sciendo

CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2021; 31 (4): 0214-0236
DOI: 10.2478/ceer-2021-0058
Original Research Article

CONTRACTS' PERFORMANCE MEASUREMENT IN CZECH CONSTRUCTION COMPANIES

Petr TRTÍLEK[1], Tomáš HANÁK[1]
[1] Brno University of Technology, Faculty of Civil Engineering, Brno, Czech Republic

A b s t r a c t

Performance measurement of construction contracts belongs to the crucial activities enabling the improvement of processes in a construction company. The main aim of this paper is to evaluate and analyse performance management practices applied by contractors in the Czech construction sector. Original data were collected using a questionnaire survey and quantified through relative frequency of occurrence. These data have been supplemented by interviews with experts in the field in order to assess the importance of the individual criteria and other relevant performance aspects. The main findings illustrate differences in approach with respect to company size, as well as the most frequently used performance indicators and criteria. The study also focused on the performance measurement of subcontractors and the factors influencing contract success. The results show that large companies have already developed elaborate measurement systems and have sufficient staff for this purpose. Companies in the Micro&Small category show worse measurement performance, mainly due to the lack of qualified staff.

Keywords: performance measurement, construction company, criterion, system, efficiency

1. INTRODUCTION

In the construction industry, there is increasing pressure to achieve high efficiency in contract management, and one of the key tools for achieving it are systems for

[1] Petr Trtílek: Brno University of Technology, Veveří 331/95,602 00 Brno, petr.trtilek@vut.cz, phone +420 601 570 320

measuring and evaluating various criteria associated with the construction process. For a long time, construction sector has been characterised by its underperformance [1]. Therefore, companies that are able to measure their contracts continuously and efficiently gain very valuable data in the form of the measurement results, which then allow them to implement changes not only in terms of future contracts, but also in projects currently being implemented, thus improving project outcomes. Neely et al. define performance measurement as a process of actions to quantify efficiency and effectiveness [2]. With the increasingly fast pace of digitalisation, these measurement systems are continuously being improved to make them easier to use and interpret their results. In countries such as the UK, USA and Japan, where the modern measurement systems originated [5], their use in construction practice is already widespread. The UK is a cradle of performance measurement systems (PMS) relying on more than just financial criteria to measure performance. The first truly multi-criteria system was the Key Performance Indicators (KPI) scheme measuring time (schedule), quality of work, work safety, error rate and client satisfaction with the product [33]. The performance measurement system called Triple Bottom line [34] is also very commonly used in the UK and the US today. In addition to other factors, this system also measures and evaluates social value as well as environmental value. In Asia and especially Japan, systems are in use that incorporate principles designed for the automotive sector in the construction industry. These trends head towards the Lean Management principles that promote a stronger prefabrication approach in the construction industry. An example of this is the Total Quality Management (TQM) [35] system that comprises not just quality management and performance measurement but represents an approach that permeates the entire philosophy of the company, including leadership and strategic management. This article aims to find out the extent to which performance measurement is used in construction practice in the Czech Republic, and what measurement criteria are used by construction companies. The remaining part of this paper is organised as follows. In the next section, a review of the current state-of-the-art is conducted and covers the development of performance measurement, as well as key areas of measurement and its criteria. The third section describes research methodology used in this paper. In the fourth section, the results are presented and discussed, and the final section summarises the main conclusions, research limitations and future research directions.

2. CURRENT SITUATION

2.1. Development of construction contract measurement

Traditional systems for measuring the performance of construction contracts have been in development since the mid-1980s. Initially, these were a form of accounting systems focused entirely on financial indicators. They started by measuring profits, cash flow and return on investment [3].In their time, however, these financially oriented traditional systems came to play an important role in improving the controlling and monitoring of business activities and improved the performance of the construction companies that implemented them [4].Construction companies were primarily interested in budget control and contract cost reduction. The traditional systems of contract performance measurement helped other participants in the construction process (especially the investors) by documenting the scope of financial responsibility [4] of the construction companies using them. Over time and with changes in attitudes in the construction industry, there was growing criticism of the traditional measurement approaches. The traditional financial focus of the measurement [5] systems could no longer keep up with the rapidly changing business environment in the construction market and was no longer sufficient. As a result of this critical pressure, new approaches such as The Balanced Scorecard (BSC) were emerging [6], combining financial indicators with other important aspects such as product quality and customer satisfaction. Companies also started paying more attention to the construction schedule, reducing delays between individual processes on site. The results of regular measurements and their detailed analysis helped to implement changes [7] in construction schedules quickly and efficiently, contributing to greater construction efficiency. Gradually, the models were enriched with another important aspect contributing to greater satisfaction of employees and all construction stakeholders, namely the measurement of risks linked to work safety. The measurement of hazardous processes [8] and the evaluation of the number of accidents on site made it possible to improve safety measures and increase compliance with them. Recently, where there has been more emphasis placed on sustainable economy and environmentally sound behaviour [9], criteria from the area of environmentally responsible management have become gradually implemented in contemporary construction contract measurement systems. The amount of waste produced, the amount of recyclable waste used on site, water management and greenhouse gas emissions are measured. The effects of construction on the surrounding environment are also given more attention [10], both in terms of environmental and social impacts. Companies are increasingly measuring the noise and dust emissions generated during construction, the traffic load generated by construction sites on the surrounding infrastructure. More and more investors, when selecting a contractor,

examine how individual companies address these issues [10] and whether they have implemented a suitable measurement system. Construction companies that have implemented comprehensive multi-criteria measurement systems early are thus gaining an increasing competitive edge in the construction market.

