Measuring the performance of construction contracts with regard to the environment

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Abstract. Performance measurement of business processes is a necessary prerequisite for efficiency improvement. The increasing demand for enhanced environmental protection in construction is also reflected in recent performance measurement systems. This paper aims to review various systems used for performance measurement in construction contracts and to discuss current developments in this area. Findings show that the importance of environmental protection is growing as the sustainability approach is becoming more common. In the construction industry, green and sustainable criteria are becoming an integral part of responsible entities’ considerations and strategies for reducing energy consumption and handling construction materials responsibly (e.g., by means of recycling/re-use), considering the high material intensity of construction production.

1. Introduction
In recent years, many sectors of the industry have undergone a push to achieve greater sustainability and reduce adverse environmental impacts. As one of the key industrial sectors, construction has a significant global environmental impact in terms of energy consumption and pollution. Under pressure from national governments and society at large, construction companies have been trying to reduce their environmental impacts as much as possible. The key tool to achieve this consists in a careful preparation, monitoring and measurement of construction contracts according to multiple criteria. Measuring financial indicators and profitability has been the traditional way to measure the performance of construction contracts. This approach, however, has proven inadequate in view of the changes in the construction sector over last 30 years, especially with regard to growing pressures to adopt new technologies and increase competitiveness that have forced Western European and American construction companies to re-evaluate their way of doing business. Since the 1990s, studies on new construction contract measurement systems have appeared. However, some of the emerging approaches have been criticised for their narrow focus and insufficient quantification of the individual criteria. The studies have often focused merely on cost management and productivity and neglected the broader context of projects and all their aspects [1]. Performance measurement of construction contracts has been approached both in terms of numerical measurement and quantitative measurement. Efforts appeared to create a systematic process of evaluating inputs and outputs on an ongoing basis over the course of a project’s development. This new conception treated the system as a systematic tool to smoothly improve the efficiency of construction, where all areas are inter-related and one area of measurement can affect the others; consequently, measurement must be approached as an
interconnected system of individual areas, not just as individual measurements carried out in separate
and unrelated areas as was the case before [2].

This article deals with issues related to performance measurement in construction contracts from the
contractors’ perspective. The objective of this contribution is to concisely describe various performance
measurement systems with an emphasis on an environmentally-conscious approach. For this purpose,
an extensive research of relevant literature was conducted, with special emphasis on journals indexed in
the Web of Science and Scopus databases. The article’s ambition is not to conduct a systematic review
of the relevant field, but to select certain articles to provide a concise overview of the current trends in
construction contract performance measurement.

2. Performance measurement models and their development with regard to the environment
This chapter describes various models of construction contract performance measurement and discusses
the development of the lists of measured criteria and the way the models approached environmental
impact.

2.1. Iron Triangle
The Iron Triangle system of project management is one of the most widely used to control projects. In
this scheme, a project’s success is define by a compromise between three main constraints: Scope
(features, functionality) expresses the extent of the total amount of work associated with a project;
Resources (also called Cost) express the resources needed for the project, such as the budgeted price
and human resources available; Schedule expresses the duration of the project, the amount of time
allocated to construction. These three parameters represent tips of a triangle where the quality of the
project lies in the middle, being a result of a suitable trade-off between the three constraints. While the
project’s manager has a certain degree of freedom in balancing the individual aspects, no constraint can
outweigh the others; for instance, a manager can significantly shorten the time needed to complete a
construction project, but only at the cost of a prohibitively large increase in price. Conversely, a reckless
drive to reduce costs could lead to delays in construction or a decrease in overall quality [3]. These
examples clearly demonstrate the interconnectedness of all three fundamental aspects and their
importance for a successful completion of a project. However, this traditional approach completely
omits a wider spectrum of criteria important in modern project management such as respect for the
building’s surroundings, stakeholders’ interests and especially the environmental impact of the project
and sustainable construction targets which are of crucial importance in the 21st century.

2.2. KPI
The system of Key Performance Indicators was developed in the United Kingdom and includes
parameters measuring the performance of projects with a view to improve construction efficiency and
eliminate recurring problems. Most of these indicators were oriented towards the construction stage of
the project, and individual parameters were determined as follows:

- Construction price;
- Construction time;
- Error rate;
- Client satisfaction with the product;
- Profitability prediction;
- Project development time;
- Work safety. [4]

What the KPI system lacked was a focus on other stages of the project, e.g. the main contractor
selection stage, and the lack of control over the selection and supervision of subcontractors; the system
also does not deal with the project’s environment (connection with the project’s surroundings and the
environment) [4]. Modern approaches in the area of construction contract performance measurement are
based on further elaboration and specification of the individual KPI criteria. An study by a Chinese research team led by Sai On Cheung [5] published in “Automation in Construction” focused on developing a tool for monitoring and the subsequent evaluation of individual construction contracts.

To determine the key criteria, Sai On Cheung et al. used the system of Key Performance Indicators as a basis; with a contribution from the Hong Kong association of managers, they defined and described 8 individual criteria, namely:

- Workers;
- Price;
- Time;
- Quality;
- Work safety;
- Environment;
- Client satisfaction;
- Communication. [5]

As can be seen above, environment is now one of the criteria, which points to the emerging attention to impacts of building projects on their environment and surroundings during and after the construction.

