INDICATORS OF ENVIRONMENTAL AND PRODUCTIVITY PERFORMANCE FOR BUILDING REFURBISHMENT PROJECTS

Ahmet Anıl Sezer[1]

Department of Technology Management and Economics, