Leading indicators for forecasting civil engineering market development

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Abstract

Civil engineering has traditionally been a closed market. However, the 21st century has seen it opening up and becoming a new business area for companies. Business knowledge is required in business management, but the availability of that knowledge is scant. It is difficult for companies to plan their future business as they often do not even have knowledge of today’s market structure or situation. The public sector also has a need for knowledge, for example when it strives to optimise the timing of individual projects or recovery activities. Private companies and the public sector link civil engineering to the state and the development of the general economy. A multitude of variables is available for the economy. Economists do not comment specifically on the interplay between civil engineering and the economy, i.e. how well these indirect variables depict the overall field. The core purpose of this study was to identify the key variables from this commonly used mass of variables that would in reality predict the short-term development of civil engineering. In the first phase, we studied whether key variables could be identified for the entire field of civil engineering. As this line of study proved unfruitful, in the second phase we divided civil engineering into three client types: local government, central government and the private sector. Going down to the level of market segments proved fruitful, but not to a sufficient degree. The third phase comprised dividing the demand in the business sector into, for example, global and typical domestic manufacturing demand. The research problem is approached within a contextual framework. The interaction is studied in the time dimension, both within the business and at the level of the operating environment. The validity of the variables is studied using statistical methods. The most detailed level of the study focuses on one country where sufficiently long-term time series are available.

Keywords: Leading indicators, Civil engineering, Short-term development
1. Introduction

The civil engineering market has changed from a closed market towards a more open one both in Finland and many other countries since the 1980’s. In several final product sectors, investments earlier financed by taxes are being financed by user fees. Actors of this sector have become increasingly international. (Nippala & Petäjä, 2004) Companies operating entirely in the international markets like IT companies have also emerged (Runeson & de Valance, 2009).

Companies and organisations need information on the actual quantitative change in the civil engineering market for both short-term (budgeting) and long-term (strategic) planning of their operations. In a closed market, the plans of the client sector were sufficient as an information source. This source of information has become less valuable because of the change in the markets. New kinds of markets also need new information sources to forecast changes in them.

Civil engineering companies have expanded their operations beyond their traditional market and assumed tasks from other sectors. For example, they are increasingly involved in works traditionally considered new building construction. Site area works and ground improvement are often continued by foundation work. Another area of expansion has been in the direction of the mining industry in the form of participating in both the opening of mines and extraction of minerals. Companies are also interested in forecasting developments in these new business areas.

The rest of the paper is organised as follows. Firstly, we shall deal with the theory and observations on the civil engineering market made at the beginning of this research already discussed at the previous CIB 2011 Conference. Secondly, we shall discuss statistical analyses of the functioning of indicators, and thirdly, we shall look at the present situation and determine the direction of further research.

2. Research objective and theory

The objective of this project is to find indicators to forecast future civil engineering markets. Here, civil engineering refers not only to traditional civil engineering but also to investments in energy supply and telecommunication networks, as well as area works of building construction, maintenance of grounds of properties and some mining operations.

The research uses the contextual research paradigm (Pettigrew, 1990) that focusses on past, present and future internal changes in infrastructure construction and its operating environment. The objective is to find key indicators that can be used to evaluate the present situation of infrastructure construction and forecast the future development of the market.

Economic indicators can be classified into three categories according to their usual timing in relation to the business cycle: leading indicators, lagging indicators, and coincident indicators (Eurostat, 2010).
A leading indicator is an economic statistical indicator that changes before general economic conditions have started to change and can therefore be used to predict turning points in the business cycle. Typical examples of leading indicators are stock prices, business and consumer expectations. In short-term statistics the number of building construction permits is a typical leading indicator.

In this research we search for so-called key indicators among these leading indicators that could forecast economic conditions earlier and more reliably than others. Furthermore, we try to identify those indicators that move in lock step with the markets under study. They are called coincident indicators.

A coincident indicator is an economic statistical indicator that moves (more or less) in lock step with the economy and therefore reflects the current status of the economy. Typical examples of coincident indicators are industrial production and turnover. A coincident index may be used to identify, after the fact, the dates of peaks and troughs in the business cycle.

Today we are flooded with information. Therefore, it is important to distinguish the above-mentioned indicators from those that reflect history, lagging indicators. A lagging indicator is an economic statistical indicator that changes after macroeconomic conditions have already changed. Typical examples of lagging indicators are unemployment figures, profits or interest rates. In short-term statistics the number of persons employed is a typical lagging indicator. (Eurostat, 2010)

3. Changes and indicators

The research started at the beginning of 2011 with an analysis of changes in history. The infrastructure construction market began to open up around 1990. The development continued until the financial crisis of the late 2000’s (Nippala, Tienhaara, 2011). Now people are clearly taking the time to estimate the effects of the development. The privatisation of public services has in some cases brought clear savings. On the other hand, the profits of companies have suffered as they have been competing for markets. Competitive bidding for public services in the infra sector was also problematic at the beginning when several companies appealed to the Market Court about it.