2.3. Triple Bottom Line

The Triple Bottom Line principle was first published in 1981 by Freer Spreckley [6], but it took many years for companies to become aware of it. The principle is based on a simple idea that can significantly improve the environment, especially due to the fact that companies will assume a greater degree of responsibility for the planet and become more environmentally-friendly; especially in the construction sector, they will apply the principles of sustainable development. The principle posits that a company should rest on three main pillars: Economic profitability of its business, environmental considerations, and social responsibility (see Figure 1).
Figure 1. Triple bottom line principles [7]

In terms of environmental friendliness, a construction company may, for instance, rethink its waste management, consumption and the types of resources it uses according to their recyclability and hazardous nature of waste. In construction, this also concerns land use and management, where investors are increasingly pushed to develop brownfields [8] and renovate existing built-in areas to protect precious land resources. It is also suitable to evaluate buildings in terms of their entire life cycle [9] and design building technology solutions to be as efficient as possible, since the construction and building sectors are among the largest consumers of primary energy on the planet. This approach is also linked to Industry 4.0, which emphasises sustainability and whose main principles encompass modernisation in terms of automation [10] and the Internet of Things (IoT) [11], which should help bring about more environmentally-friendly manufacturing processes that also produce significantly less waste [12]; IoT is also closely associated with energy consumption of devices and efficient use of energy [13], as well as more environmentally-conscious use of resources such as water and soil.

2.4. PPE and SPM – an Australian approach
The Australian Project Performance Evaluation (PPE) system of construction contract performance measurement includes a large number of individual measurable categories and emphasizes especially the construction time, cost, quality, safety, environment and adds a system of settlement of disputes among the individual stakeholders, as well as management of contractual matters. A benefit of this new approach consisted especially in a more detailed focus on previously neglected parameters, which are nevertheless important in terms of contract efficiency [5]. Many performance measurement systems completely ignore the ways in which the individual stakeholders participate in the construction process, and the interactions between the contractor and the client. This fact was noticed by a team from Curtin University (Perth, Western Australia) led by Peter E.D. Love who focused on the relationships between the client, contractor, staff, financiers and the broader community. They created the SPM (Stakeholder Perspective Management) model and defined three main pillars: listening to the interests of the client and other stakeholders (measure how satisfied they are with the product/how successful the product is); target-profit orientation (measure the financial performance of the contract); systematic handling of inputs and their transformation into a building and interactions with its environment/surroundings (measure competitiveness, productivity and quality). This approach should yield an optimised performance of individual contracts, as well as the company as a whole [14]. As is clear from the selection of criteria, this system completely lacks the building’s environmental impact aspect – it focuses on improving performance of construction contracts especially in terms of better communication between stakeholders.

2.5. Models based on a multi-criteria analysis
A frequent problem appearing in developing a model for evaluation of construction contracts’ success lies in choosing the right indicators for performance measurement. A study by Vilnius Gediminas Technical University [15] dealt with the use of aggregated construction contract performance measurement indicators, using the principles of the multi-criteria analysis method and a logarithmic normalisation method. It also dealt with the issue of correct resolution of input information and sorting, evaluating and relevance of the individual input data necessary for a model of construction project management, as well as assigning individual relevant sources to performance measurement indicators. It modelled situations where one project manager is responsible for several different construction projects simultaneously and has to, with respect to each building, assess various performance metrics such as: the duration of construction, utilisation of project budget, the number of working teams etc. to evaluate the correctness of the decisions made and their impact on the construction contract’s efficiency. The study presented a diagram of problematic factors, essentially a chart of individual causal relationships. The chart is based on four main project performance indicators, namely: financial
profit/loss on the project, financial resource management, time management, quality management, project and working team performance, plus subcategories related to these indicators.

2.6. Systems focusing on project managers’ decision-making

Success in all kinds of construction contracts often hinges upon the ability of project managers to make the right decisions at the right time. The quality of individual decisions often depends on the ability of the project manager to objectively assess individual input data, compare them and sort out the input data most important and relevant for the particular situation to serve as a basis for making correct decisions. “Twin evaluation” can serve as a suitable tool in this regard. The project manager has to balance out two specific critical points:

- The current course of the project (generally speaking);
- The potential future course of the project affected by a current decision, including the consequences of the decision for the project (comparison of the present with a potential future).

Each successful construction contract performance evaluation system should contain a part dealing with the elements of effective planning, control and evaluation of project managers’ decisions taken at critical junctions as well as at other important milestones of the project, while approaching the project as a whole [16].

