 18 of the 27 monitored European countries. At the time, the economic situation in Europe was good. It was also good in all major economic regions on different continents (World Bank database, referred 29.10.2012). The U.S. economy was growing at 2 per cent, and though there were indications of losses suffered by banks there, the Federal Reserve was expected to be able to manage the situation. Economic growth was about the same in Europe and Japan. Russian growth (7%) was accelerated by oil. In the developing Asian markets economic growth was many-fold compared to the old economies. China was growing at 11 per cent and India at 8–9 per cent.

In 2007 the world market price of oil shot up as production could not keep up with demand. Problems with production in Nigeria (The New York Times 17.9.2008) and a reduction in Russian production occurred at a time when China's demand for oil surged (OPEC press release 24.10.2008). At the time, it was assumed that the economic downturn would cut consumption of energy and lower the price of oil.

Economic growth generated tax revenue for the public sector. Its solid financial situation allowed increasing investment in civil engineering works in many EU countries. Typically, investments exceeding the normal level for civil engineering lag behind economic growth (Graf, 2000). Statistics show that the volume of civil engineering works remained high until 2009. In 2010 it collapsed. Despite the collapse, the cost level of European (EU27=100) civil engineering has increased.

## 4. Anticipation of cost changes – results of correlation analysis

Based on earlier analyses, the variables chosen for more in-depth study against the cost of civil engineering works were gross national product (GDP), inflation, wage development, oil price, bitumen price, metal price, soil and rock material prices, transport service price, , building construction volume and civil engineering volume,

The reviewed material consists monthly observations from 2000-2011 (144 observations). The relations of the variables were examined by methods typically used with time series. Because the material consists of annual data, trend removal, proportioning (logarithmic conversion) or differentiation are used to filter the material, as necessary.

Time-series which have constant mean and variance over time are said to be stationary. Stationarity is assumed for achieving reliable conclusions: non-stationary time-series may yield random results. As most of used variables are not stationary but time-dependent they are dealt with trend-removal. (Kendall, Ord 1990)

For yearly data the existence of a trend is dealt with filtering the observed trend. The direction of change may also be other than linear, for example, quadratic and time-dependent, which is why filtering is performed case by case. The quarterly data is processed with differencing to remove seasonal trend and thereby introduce stationarity. (Kendall, Ord 1990) In the analysis of civil engineering or the economy, trend removal refers, for example, to converting current prices to flat rates. The purpose of trend removal is to eliminate the change that takes place in the series in any case, such as recurrent economic fluctuations, to be able to examine their deeper nuances.

Logarithmic conversion is used to normalise the variables, that is, to observe relative changes in the variables. Logarithmic values were used in the comparisons when possible. Because a logarithm can only be taken of a positive number, some variables were defined as a percentage of GDP if they contained also negative values and had originally given in that form in the material. The percentages also indicate relative values.

The variables are compared one at a time against civil engineering. The relation is first examined using graphic descriptors to assess their joint integration. Graphs are also made for trend-filtered variables to get a more accurate result for the dependencies of the directions of variables.

Change balances, i.e., sums of the numbers of changes in the same direction, are calculated for the pairs. This figure may support the correlation, which makes it possible to conclude whether the variables affect directly or inversely each other's changes. If the balance figure were close to half of the number of common events, it could be interpreted to imply that changes between the variables are not closely interconnected. By contrast, if the balance figure is close to the extreme ends (0 or maximum number of observations), it can be assumed that the variables are interrelated directly or through a third variable. For example, if 80% of the changes in variables *a* and *b* are in the same direction, they can be considered to be strongly directly proportional. Should the variables have only 20% changes in the same direction, they would have 80% changes in a different direction, indicating strong inverse proportionality.

Correlations indicate linear dependencies. In the case of time series variables, the correlations calculated for the initial values are rather high for unlimited variables, since time series often have a trend, a direction of development. Thus variables that increase or decrease over time may have significant correlations, as the scatter plots generated from them follow a trend. Filtered variables, again, have had their trend removed, so it is possible to observe similarities previously masked by apparent dependencies. Significant correlations between stationary series are a more reliable indicator of dependence than correlations between the original values.

Time-dimension is important feature in this study. Since correlations are calculated with time-series compared each other, they are placed in comparison with time too. Normally correlations are taken from values that occur simultaneously. This will yield only the dependency of concurrent events. By moving the compared value pairs we are able to observe the correlations between lagging and delaying variables. The method is called cross-correlation and it is instrumental in estimating the degree to which two series are correlated. From these correlations it is possible to gain findings from the causality between two series. Are changes taking place at the same time? (Kendall, Ord 1990)

While moving the series in time dimension the amount of compared pairs reduces. This is particular fall for those variables with small observation amount. This is particularly the case for those variables with a small number of observations.

The examined variables were divided in four groups based on the correlation analysis: leading, lagging, coincident and acyclical variables. Leading variables are those that in the light of the results of this analysis forecast changes in civil engineering costs. They included

GDP, building construction volume and oil price. These three test results for the cross-correlations are explained and visualised as 3D graphs (figures 5–7).