2.2. Measurement areas and criteria

As mentioned in the previous chapter, financial aspects used to be the key area where measurements were conducted. Today, however, there is a wide variety of measurement criteria available that approach the construction work from many different perspectives, which are presented in this chapter for convenience. The most fundamental areas of construction contract measurement are time, cost and quality [11]. The measurement of financial indicators is still one of the key criteria for a construction contract's success. The key measurement criteria are as follows: rentability [12], profitability [13], growth and stability, revenue growth rate [14], project profit margin [15], construction cost [32], and cost overruns [14]. The area of time and project management includes criteria important for monitoring proper management of a project in all its aspects. In particular, it deals with measuring the performance of the construction contract implementation team. Time performance is measured with respect to the criterion of time overruns [16], where the deviation from the planned schedule is monitored. Also important is the criterion of communication between stakeholders [17] with an emphasis on the quality of communication and the amount of erroneous or misinterpreted pieces of information that may result in financial or time difficulties in the contract. Also, client satisfaction is one of the key indicators of a construction company's success and affects, among other things, the construction company's market share. Measurement indicators include customer satisfaction ratings [18] and it is also advisable to supplement the measurement system by monitoring the percentage of repeat customers [18]. The construction company's relative market share [19] is also a suitable indicator for measurement. Work and safety are a very important areas for the successful management of construction contracts and provides a wide range of criteria for measurement. The accident rate [20] at the construction site is a suitable criterion that is examined and compared with the company average, where the deviation is evaluated and further analysis of the causes of higher accident rate at the construction site is performed on its basis. A higher accident rate goes hand in hand with the incident cost criterion [21]. A company may both incur damage to the construction site and machinery, but the potential need to find replacements for injured workers taken out of the construction process also represents a significant cost. The loss of manpower then also has an impact on the time lost to accidents criterion [22], where the loss of a large number of employees can mean significant delays and this can pose a serious issue for the construction company due to penalties for not meeting contractual deadlines. Consequently,

suitable steps must be taken to prevent accidents at work. The safe and healthy audit criterion [23] represents such a tool for prevention, where the frequency of such audits and especially their results are carefully monitored. The information from these audit reports should be evaluated and appropriate measures incorporated into the construction practice as quickly as possible to remedy the identified work safety deficiencies. The most topical area of measurement in construction contracts concerns the environment and aims to make the construction industry as responsible as possible in terms of environmental protection and sustainable development of the human population. Measurement indicators can include energy and water consumption, waste and scrap levels, and contribution to the community. The contribution to the community [24] criterion in particular has other overlaps with the socio-economic criteria of the impact of the construction site on the surroundings and the community.

We have discovered from review that the measurement of contractors and subcontractors is not a very widespread measurement area. This area should be incorporated more into construction contract measurement systems. The objective is to achieve an effective supplier management [25]. The range of measured indicators is constantly growing, but we find in our review that only a few criteria are actively measured in Performance measurement systems. These actively measured criteria are supplier on-time delivery [26], flexibility [27] and quality of work [28]. As construction contracts are becoming increasingly complex with a high level of specialised work, the "general contractor" model represents an increasingly common way of carrying out construction contracts. It is for this reason that there is an increasing need for construction companies to measure these subcontractors effectively, both in terms of the quality of their work and their flexible approach to potential changes during the execution of the construction project. With the growing digitalisation in the construction sector, measurement systems are increasingly being connected to new digital tools for monitoring and measuring construction. Construction companies' investment in these technologies and their effectiveness is emphasised. It is this efficiency of investments into new digital technologies that can be measured by the standard financial return on investment (ROI) indicator, but it is also necessary to consider which competitive advantages the introduction of innovations such as BIM, Lean Management [29] and other innovative technologies linked to Industry 4.0 principles [30] can bring to a company in the future. The integrated performance index [31] is an increasingly used method for measuring and evaluating construction contracts. In consists in calculating a specific index composed of the individual parts of the measurement areas. This index is specifically quantified and expresses the overall project performance.

