Performance measurement in construction logistics

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Abstract

The need for performance measurement systems is imminent in the construction firms. Construction firms have many simultaneously ongoing construction projects, from which the relevant performance information is needed. There are also tens of material groups and subcontractors, whose performance should be monitored together with construction firms’ practices. In addition to monitoring, performance measures can also be used as a basis for progressive improvement of company productivity. In this paper, a new framework is introduced for measuring construction logistics. It is a two-dimensional model where measures are grouped by the use of measures and by the focus of measures. The first dimension of the classification; use of measures contains two kinds of measures. The first measures, called improvement measures, help construction industry to find out the problems with current practices. These measures are mainly used during development projects. The second measures, called monitoring measures, are used for continuous monitoring of operations. These measures are vital, because both firms’ top management and operational managers need continuous feedback on operational activities. The second dimension of the framework is the focus of measures. It clarifies at which organisational level measures can be used. There should be information available at the company and project level, as well as at the specific supplier or subcontractor level. The paper presents concrete measurement experience gathered from a number of practical cases. It illustrates examples of both improvement and monitoring measurement results. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Performance measurement is a current issue in academia, as well as in business community. However, in the construction industry its usage as a tool for improvement and control of logistics has so far been limited. That is why a new framework for performance measurement in construction logistics is introduced in this paper. The general objective of the paper is to find new solutions to improve productivity of logistics in the construction industry.

Construction industry is a project-oriented industry. Although every building, road, bridge or process plant construction project involves a similar set of process stages, each project is regarded as unique. Every project is a prototype, because each site is different and hence the design is different. Also the team assembled to carry out the project is usually gathered just for this project. Additionally, all the main players in a construction project;
an architect, structural and mechanical engineers, a construction contractor and dozens of subcontractors, they all look the construction process from their own point of view.

In contrast to temporary nature of project teams, the industry has some long and entrenched traditions. While each project is different, every project is approached very conservatively in process terms. In fact, there is no process view in typical construction project, while the project is seen simultaneously as independent project stages and different actors with no common goal.

Competitive bidding is also deeply rooted in construction tradition. The lowest bidder gets the contract. The contractor produces the product which is then inspected. The project is incrementally accepted or rejected based on conformance to technical specification. Other measures of performance which relate to the process itself are neglected or at least assigned to a distant secondary position of importance [1]. In this situation the industry cannot continue doing what they have always done and expect better results [2]. It has to find new process oriented approaches to improve their operations.

The process management paradigm, according to which companies should focus on and be organised around a number of core business processes, has been recognised to provide significant advantages in terms of improved organisational performance [3].

Process view is one of the key elements in logistics and supply chain management. According to Christopher [4]:

Logistics is a process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels in such a way that current and future profitability are maximised through the cost-effective fulfilment of orders.

A logistical view is a solid basis for productivity improvement also in construction industry. Every construction project can be seen as an order-delivery process where all the parties along the logistics chain are involved (Fig. 1).

A key aspect of success in process improvement is effective management of information about process performance, even independent of information technology [5]. Therefore, performance measures are also needed to improve logistical processes in construction industry.

2. Performance measurement concept

Performance measurement describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives. Performance measurement systems should answer two simple questions [6]:

- Are functions and departments doing the right things?
- Are they doing them well?

Performance measures are used to measure and improve the efficiency and the quality of the

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Fig. 1. Order-delivery process of the construction project.
business processes, and identify opportunities for progressive improvements in process performance.

Traditional measures, however, are usually ineffective barometers of performance because they do not isolate non-value-added costs. In addition, most measures overlook key non-financial performance indicators [6].

Example. Purchase price is a traditional measurement that ignores quality and delivery aspects. Based on the purchase price measure, purchasing increases order quantity to get lower price. The results are excess inventory and increased logistics costs in general. Total delivery costs (including logistics costs) should be used instead of purchasing price [7].

Performance measures are classified in several ways in the literature. Measures are grouped, for example, into soft and hard measures [8], financial and non-financial measures [7] as well as process and output measures. One classification is based on the organisation level where the measuring data is collected or used. For instance, measurement can be instituted at national, company, department and team level [9]. Also Juran’s pyramid [10] shows how performance measures are used in different organisation levels (Fig. 2).