Simultaneously with the opening up of competition, design-build-finance-operate (DBFO) contracts were introduced to Finnish public sector infrastructure projects. That also aroused some criticism. Financing costs are often higher in the private sector than in the public sector and, despite efficient production, often lead to expensive acquisitions. The positive economic impacts of private financed projects are immediately available to society, but limit future contracting markets as the annual payments of private financed contracts implemented earlier must be paid out of the public sector budget.

When the infrastructure market opened up for competition, the market economy entered the picture. Civil engineering started to undergo more economic fluctuations. Monitoring of business cycles started focussing also on the plans of other clients and builders’ order stocks and willingness to bid along in addition to public sector budgets. As the size of infrastructure projects grew, extraordinarily
big infrastructure projects, such as major ports and big power generation plants were also placed under monitoring. (Nippala, Tienhaara, 2011)

However, forecasting of business cycles on the basis of plans is more like establishing the current situation. Such information was needed, for example, during the financial crisis to decide about the government’s stimulus measures. During decision making the infrastructure sector and the government had a heated debate on whether demand in the sector was poor, normal or even overheated. Decisions could not be based on statistical data because the statistics lagged behind the present situation and were even partly contradictory.

New indicators to forecast changes in the civil engineering market volume have been searched from the business cycle forecasts on 19 countries produced by the Euroconstruct network (Nippala, Tienhaara, 2011). They do not link the quantitative development of civil engineering to indicators by mathematical formulas. These are mentioned only as reasons for the economic development without evaluating their effectiveness. The most commonly mentioned indicators include:

- general economic situation
- good/bad economic situation of the public sector
- legal obligations (quality of water/air, waste water treatment, energy consumption)
- political programmes (TEN channels, TEN energy, TEN telecommunications)
- political decisions (Maastricht, free competition, CO2)
- local government elections
- price of oil
- growth of consumption (traffic volumes, energy consumption, water consumption)
- capacity and age of infrastructure.

The forecasting of civil engineering developments on the European level has proven really difficult in recent years. Semi-annual Euroconstruct forecasts from recent years are shown in the figure below (Figure 1). The difference between the forecasts for 2011 is 15 per cent units, ~ 50 billion euros. The realisation was 302 billion euros (Abrahamsen, 2011).
4. Testing indicators

4.2 4.1 Test method

The reviewed material consists of two types of data. Total civil engineering market data includes quarter observations from 1970–2010 having a maximum of 160 observations, which limits to 120–140 findings for some variables. The second type of data was examined for submarkets, placed for era 1975–2010 and consisting only yearly data. It holds a maximum of 36 observations per variable. However for some variables, there were only 16–25 observations to be found. 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 persuade 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 happened on same moment. 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. Thus, the time differences used in this study are relative small (±3 for yearly data, ±8 quarters for quarterly data).

The test results for the cross-correlations are visualised as graphs. The horizontal axis shows the difference between the value of the variable and investments in infrastructure at a given point in time. At zero, the variables represent the same year, at -2 the correlation of the variable is shown 2 years (/quarters) before the infrastructure investments, and +2 shows the reaction of the variable two years(/quarters) after the investments. Only indicators whose correlation exceeds 0.7 at least one year earlier are qualified as key indicators. The values of the curves for the key indicators would appear on the timeline between -1 to -3 years and have a correlation factor of over 0.7, that is, they would show in the top left corner of the graph. Correlations between 0.3–0.7 (from absolute values) are seen more suggestive results.

### 4.3 Testing of indicators, Phase 1 – Total Civil Engineering Market

The first two indicators mentioned by the Euroconstruct network were tested statistically for forecasting the development of Finland's entire civil engineering volume. GDP and investments (machine investments, residential building investments other building construction investments) were
used as indicators of the overall economic situation. Public sector consumption was used as an indicator of the state of public finances. (Figure 2)

**Figure 2. During the time period -1 to -3 years none of the tested indicators had a correlation exceeding 0.5. (Sources: see statistical references).**

### 4.4 4.3 Testing of indicators, Phase II – sectors separately

As the first round did not yield a result, the search for indicators was continued in submarkets. The selected submarkets were different types of customer sectors: state administration, local government (municipalities) and companies. All three were examined separately to see which factors could affect investment decisions. Suitable indicators were chosen to represent the factors, and their relation to civil engineering was statistically tested.

During round II, the following variables or potential key indicators were tested:

**State investments:** GDP, tax revenue, government budget deficit, road traffic output, traffic and communication expenses price index, price of oil, earth work costs, unemployment

**Municipal investments:** GDP, tax revenue of municipalities, indebtedness of municipalities, local government deficit, building construction, population growth

**Private investments:** GDP, inflation, building construction, industrial confidence, world trade, price of oil.
State investments

On the basis of statistical testing, unemployment correlates best with civil engineering. However, the correlation was of the wrong kind. Instead of forecasting, it reacted to changes in civil engineering with a delay of 1 to 2 years. It was thus a so-called lagging indicator. The best indicator for forecasting future volumes of state implemented civil engineering were the plans of the Ministry of Transport and Communications – exactly the same indicator used for forecasting while the market was closed. The rather weak correlation of this indicator is, however, surprising: three years in advance it is 0.5 (Figure 3).