Table 1. Literature concerning the main areas and individual measurement criteria with sources that deal with these criteria in detail

Measurement area	Main criteria	References
Financial	rentability	[12] Liu, J. et al. (2015), [14] Ali, H.et al.(2013).
	profit margin, profitability	[12] Liu, J. et al. (2015), [13] Balatbat, M et al. (2011), [14] Ali, H et al. (2013), [15] Marzouk, M and Gaid, E (2018).[19] Yu, I et al. (2007).
	revenue growth rate	[14] Ali, H et al. (2013) [32] Yu, I et al. (2007).
	project profit margin	[15] Marzouk, M and Gaid, E (2018), [16] Ali, H et al. (2013).
	construction cost	[32] Bassioni, H, A et al. (2004).
	cost overrun	[14] Ali, H et al. (2013), [15] Marzouk, M and Gaid, E (2018).
Time & Project management	time overrun	[16] Otman, I et al. (2017), [17] Wu, G et al. (2017).
	communication between stakeholders	[17] Wu, G et al. (2017).
Client satisfaction	customer satisfaction ratings	[18] Chia, A et al. (2009).
	percentage of repeat customers	[18] Chia A et al. (2009), [19] YU, I. et al. (2007).
	relative market share	[19] Yu, I et al. (2007).
Work and safety	accidents level rate	[20] Peñaloza, G et al. (2020), [22] Lingard, H et al. (2011).
	incident cost	[21] Mohammadi, A et al. (2018).
	time lost to accidents	[22] Lingard, H et al. (2011). [21] Mohammadi, A et al. (2018).

	safety and health audit	[23] Smallwood, J (2015), [20] Mohammadi, A et al. (2018).
Suppliers (subcontractors) measurement	supplier on time delivery	[26] Halman, J and Voordijk, J (2012), [28] Love, P and Irani, Z (2003),[27] Chithambaranathan, P., et al. (2015).
	flexibility	[27] Chithambaranathan, P., et al. (2015).
	quality of work	[28] Love, P and Irani, Z (2003). [26] Halman, J and Voordijk, J (2012).
Quality	defects	[32] Bassioni, H, A et al. (2004).

Based on this search, the criteria found in the literature were identified. This summary is presented in the table above. It demonstrates that in the financial area of measurement, the most frequent criterion is the cost of construction, followed by the profit margin, while the least frequent criterion is the revenue growth rate. In the area of project management and construction time, time overrun against schedule is the most frequent criterion. The satisfaction measuring area is generally the least mentioned. The most frequently mentioned criterion is the percentage of repeat customers. The work and safety area has a similarly wide range of criteria as the financial area. The criteria there are mentioned with a roughly similar frequency: accident rate, time lost to accidents and safety and health audit. Subcontractor measurement is the final area under examination. Here the criterion of subcontractor compliance with on time delivery clearly dominates. The second is the quality of the subcontractors' deliveries and the least frequent is the subcontractor flexibility. The presented review of available literature confirms that advanced performance management systems are used in many developed countries. However, it is desirable to look more closely also on those member states of the European Union which, at the end of the 20th century, underwent a process of economic transformation. From this perspective, it can be expected that the managerial approach to performance issues might be different. Furthermore, there is also a need to contribute more to the performance management in the supply chain, more specifically, in the direction from the general contractor to the subcontractor. Consequently, the authors would like to fill this gap by providing the research community with (a) original findings related to the perception and use of performance management in the Czech construction industry from the suppliers' point of view; and (b) an expanded insight into the criteria for subcontractors' measurement. On the basis of the review presented

here, we discovered that some criteria that we consider important have not been mentioned in the literature. Consequently, we propose the following criteria to be added to our questionnaire survey: subcontractor communication quality, the amount of additional work required and environmental friendliness.

3. METHODOLOGY

An analysis of the state-of-the-art has identified key areas of measurement and the specific criteria that can be used to quantitatively evaluate performance. In order to meet the research goal, the research methodology applies both quantitative and qualitative approaches in explanatory sequential design. From the quantitative perspective, primary data have been collected by using a web-based questionnaire survey. The survey contained 10 questions divided into 3 sections. The first set of questions asked about basic characteristics of respondents such as specialisation of the company within the construction industry, size of the company and the length of time respondents were doing business in the industry. The second set of questions focused on issues related to company performance measurement in individual contracts. Finally, the third set of questions dealt with subcontractor measurement. A total of 250 potential respondents from various segments of the construction industry were invited to take part in the survey. Between January and May 2021, 61 valid responses were received, representing a 24.4% response rate. The data analysed for each question were presented in tabular or graphical view, depending on their specific nature, and quantified through relative frequency of occurrence. Detailed results and commentary are provided in the Results and Discussion section. In order to establish a better understanding of the quantitative data analysed and the results obtained, semi-structured interviews with five experts have been conducted. The set of predetermined topics/questions have been prepared in order to guide the interview with a focus on open-ended questions. Such an approach facilitates addressing the core areas of the researched topic, as well as reveals some important potential elements that were not covered by the questionnaire survey. Because some of the questions are created only during the interview, such a semi-structured interview supports the flexibility needed to probe for details and discuss issues.

4. RESULTS AND DISCUSSION

4.1 ANALYSIS OF QUESTIONAIRE SURVEY DATA

The initial questions in the survey asked about basic information on the construction company where the respondents work. The first question (see Table 2) inquired about the sector of the construction industry where the company or a

branch was doing business. The following basic sectors were offered as choices: residential and public construction; industrial construction; transport and utility construction; and finally, water engineering construction.