One dimension found in the literature is the frequency of measurement. There are measures that are global in nature, covering a wide scope of activities. Global measures provide top management with a sense of whether strategic objectives are being achieved. They are monitored month-to-month or quarter-to-quarter. In a sense they keep management in touch with the outside world. The other kinds of measures are more specific to the internal workflow. They represent day-to-day measures of operating effectiveness and efficiency [6].

3. Framework for performance measurement in construction logistics

This chapter introduces a new framework for performance measurement in construction logistics. The new framework introduces two dimensions to classify performance measures. The first dimension, use of measure shows the application area where the measures are mainly used. Measures are divided into improvement and monitoring measures. There is usually a significant difference between improvement measures and continuous monitoring measures. In spite of that, this classification seems to be missing in the literature at the moment.

The second dimension of the framework is focus of measure. It illustrates the organisation level where measures are used. This classification is already known in the literature. However, it is also suitable for performance measures of construction logistics. Construction industry is a project-oriented industry, where it is difficult to cumulate performance experience without special arrangements.

The dimensions of performance measurement system are summarised in Fig. 3. The nature of both dimensions is more thoroughly discussed in the next Sections.
3.1. Use of measures

Performance measures can be divided into two groups based on the use of measures. The first group of measures is improvement measures that are vital when starting new development and cooperation projects. The need for that kind of measures is obvious: if you do not know your current practices, you cannot develop your operations further effectively. Objective information about current situation is necessary when starting co-operation with different players of business processes. Additionally, development measures can be used for benchmarking different practices. By comparing different practices one can find out best current practices and cost saving potential of different practices. The improvement measures are applied infrequently and their aim is to find out the present logistical performance level and improvement potential. Typically, the literature ignores these important measures because it deals with firms' constant performance measurement systems only.

The second group of measures consists of monitoring measures. These measures are needed for screening and controlling companies' every-day actions continuously. Commonly the literature treats only these measures. Hence, the theory presented in the previous chapter suits well for monitoring measures. Usually, the set of measures is tailor-made for each company and the data collection, as well as the reporting procedures are planned for regular use.

3.2. Focus of measures

The second dimension of the performance measurement framework is focus of measures. Different measures are needed in different levels of organisation. There should be information available for strategic management purposes at the company level. On the other hand, information is needed also for operational management at the work shop level. When construction logistics is concerned, measures can be used mainly on three levels. Firstly, construction companies can analyse general environment and their own performance at company level. Secondly, they can measure individual projects' performance. Finally, they can focus on special subcontractors and material suppliers.

In the next Section, several concrete measures are introduced to show how construction logistics performance can be measured in practice.

4. An application example of performance measurement in the construction industry

A large national logistics development program in the construction industry has been carried out in 1992–1996 in Finland. Several performance measures have been developed and tested during this program. The improvement measures have been developed at the beginning of the program and those measures have been extensively used in several co-operative development projects [11]. Continuous monitoring measures have been developed during the whole program and the final results have been gathered and tested in the end of the program.

The experiences of improvement measures were collected and documented from over 30 construction sites and for eight material items. The monitoring measures were tested at 15 building sites of three different construction companies.

4.1. Case results of improvement measures

During the national logistics development program, two tools were developed and applied to measure improvement potential of delivery processes. The tools measured costs and time of delivery chains. The cost measure is based on the theory of activity-based costing (e.g. see [12]) and the time measurement is based on the theory of controllability engineering (e.g. see [13]) and time-based management (e.g. see [14]). Both measures concentrate on process view and complete material delivery chains. Development projects were mainly co-operation projects between special material suppliers and construction firms. Therefore, developed measures were typical supplier level measures. However, benchmarking results of different material groups can also be used on general company level as a basis for improvement.
The first measure, *activity and cost analysis*, aims at (1) finding out the activities and costs of the material flow and (2) to show costs of unnecessary work in the delivery chain. The idea of the second measure, *accuracy and delivery time analysis*, is to clarify (1) the structure of the delivery time and (2) the accuracy of performance within delivery chains. Background, objective and benefits of the two tools are summarised in Table 1.