Many studies dealing with construction contract performance show that it is impossible to devise a universal list of measurement criteria. The criteria often differ between projects and are dependent on their distinctive, unique characteristics determined by their complexity, size, number of stakeholders, etc. Consequently, the list of all monitored criteria has to be as broad as possible and adjusted to suit the needs of a particular project by removing criteria irrelevant in terms of the project’s aims and context. In this regard, the Project Management Body of Knowledge organisation has prepared a list of nine basic areas for measuring the performance of individual projects that can be adjusted by project managers with regard to the unique characteristics of each project already during the preparatory stage:

- Process of integration of the individual elements of the project (with emphasis on coordination of the individual project parts);
- Scope of the project’s initial stages (the need to secure the necessary scope of inputs);
- Determination of time necessary to complete individual project stages;
- Project cost management (ensuring the project meets the approved budget);
- Construction quality management (ensuring sufficient quality of the building);
- Human resources management (effective use of workers employed by the project);
- Ensuring timely and full collection and sharing of information;
- Management of individual risks (analysis and response to individual risks);
- Management of project subcontractors.

These are known as PMI Standards and the usefulness of this approach to project management has been demonstrated in many large-scale projects implemented in Southern Europe, where it improved project efficiency and risk evaluation at the project design stage as well as the project construction stage [17]. ISO 10006:2003 represents another standard for project management and evaluation. This standard defines project management as a set of business processes and simultaneously emphasises a strong link between behaviour and decision-making processes in project management. It supplements the system with a more detailed breakdown of the project according to WBS (Work Breakdown Structure) [18].

Most authors of studies dealing with construction contract performance measurement conclude that project managers need to measure the performance of the contract for two main reasons: to identify criteria and areas in need improvement, and to supervise and evaluate the behaviour of their subordinates. In other words, they need to establish a strategic control of the project. Such strategic
control can significantly influence the behaviour of people working on the project. Such controlling enables team members to get feedback quickly, to better interpret and evaluate the steps taken, and to see the effect of decisions on cost management and the benefits of correct decisions on the course of the construction contract; consequently, team members can better maximise project profits and, thanks to the financial motivation (share of profits derived from the contract), they are highly motivated to achieve the best results. Employees can also be motivated by means of penalties. If the project team is aware that an effective system of measuring their performance (and performance of the entire project) exists and is able to immediately report to the project management the current conditions and the immediate effect of the team’s decisions, team members are better motivated to carefully consider the consequences of their decisions and work harder towards the success of the project [4]. In its most recent versions, this system increasingly accentuates environmental friendliness of construction, especially in terms of the types of construction materials used, i.e. materials may be chosen with regard to their ecological footprint [19]. Emphasis is laid on the use of partially or fully recyclable materials. The system also deals with construction waste management, where it emphasises storage and disposal of hazardous waste that could contaminate the environment around the construction site.

2.7. PS3 system – a French approach

PS3 is a system that has gradually emerged in France [20]; it aims to further aggregate the individual construction contract performance measurement indicators in order to create a multi-criteria and comprehensive system. The system relies on comprehensive reporting of individual outputs to all project stakeholders and the subsequent integration of their feedback in order to achieve the best trade-offs in terms of balancing the interests of the individual stakeholders. In terms of project decision-making and management, the model comprises several basic pillars:

- Identifying individual tasks and targets;
- Identifying suitable measurement tools (e.g. software tools);
- Specifying measurement rules to be adhered to;
- Specifying units of measurement for the individual criteria.

As regards the individual areas of measurement, the system basically adopted PMI standards using nine areas; however, it newly includes the important insight that none of the areas can be understood as completely independent, but should rather be seen as interlinked and affecting each other. It highlights especially the fact that criteria focused on construction time and construction cost are distinct in that it is not immediately clear where there is accumulation of deviations that could manifest as late as in the final stage of construction. An important insight confirmed in practice is the fact that multi-criteria models of management and evaluation of construction contracts enable a broad and comprehensive perspective of the project and its individual parts, thus enabling a faster and better adoption of remedial measures to correct for mistakes and potential hazards. As is increasingly clear, multi-criteria models can, thanks to their comprehensiveness, better capture criteria related to sustainable development and the environmental footprint of construction and buildings. The current interests of human society at large were included in the Stakeholders Interest category, including values such as environmental protection and the building’s environmental footprint during and after construction, i.e. in the operation phase; a current trend is to implement rainwater collection systems, green roofs and a greater amount of greenery around the building or on its surface or other parts. An emphasis is also laid on using energy-efficient measures, where France is one of the leading countries in promoting sustainable principles in construction.

3. Conclusion

As was demonstrated on the overview of the individual systems listed above, measurement systems originally focused solely on economic and financial indicators. They were gradually expanded to include criteria related to many other areas important for management and successful completion of projects
such as HR management, work safety, management of communication between stakeholders, management of contractual relationships and conflict prevention. In recent years, the list of criteria is expanding even more to encompass the areas of social responsibility, environmental protection, waste recycling and disposal, and sustainable development in construction. Since construction is one of the key sectors affecting the environment, this trend comes at a time when it is urgently necessary to address environmental topics, especially with regard to the accelerating climate change and its impact on the landscape. Many construction companies across the world have already adopted these modernised systems and use them alongside the principles of Industry 4.0 to bring a fundamental change into the construction sector with the potential to achieve better efficiency and reduce impact on the environment and biodiversity. This is a welcome development with regard to the future of construction and the development of new trends in this industry leading to a truly sustainable construction sector that efficiently uses primary and secondary resources and contributes to better energy use on the planet and the protection of the environment as a whole.

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