Table 2. Percentage share of respondents according to their specialisation in the construction industry

Construction sector	Relative frequency (%)
residential and public construction	68.5
industrial construction	22.2
transport and utility construction	5.6
water engineering construction	3.7

The results show that respondents willing to provide answers were concentrated mainly among residential and public construction companies. This result was expected because these companies make up most of the construction market. The next question inquired about the time respondents have been doing business in the industry.

Table 3. Length of respondents' experience in the industry

Length of experience	Relative frequency (%)
0-2 years	9.1
2-5 years	25.5
5-10 years	21.8
Over 10 years.	43.6

As can be seen in Table 3, two-thirds of the respondents have more than 5 years of experience in the industry, which improves the quality of the survey, as the respondents have been in the construction industry for a long time and can thus better assess the processes used in construction contracts. This enables them to answer the questions more competently and with professional erudition. The third question focused on the size of the construction company in which the respondents worked. Potential respondents were approached in such a way that their distribution across size categories was comparable. However, the results (see Table 4) show that companies with under 10 employees (micro companies) are

less likely to respond to similar surveys, which can be explained mainly by the high employee workload in companies in this size category. Based on this result we decided, in the following sections, to merge the micro and small company size categories.

Table 4. Size of respondents' construction companies in terms of the number of employees.

Company size	Relative frequency (%)
Under 10 employees (micro company)	3.6
10-49 employees (small company)	25.5
50-249 employees (medium-sized company)	34.5
Over 250 employees (large company)	36.4

A total of 70.9% of the respondents were employed in construction companies with over 50 employees. This means they represent companies that are expected to have the financial resources to measure their projects and sufficient staff for this purpose, while at the same time investing more in the digitalization of their processes and possibly also of processes related to contract measurement.
Subsequently, a set of questions was asked about contract measurement and the criteria used. The first question inquired about whether companies evaluated the results of their contracts.

Table 5. Evaluation of construction contract outcomes

Evaluation of contracts	Relative frequency (%)
Yes, we evaluate each contract	81.8
Yes, but we only evaluate contracts above certain value.	9.1
No, we do not evaluate contracts at all.	9.1

It is clear from the data shown in Table 5 that over 90% of construction companies already evaluate their contracts in some way, but 9% of construction companies do not evaluate their contracts at all. It is interesting to note the size of the companies from where the 9% were recruited, which is shown in Figure 1.
The result shows that the 9% of construction companies that do not evaluate contracts mostly include micro and small companies. As expected, no evaluation of contracts is rare in companies with over 50 employees. The companies that do

not evaluate their contracts at all were then asked to answer the following question: "What is the reason why you do not evaluate your contracts at all?" The answers shows that the companies that do not measure their contracts at all do not do so because they would not consider it important. The reasons include the lack of time as well as insufficient staff, which are obviously interrelated factors. If a construction company lacks sufficient staff, this logically creates time constraints to individual tasks and seemingly less important tasks are then neglected.

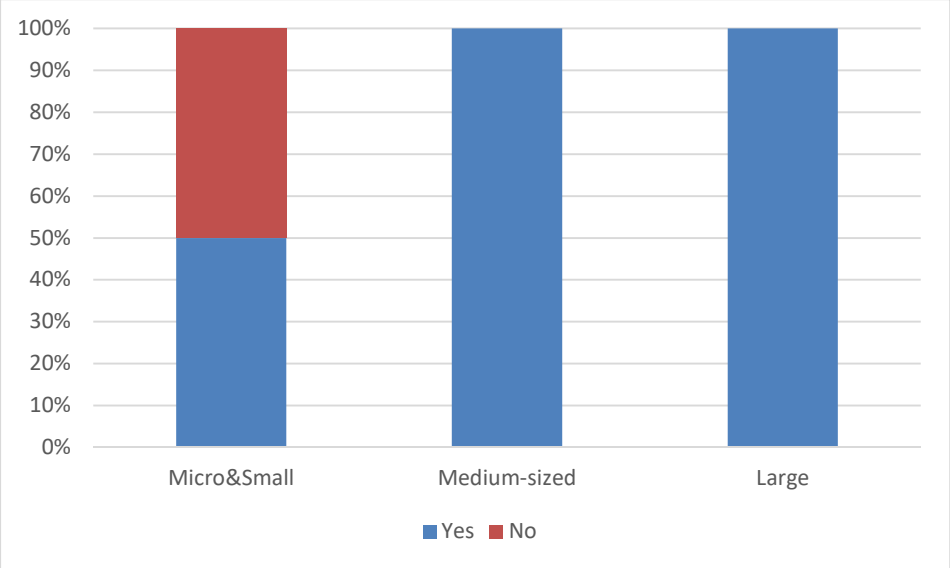

Fig. 1. Evaluation of contracts based on company size

The next question inquired about the frequency of evaluating (measuring) contracts over time. The aim was to find out whether construction companies measure their contracts during the process or only after they are completed.