In the next Section two examples show how to use these improvement measures in practice.

### 4.1.1. Improvement measure example on supplier level

The first example illustrates how the activity and cost analysis results can be used on specific material supplier level as a basis for improvement. In this case example, construction firm and plasterboard supplier wanted to develop their material deliveries together. The first step was to identify all the activities from the supplier's production line to the final assembly of product on construction site. The second step was to calculate costs of each activity and finally to present the results in an informative way.

The total logistics costs of this supply chain were 27% of the purchasing price. The costs were divided so that 60% were caused on the construction site, 24% were transportation costs and only 16% supplier's costs. The detailed division of the logistics costs both on the construction site and at the supplier's is presented in Fig. 4. By the help of this information firms easily saw what are the most expensive activities and how firms should use their shared efforts during the development project. The size of the area is comparable with the costs of the activity.

The use of time measure typically supports the results of the activity and cost analysis. The practical target of the simple time measure is to show how well the companies have planned their deliveries and how well they have managed to carry out the plans. Fig. 5 gives an example of time analysis of a plasterboard supplier and a construction company. Analysis results show that the delivery was not well planned. According to the construction company's plans, the supplier had only one day to deliver plasterboard, although the planned start of the assembly was one week later. Actually, the assembly started two weeks after the delivery.

### 4.1.2. Improvement measure example on company level

The logistics cost data can also be used on the company level if enough cost data have been

<table>
<thead>
<tr>
<th>Measure</th>
<th>Activity and cost analysis, ABA</th>
<th>Accuracy and delivery time analysis, TBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>Based on Activity Based Costing method</td>
<td>Based on time based management principles and controllability engineering</td>
</tr>
<tr>
<td>Objective</td>
<td>Finds out activities and costs of logistics chain</td>
<td>Clarifies the structure of the delivery time and the accuracy of performance</td>
</tr>
<tr>
<td>Benefits</td>
<td>Shows unnecessary activities and cost saving potential of material flows</td>
<td>Shows slack times in delivery processes Shows improving potential of information flows</td>
</tr>
</tbody>
</table>
collected from construction projects. The focus of improving and developing efforts can be determined using this kind of logistics costs summary data. (see Fig. 6). A general remark is that cost variations within and between different material groups were very significant.

4.1.3. Experiences on improvement measures
Experience on cost and time measures has been very positive. Objective information about delivery processes has been found very useful in developing delivery processes in co-operative projects.

The usefulness of the measures depends on the type of material. The standard materials, like timber, mortar and plasterboard, have the biggest logistics costs of material flows as percentage of the purchasing price, because the logistics chain of standard materials consist of many movements and warehousing. Therefore, the importance of the
activity and cost analysis is emphasised in the development of standard material deliveries.

The accuracy and delivery time analysis is most useful in the development of customised material deliveries, like windows, concrete elements and kitchen cabinets. Logistics chains of such non-standard materials involve many actors in different companies. With the accuracy and delivery time analysis, the improvement potential in information flows and co-ordination can be identified.

4.2. Case results of monitoring measures

A large number of measures has also been developed for continuous monitoring of construction firms’ logistics. The scope of the monitoring measures has been on the firm and the project level. Measures have been tested in 15 case construction sites from three Finnish construction firms.

Based on action research methods (e.g. [16]) personnel from case companies has actively participated in creating proper measures. In this way researchers could ensure that tested measures were in the first place quite practical and, at least according to employees opinion, suitable for continuous use of construction companies. Tested monitoring measures are listed in Table 2.

4.2.1. Monitoring measure example on company level

An example of company level measurement results is presented in Fig. 7. The figure illustrates what is the average number of incoming invoices of suppliers and subcontractors per day in three case construction firms.

This measure gives one angle to the company’s purchasing policy; if the number of invoices is big it normally means that there is either a huge amount of small pick-up purchases or that invoicing policy of subcontractors has not been agreed upon properly. The measure is a typical firm level measurement that can be used to monitor long-term trends of purchasing and invoicing practices and alarm if the value begins to rise. The measure can also be used on project level for benchmarking different projects.