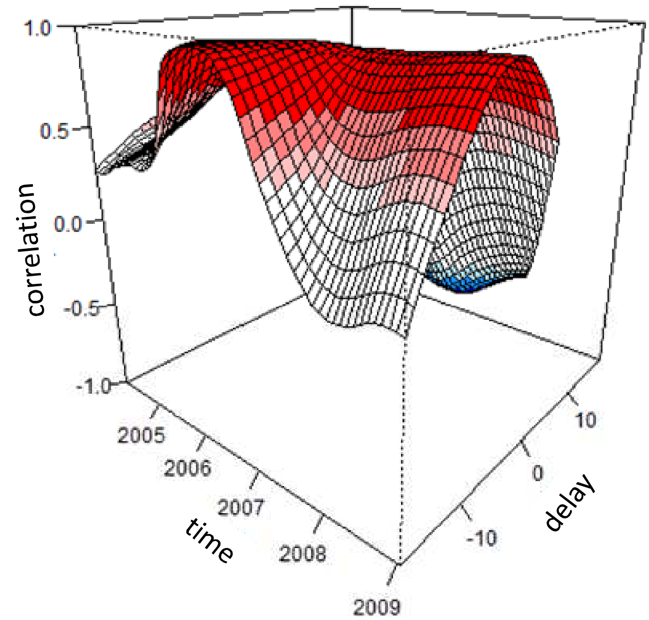


***Figure 5: GDP reflects changes in the cost level of civil engineering works throughout the time series. The lead time has been halved in a short while (NB delay in months). Earlier, GDP development could forecast changes in costs of civil engineering works up to 18 months in advance. Presently, the lead time has shrunk to five months.***

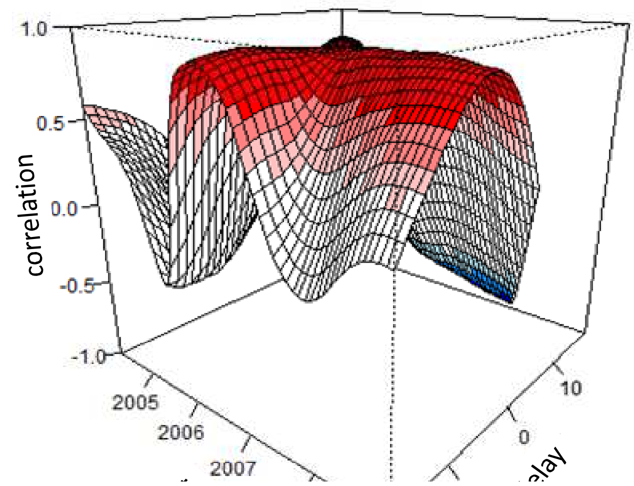


***Figure 6: Changes in building construction volumes forecast cost changes. The delay between the changes has become shorter and stabilised at 5−6 months.***

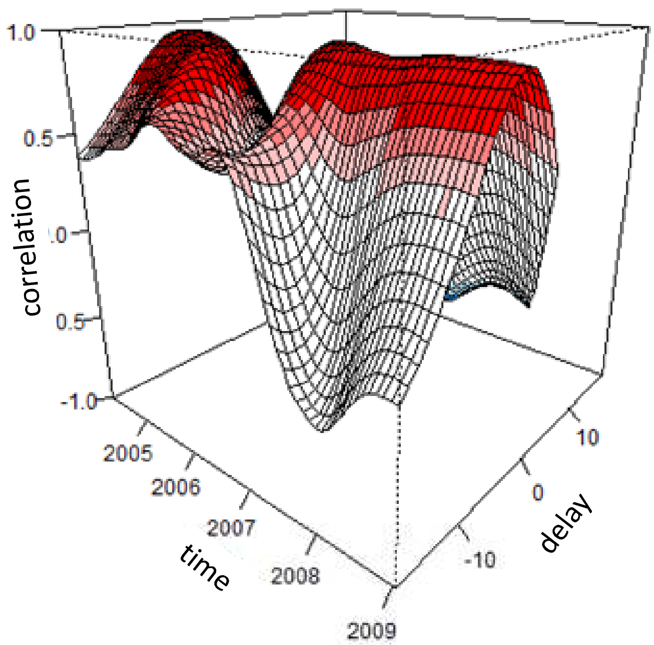


***Figure 7: Changes in the price of oil unavoidably mean changes in costs of civil engineering. Earlier, the delay between an oil price change and cost changes was 6–12 months. Presently, it is only 2−4 months.***

Correlating factors also affect the index either directly or through a common so-called third factor that affects both simultaneously. Changes in the prices of transport services and the volume of civil engineering works also occur concurrently with cost changes. Coincident reaction of transport services became established only in the 2000's. Earlier, transport service prices forecast changes in costs of civil engineering works.

Changes in the volume of civil engineering works also used to precede changes in the cost level, but today they change simultaneously (see figure 8). Thus change in civil engineering work volume is not significant from the viewpoint of cost forecasting.