Table 6. When construction contracts are measured

Time of measurement	Relative frequency (%)
Only after completion	6.1
During the performance of contract and after its completion	89.8
Only during the performance of the contract.	4.1

The result in Table 6 shows that companies that have already decided to implement a measurement system then logically measure construction contracts during as well as after they are completed. Around 6% of companies only measure

contracts after they are completed; 100% of companies that responded in this way were firms with 10 – 49 employees. A total of 4% of companies responded that they evaluate contracts only during their performance; this was the case in companies in the transport construction sector. It is very important to be aware of the criteria used to measure contracts in practice. Figure 2 shows which companies (according to their size) measure their contracts during or only after these contracts are completed.

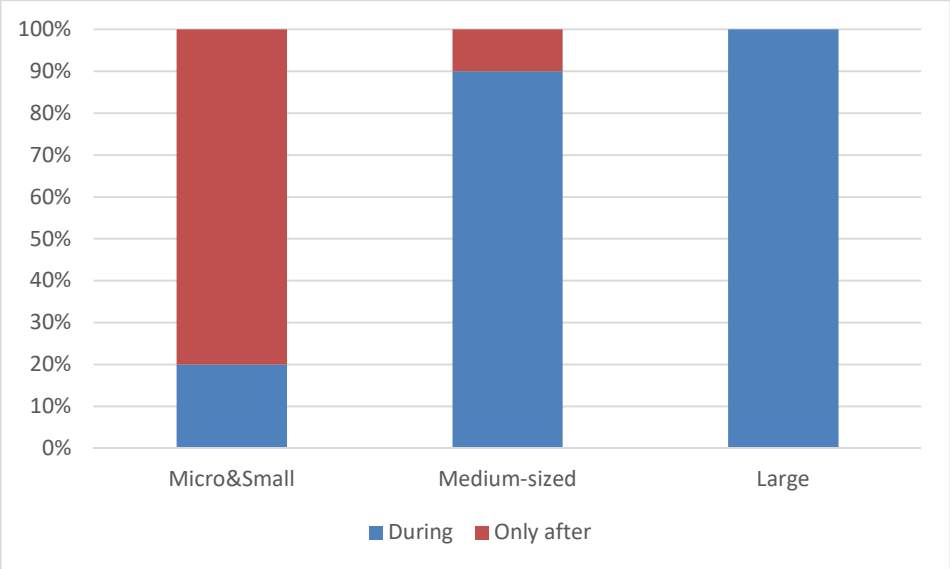

Fig. 2. Measurement of contracts during the execution of works and only after the contract is completed

Results clearly show that 80% of micro & small companies do not measure their contracts during the execution of construction works, but instead only after the completion of work on the contract. On the other hand, all large companies measure their contracts already during the execution; 90% of medium-sized companies conduct measurements during the whole construction process. The next question focused on individual measurement criteria. The data in Table 7 clearly show the criteria most frequently used by Czech construction companies.

Table 7. Ranking of individual criteria that respondents said they evaluate and measure in their company

Measurement criteria	Relative frequency (%)
Construction cost	91.8
Construction time	77.6
Client satisfaction	61.2
Rentability	59.2
Number of defects, quality of work	57.1
Work safety	40.8
Communication among stakeholders	38.8

As expected, the most frequently evaluated criterion was the cost of construction, where companies assess whether the planned costs correspond to the actual expenditures. Construction time was also a very frequently used criterion. Perhaps a little surprisingly, client satisfaction came in third place. However, this reflects recent trends in the business where more and more emphasis is placed on client satisfaction – not only with the product, but also with the conduct of employees and their helpfulness in flexibly responding to client requirements. Less than half of the companies measure work safety, which is not a positive finding. Communication between construction participants is assessed or measured in 38.8% of companies, which is a result comparable to that of work safety. Another area surveyed was subcontractor measurement. Firstly, respondents were asked whether they measured the performance of their subcontractors at all (see Table 8). A total of 81.9% of respondents gave a positive reply, which is a rather high number. Moreover, 65.5% of the companies measure this aspect for all their contracts, while another 16.4% of the construction companies measure their subcontractors at least in selected construction contracts. It can be assumed in this regard that these are the most important contracts for the given company. The types of these specifically selected contracts and the criteria for selecting them could be a subject for future research. A total of 9.1% of construction companies are already planning to start measuring subcontractors in the future, while the same percentage do not consider it important at all.

Table 8. Measurement and evaluation of subcontractors

Measuring and evaluating subcontractors	Relative frequency (%)
Yes, we do so in all our contracts.	65.5
Yes, but not in all contracts.	16.4
No, but we plan to start in the future.	9.1
No, and we do not consider it important.	9.1

Respondents who answered positively to the question on measuring subcontractors were then asked about the criteria they used to measure these subcontractors (see Table 9). This resulted in the percentage frequency of the respondents' answers. All respondents said that they measure on time delivery, which was expected. Almost all respondents answered that they also measure the quality of the subcontractors' deliveries (work). The overwhelming majority of companies (91.1%) monitor the ability to meet the original price offered by the subcontractors, while 68.9% assess their time flexibility, that is the ability of subcontractors to respond flexibly to changes in the time schedules necessitated by the actual situation on site. Finally, 62.2% of companies assess the quality of communication with their subcontractors. Good communication is essential in the context of an accelerating flow of information requirements and changes on site, where it is essential that subcontractors are able to explain the necessary issues well and make an effort to understand all the required inputs. The amount of additional work required is only measured by about half of the respondents and environmental friendliness by only 17.8%. This is not a very good result and it demonstrates that there is still a long way to go in terms of sustainability in construction.