Another company and project level example is presented in Fig. 8. The figure illustrates, how tight is the timetable of different projects (= contract price divided by time for completion) in three case construction firms. The bigger the contract price and the shorter the time for completion, the more efficiently the construction time has been utilised in the project.

This project schedule related measure gives important information about construction environment to the managers. Top managers should take into account compressing timetables when planning strategies for the future. This measure also tells what are the conditions for managing logistics on construction projects. The tighter the project schedule, the more the material deliveries which need to be handled at the same time. The number of subcontractors working simultaneously on site also increases when this measure increases.

Table 2
Tested monitoring measures for construction logistics

<table>
<thead>
<tr>
<th>Name</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project time efficient (FIM/day)</td>
<td>Company or project level</td>
</tr>
<tr>
<td>Value added (%)</td>
<td>Company or project level</td>
</tr>
<tr>
<td>Subcontracting percentage (%)</td>
<td>Company or project level</td>
</tr>
<tr>
<td>Number of invoices per day (pieces)</td>
<td>Company or project level</td>
</tr>
<tr>
<td>Amount of small (&lt; 1000 FIM) invoices (%)</td>
<td>Company or project level</td>
</tr>
<tr>
<td>Disposal costs</td>
<td>Company or project level</td>
</tr>
<tr>
<td>Reply percentage of tenders (%)</td>
<td>Specific case level</td>
</tr>
<tr>
<td>Amount of changes in subcontract (FIM)</td>
<td>Specific case level</td>
</tr>
</tbody>
</table>
4.2.2. Monitoring measure example on supplier level

Fig. 9 shows an example of specific case level measure. With this example measure construction firms can monitor how good are the tendering practices with different material suppliers and subcontractors. In the case of low reply percentage of tenders, purchasers should find out the reasons for poor practices. Have the invitations to tender been sent too late? Should we cut down the number of subcontractors and increase co-operation with the remaining ones?

4.2.3. Experiences on monitoring measures

At the moment, none of the three case construction companies collects systematically data from logistics performance, though they were among the biggest construction companies in Finland. Only the measure called subcontracting percentage was used in the firms. However, the testing results of 15 cases were promising. All the needed data were found and the results showed that there is a need for continuing measurement as well. Still, one data gathering problem should be solved before monitoring measures can be used continuously. At present, the data for monitoring measures can not
be collected automatically from current information systems.

Eight continuous monitoring measures for logistics might be too much for a small or medium-size construction company. It is better for a small company to pick only a couple of measures and start with them. The frequency of the measuring process has not been discussed during the testing period. Appropriate frequency for company level measures might be once or twice annually. Project measures could be used once in a project, as well as the supplier level measures.

If a company has not used performance measurement before or if a company is very small, they can start to use monitoring measures as improvement measures. This means that they can find out the current performance and improvement potential of the firm by applying occasionally these monitoring measures.

5. Conclusions

When talking about performance measurement, one has to realise that there are two kinds of measures: those used during the development projects and those used to monitor day-to-day activities. Improvement measures can be more complicated and time-consuming to apply than continuous-monitoring measures. This is because they are used occasionally in the beginning and the end of the development project to find out improvement potential and to realise savings. Continuous monitoring measures should be simple and the data collection should be standardised. Furthermore, monitoring measures should be used effectively. There is no idea to collect a lot of information that is not used in decision making. What is done with the measures is even more important than what the measures are.

Generally used slogan in business community is that “If you want to improve something – Measure it”. Based on our experience, there is no doubt that the statement is true. The measures used during the development projects have offered a lot of information about delivery processes. Objective information has been found very useful especially when developing delivery processes in co-operation with contractors and material suppliers.

However, the improving efforts have taken place only on the operational level. The strategic performance measures and company level co-ordination are still missing in the Finish construction industry.

At the moment, there is a lack of continuous monitoring measures as well. Finnish construction firms do not usually have continuous data collection systems for logistics measures. The experience on test collection showed, however, that it would be very useful to establish a systematic way for monitoring logistics and subcontracting practices.

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