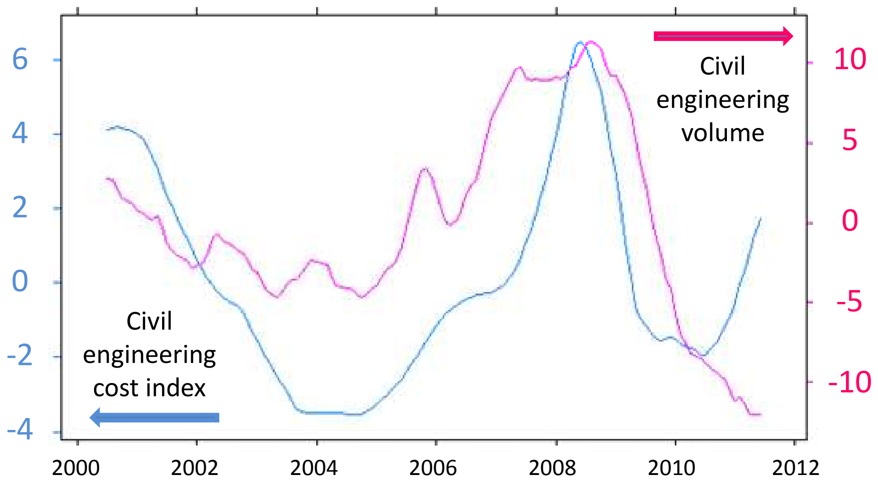


***Figure 8: The demand does not come before but simultaneously with increase in prices.***

Analysis of the lagging variables showed that their role can change. The results indicate that part of them have had a coincident or even leading relationship to the index. Yet, over time, the nature of the relationship has regressed and they have become lagging variables. An interesting fact is that sector wage development has lagged behind cost development, initially by 10 months, and now by as much as two years. Changes in the price of an important input of civil engineering works, soil and rock materials, are no longer a coincident variable, but lag behind changes in the cost index by 6 months.

The prices of fabricated metal products used to move quite inconsistently in relation to costs of civil engineering works, but have started to behave more consistently over time. The delay is about 9 months. The price of bitumen reacts similarly with a delay of 10 months.

The impact of inflation has varied during the review period. For long, it followed the costs of civil engineering works, but in the last few years the delay has shrunk so that changes occur almost simultaneously. It is no longer possible to determine whether inflation is a lagging or coincident variable to civil engineering costs (figure 9). Inflation is on the way of becoming a leading variable.

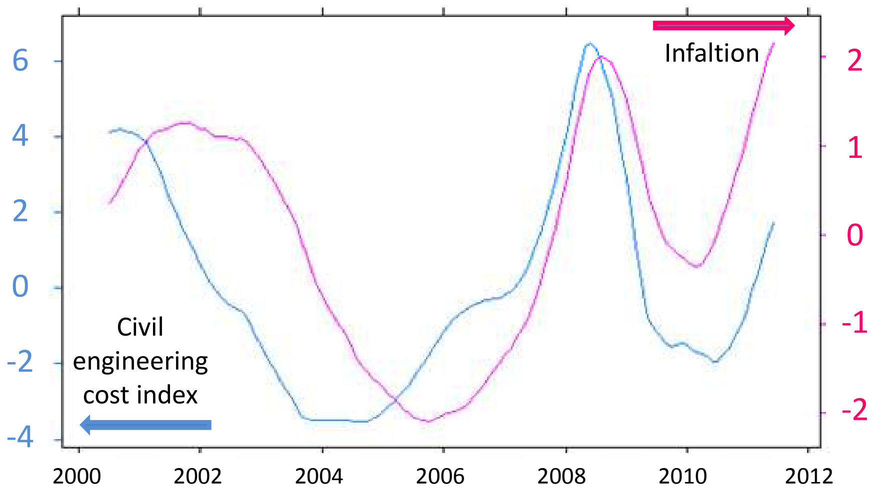


***Figure 9: An interrelationship between civil engineering costs and inflation has been turbulent.***

## 5. Summary

Civil engineering involves many types of work that require petroleum products. These products are needed to transport soil materials, to operate earthmoving machinery and to pave roads and streets. The aim of EU climate policy is to reduce the use of petroleum products. The means to achieve that goal include emission fees and taxes on fossil fuels. The increase in the world market price of oil and taxes together have increased petroleum products' share of the cost of civil engineering works to 20 per cent.

Globalisation and data communication have integrated the world's economies. This is evidenced e.g. by the fact that the delay between an increase in the price of oil and one in the input costs of civil engineering works has shrunk to a few months.

World market prices of raw materials also influence domestic inputs. According to the traditional theory of supply and demand, only growing demand increases prices until equilibrium is produced by increasing supply. The theory posits that a cost increase should follow from an increase in the volume of civil engineering works. Yet, according to the analysis of this study, that is not the case. Instead, volume and cost level increase simultaneously with each other and economic growth.

Civil engineering is local activity, but yet highly susceptible to changes in global economy. One indication of that is that the costs of civil engineering works have continued to grow even though demand has collapsed. Cost development is governed by international economic development instead of local supply and demand.

Thus, not only development of the national economy, but also development of the global economy and the world market price of oil must be considered in forecasting costs of civil engineering works. In the case of special work types, local supply may become the key factor in determining the cost level.


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