Table 9. Frequency of subcontractor measurement criteria

Subcontractor measurement criteria	Companies which currently measure subcontractors	Companies which currently consider measuring subcontractors
	Relative frequency (%)	Relative frequency (%)
On time delivery	100.0	100.0
Quality of work	97.8	100.0
Meeting the original price	91.1	60.0
Time flexibility	68.9	40.0
Communication quality	62.2	30.0
Amount of additional work required	53.3	10.0
Environmental friendliness	17.8	0.0

Respondents who answered that they would like to start measuring were then asked which criteria they would choose for future measurement (see Table 9). With two exceptions, the responses more or less reflected the distribution of responses to this question by respondents who already do implement contract measurement. The first exception was that there were about 30% fewer positive responses concerning the meeting of the original price criterion. This could be interpreted as meaning that companies that have been doing such measurements for some time have gradually improved their systems based on the results obtained in practice, where they have identified criteria that were previously missed. The second exception, where the result for the criterion of the amount of additional work required was around 40 % lower, can be interpreted similarly. Unfortunately, not a single company indicated plans to measure environmental friendliness, which is a result worse even than in the construction companies that are already actively conducting measurement.

4.2 FINDINGS RESULTING FROM THE INTERVIEWS WITH EXPERTS

The respondents to be interviewed were selected from a wide range of construction companies with the aim to cover all three company group sizes examined. Each respondent represented a different construction company and,

therefore, a total of five key respondents from five companies were interviewed. The basic information about the respondents is provided in Table 10. The presented data show that all interviewees are experts with significant professional experience, which is essential to ensure high relevance of their answers and to draw valuable conclusions.

Table 10. Information on the interviewed experts

Identification	Position	Years of experience	Company size
Expert 1	Technical manager	25	Micro&Small
Expert 2	Project manager's support team	10	Micro&Small
Expert 3	Site manager	3	Medium
Expert 4	Production centre officer	35	Large
Expert 5	Site manager	12	Large

The first question aimed to find out if the respondent's company measured contracts only after their completion or already during the construction process. Most of the experts confirmed that they also measured during the course of the contract, which was especially true for respondents from large construction companies, who stated that they were required to do so for all construction contracts by the management. Experts from micro and small enterprises, on the other hand, stated that their companies only measured contracts above a certain amount, whereas Expert 1 specified this amount to be CZK 100 thousand or more. It should be added that respondents from large construction enterprises also stated that they only accepted larger contracts from about CZK 1 million (excl. VAT) upward. The second question in the interview inquired about the differences in measuring divergent types of construction contracts, according to their volume. Here the experts answered that their companies measured large contracts much more accurately and precisely and also that in large contracts, they devoted significantly more time to the actual measurement. Experts from large enterprises then stated that their companies used specialised employees, who only worked on measurement, for major and large contracts. The next question concerned satisfaction with their measurement system. Respondents were asked if they thought that their performance measurement system should be somehow improved or expanded. Respondents from medium and large companies answered that their companies had quite sophisticated measurement systems that no longer needed to be improved significantly, but that they naturally tried to tweak individual measurement details on an ongoing basis. Respondents from Micro&Small enterprises indicated that if their staff was increased, they would be able to significantly improve their measurement systems. We further looked at

measuring the individual criteria used in their measurement systems and the importance that the respondents attached to them in terms of obtaining the best possible result from contracts. We asked them to assign a weight from 1 to 5 to the individual criteria. Weight 5 meant the highest importance, while Weight 1 meant the lowest importance. The results of this survey with the order of the weights of the individual criteria are provided in Table 11.

Table 11. The order of criteria according to the average weight assigned to them by the respondents

Criterion	Weights average	Position
Construction cost	4.2	3=4
Construction time	4.6	1
Client satisfaction	4.4	2
Rentability	3.6	5=6=7
Number of defects, quality of work	4.2	3=4
Work safety	3.6	5=6=7
Communication among stakeholders	3.6	5=6=7

All respondents agreed that construction time, client satisfaction and construction cost were the most important measurement criteria. By contrast, work safety and communication among stakeholders were rated as less important. An interesting finding was that respondents from large enterprises gave significantly more weight to work safety than respondents from Small & Micro enterprises. When inquired about why they felt this way, they stated that they mostly performed large contracts for multinational corporations, which hire technical and safety supervisors to oversee construction sites and strictly require compliance with workplace safety rules. The next question concerned the issue of individual factors' influence on achieving the best contract performance. We asked about the respondents' opinions as to how important the factors listed below are on achieving the best contract performance.