A large part of state-financed civil engineering involves maintenance of existing civil engineering constructions, and the share of new investments is contracting. Economic fluctuations or financial crises do not affect this market segment. Big investments are political decisions made by the government. None of the analysed variables considers this viewpoint. (Figure 3)

![Graph showing correlation between civil engineering and variables](image)

**Figure 3.** Not a single indicator with a correlation with actual civil engineering exceeding 0.7 was found among the indicators of state-financed civil engineering works. (Sources: see statistical references).
Municipal investments

Municipal population growth correlated with the infrastructure investments of municipalities 3 years in advance. However, the correlation coefficient was weak: 0.5. An almost equally good indicator would seem to be the tax revenue of municipalities. It forecast municipal infrastructure construction one year in advance. Even better key indicators were economic development (GDP) and building construction permits. There was a strong correlation of 0.7 to 0.8 between these phenomena. (Figure 4)

Municipalities must build transport connections, water supply and power supply networks and public services such as schools and day-care centres for new focal areas of building. This often takes place simultaneously with building construction. However, building construction permits are applied for well in advance, 1 to 3 years before building starts, and therefore this indicator is indeed good for forecasting future municipal civil engineering volumes. (Figure 4)

![Figure 4](image)

*Figure 4. GDP and building construction permits correlate best with municipal civil engineering one year in advance. (Sources: see statistical references).*
Private sector investments

Only one key indicator, and two that nearly make the grade, were found for the private sector. Based on correlation, the industrial confidence indicator published by the European Union Statistics Office turned out to be a key indicator. Industrial confidence is inquired on a monthly and quarterly basis. The correlation factor of material published one year in advance is almost 0.8, which is high enough for a key indicator. (Figure 5)

Figure 5. Analysis of private sector key indicators. (Sources: see statistical references).

It is indeed logical that the industry invests when confidence in future is high, and curtails investment when confidence is low. That is also indirectly reflected in industrial civil engineering investments. Many investments include components of machinery and equipment as well as building and civil engineering investments.

5. Discussion

Before 1995 the infrastructure market in Finland was relatively closed. When a public sector contractor had a significant share of the market, the leading indicators were public sector budgets, state subsidies, regional politics and the GDP forecast.

After 1995, the Finnish civil engineering market has largely opened up for competition. Therefore, it is assumed that forecasting indicators have also changed. To find out whether that is true, it was first determined if some variable commonly used on the European level is better than the others in
forecasting the development of the civil engineering market. None of the statistically analysed variables correlated strongly enough to earn the status of a key variable.

The reason was thought to be the fact that the subsectors of the civil engineering market follow different logics and may cancel out each other's fluctuations. It is difficult to find common explanatory factors for such a market.

It was decided to run statistical analyses separately for each submarket. Civil engineering was divided into subsectors based on the availability of information. The subsectors were investments in infrastructure by state administration, local government (municipalities) and companies. Separate logical factors affecting decision-making were chosen for each of the three subsectors.

No key indicator was found for the state sector even in the second round of analysis, although investments are seemingly outlined, for example, in the government programme. The researcher's opinion is that decision-making is affected by politics and cannot thus be forecast.

Two key indicators were found for the municipal sector, i.e., GDP and building construction permits as indicators of the economic situation. Municipalities are a post-cyclical sector in relation to general economic development, which makes it easier to forecast their investments. Building construction permits also indicate what happens in civil engineering, that is, the building of street, water supply and power supply networks.

One key indicator was found for the private sector, the industrial confidence index. Economic development also seems to almost deserve that name. The correlation of the industrial confidence indicator with private sector investments is logical. When industry is confident that demand will increase, the threshold for investments is exceeded and investments in civil engineering start.

6. Conclusion

The focus of this paper is on the key indicators for Finnish civil engineering construction. The need to identify key indicators arises from changes in the market structure, which have increased the need and demand for forecasting. People also want to make monitoring and forecasting more effective by excluding irrelevant data.

The findings on the Finnish and European civil engineering markets are quite similar. The most significant differences are the roles of private sector and the time horizon. Even though the Euroconstruct network tries to forecast business cycles, the reports focus on long-term drivers. And even if there is a lot of talk about co-operation between the public and private sectors, the effect of the private sector on changes in the market is not recognised.

No key indicators that could forecast changes in the overall volume of civil engineering in the near future were found. By contrast, analyses by client sectors found a few key indicators, such as European level industrial confidence, as a key indicator for private sector investments, and economic development and building construction as an indicator for municipal investments. Although state
investments are outlined already in government programmes, day-to-day politics change plans to the extent that even the plans of the responsible ministry fail to correlate with the investments it finally finances.

The analysis will be continued at least with regard to state and private sector investments. It is also our intention to find an alternative way to break the whole down into submarkets and find key indicators for them. The boundary conditions for this alternative are set by the available input data.

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