Table 12. The importance of factors' influence on the best possible result of construction contracts

Influence	Weights average	Position
Right selection of supplier/subcontractor	4.2	2=3=4
Quality of inputs for the tender	4.4	1
Errors in project documentation	4.2	2=3=4
Quality and balance of contract	3.4	5=6
Specifics of contract - complexity, e.g., reconstruction compared to new construction, etc.	3.4	5=6
Insufficient communication between project stakeholders	4.2	2=3=4

Respondents most often stated that the most important factor was the quality of tender documents and the correct selection of suppliers/subcontractors. All respondents also agreed about the importance of good communication between the different stakeholders. Respondents from smaller enterprises in particular mentioned that the quality and balance of the contract for work was less important. When asked why this was the case, they stated that it was often the reality of construction practice that if there was good communication with the investor and everything was going well, the investor would not insist on all the contractual requirements, which are only put into the contracts by lawyers to protect the company in case of a lawsuit. An important part of our research aimed to learn about the subcontractor measurement practices in Czech construction companies. The following question thus asked about the importance of each area in subcontractor measurement. We asked the respondents again to assign a weight from 1 to 5 to the individual criteria of subcontractor measurement. Weight 5 meant the highest importance, while Weight 1 meant the lowest importance. The results are presented in Table 13.

Table 13. The order of criteria according to the average weight assigned to them by the respondents

Criterion	Weights average	Position
On time delivery	4.8	1
Quality of work	4.6	2=3
Meeting the original price	4.6	2=3
Time flexibility	3.6	5
Communication quality	4.2	4
Amount of additional work required	3.2	6
Environmental friendliness	3.0	7

The results show that the respondents considered the following criteria to be the most important: on-time delivery, quality of work and meeting the agreed price. More or less all respondents agreed on this. Respondents from large enterprises then gave relatively high weight to the criterion of communication quality. Compared to respondents from large enterprises, respondents from small and medium enterprises assigned far lower importance to environmental friendliness. The amount of additional work required was considered significantly more important by respondents from medium and large enterprises, who commented on the fact that they handled contracts with a large number of subcontractors and need to have a good overview of the additional work required and what caused it so that they could then communicate about these issues effectively with the investor and the designer. They also stated that most of the time, errors in the documentation or materials from the designers were the reason for the additional work required.

5. CONCLUSIONS

This paper focused on the performance measurement in the Czech construction sector. The result of the analysis shows that about 90% of companies measure their contracts. The main reasons for small and micro companies not to measure their contracts consists in the lack of time and insufficient staff. A positive finding

is that the vast majority of companies measure their contracts not only after their completion, but also during the implementation of the construction project. This approach allows for an early detection of potential problems on site, enabling the companies to take a prompt corrective action. The results also revealed the most commonly used measurement criteria in the construction industry, both in terms of the companies' own construction contracts and in relation to their subcontractors. The result of the interview with experts from construction companies who were asked to comment on the importance of the individual criteria for the successful outcome of a construction contract shows that construction time, client satisfaction, construction cost and quality of work were considered the most important. Room for improvement in measurement was identified especially in the context of work safety and environmental perspectives. Due to the employee composition in the construction market, this indicates a potential for insufficient occupational safety, and it would therefore be appropriate to give more emphasis to safety issues in the context of performance measurement. This is because a reduction in safety incidents brings more stability to the workforce and avoids putting workers off work for longer periods of time, with corresponding difficulties in finding replacements. A relatively high number of companies that do not measure quality are at risk of potential complications during the handover of the work and a higher number of subsequent claims of defects during the work's warranty period. This creates additional costs to the companies, cutting into their profits and putting pressure on the companies' cash flow. In the area of measuring subcontractors, the experts considered the most important criteria to be: on-time delivery, quality of work and meeting the agreed price. The least important for them was the supplier's environmental friendliness. This finding, given the current trend emphasising more sustainability in the construction industry, is not encouraging and the importance of this area will have to be explained more patiently to construction experts. This research represents an initial insight into the performance measurement practices applied by companies in Czech construction market. Accordingly, the results presented in this paper show general trends and do not focus on specific details. Instead, the results reveal several aspects that should be explored further, e.g. the appropriate measurement range and structure of criteria from the perspective of the financial scope of contracts and the type of construction work.

ACKNOWLEDGMENT(S)

This research paper was written with the support of Brno University of Technology, grant project no. FAST-J-21-7352 "Performance measurement of construction contracts".

REFERENCES

1. Kagioglou, M, Cooper, R and Aouad, G 2001. Performance management in construction: a conceptual framework. *Construction Management and Economics* **19,** 85-95.
2. Neely, A 1999.The performance measurement revolution: why now and what next? *International Journal of Operations & Production Management* **19**, 205-228.
3. Yaghoobi, T and Haddadi, F 2016. Organizational performance measurement by a framework integrating BSC and AHP. *International journal of productivity and performance management.*
4. Niven, P 2005. *Balanced scorecard diagnostics: Maintaining maximum performance: Maintaining maximum performance* (John Wiley & Sons).
5. Noordin, N, Haron, S and Kassim, S 2017. Developing a comprehensive performance measurement system for waqf institutions. *International Journal of Social Economics* **44,** 921-936.
6. Subramani, T, Lishitha, P and Kavitha, M 2014. Time Overrun and Cost Effectiveness in the Construction Industry. *Journal of Engineering Research and Applications 4 (5),*111-116.
7. Lehtola, M et al. 2008. The Effectiveness of Interventions for Preventing Injuries in the Construction Industry: A Systematic Review. *American Journal of Preventive Medicine* **35,** 77-85.
8. Goel, A, Ganesh, L and Kaur, A 2019. Sustainability integration in the management of construction projects: A morphological analysis of over two decades. *Journal of Cleaner Production* **236,** 117676.
9. Okoye, P 2021. Factors Influencing Clients' Commitment to Sustainable Construction Practices. *Planning* **16,** 39-48.
10. Meng, X 2012. The effect of relationship management on project performance in construction. *International journal of project management* **30,** 188-198.
11. Ankrah, NA and Proverbs, D 2005. A framework for measuring construction project performance: overcoming key challenges of performance measurement. *In 21st Annual ARCOM Conference* **2**, 959-969.
12. Liu, J, Love, P, Smith, J, Regan, M and Palaneeswaran, E 2015. Review of performance measurement: implications for public–private partnerships. *Built Environment Project and Asset Management* **5,** 35-5.
13. Balatbat, M, Lin, C and Carmichael, D 2011. Management efficiency performance of construction businesses: Australian data. *Engineering, construction and architectural management.*
14. Ali, H, Al-Sulaihi, I and Al-Gahtani, K 2013. Indicators for measuring performance of building construction companies in Kingdom of Saudi Arabia. *Journal of King Saud University - Engineering Sciences* **25,** 125-134.

15. Marzouk, M and Gaid, E 2018. Assessing Egyptian construction projects performance using principal component analysis. *International Journal of Productivity and Performance Management* **67,** 1727-1744.
16. Othman, I, Shafiq, N and Nuruddin, M 2017. Time overrun in construction project. *IOP Conference Series: Materials Science and Engineering.* vol. 291 (IOP Publishing), p. 012016.
17. Wu, G, Liu, C, Zhao, X and Zuo, J 2017. Investigating the relationship between communication-conflict interaction and project success among construction project teams. *International Journal of Project Management* **35,** 1466-1482.
18. Chia, A, Goh, M and Hum, S 2009. Performance measurement in supply chain entities: balanced scorecard perspective: balanced scorecard perspective. *Benchmarking: An International Journal* **16,** 605-620.
19. Yu, I. et al. 2007. Comparable performance measurement system for construction companies. *Journal of Management in Engineering* **23**, 131-139.
20. Peñaloza, G, Saurin, T and Formoso, C 2020. Monitoring complexity and resilience in construction projects: The contribution of safety performance measurement systems. *Applied Ergonomics* **82,** 102978.
21. Mohammadi, A, Tavakolan, M and Khosravi, Y 2018. Factors influencing safety performance on construction projects: A review. *Safety Science* **109,** 382-397.
22. Lingard, H , Wakefield, R and Cashin, P 2011. The development and testing of a hierarchical measure of project OHS performance.*Engineering, Construction and Architectural Management.*
23. Smallwood, J 2015. Optimising the elements of a construction health and safety (H&S) programme and audit system *Procedia Engineering* **123,** 528-537.
24. Kang, H, Lee, Y and Kim, S 2016. Sustainable building assessment tool for project decision makers and its development process. *Environmental Impact Assessment Review* **58,** 34-47.
25. Takim, R and Akintoye, A 2002. Performance indicators for successful construction project performance. *18th Annual ARCOM Conference* vol. 2 pp. 545-555.
26. Halman, J and Voordijk, J 2012. Balanced framework for measuring performance of supply chains in house building. *Journal of construction engineering and management* **138,** 1444-1450.
27. Chithambaranathan, P, Subramanian, N and Palaniappan, P 2015. An innovative framework for performance analysis of members of supply chains. *Benchmarking: An International Journal* **22,** 309-334.

28. Love, P and Irani, Z 2003. A project management quality cost information system for the construction industry. *Information & Management* **40,** 649-661.
29. Banawi, A and Bilec, M 2014. A framework to improve construction processes: Integrating Lean, Green and Six Sigma. *International Journal of Construction Management* **14,** 45-55.
30. Cai, S, Ma, Z, Skibniewski, M and Bao, S 2019. Construction automation and robotics for high-rise buildings over the past decades: A comprehensive review. *Advanced Engineering Informatics* **42,** 100989.
31. Yang, H et al. 2010. A critical review of performance measurement in construction. *Journal of Facilities Management* **8**,269-284.
32. Bassioni, HA et al. 2004. Performance measurement in construction. *Journal of management in engineering* **20**, 42-50.
33. Robinson, HS et al. 2005. Business performance measurement practices in construction engineering organisations. *Measuring Business Excellence.*
34. Kucukvar, M and Tatari, O 2013. Towards a triple bottom-line sustainability assessment of the US construction industry. *The International Journal of Life Cycle Assessment*, **18**(5), 958-972.
35. Hoang, DT, Igel, B and Laosirihongthong, T 2010. Total quality management (TQM) strategy and organisational characteristics: Evidence from a recent WTO member. Total quality management, **21**(9), 931-951.

Editor received the manuscript: 04.08.2021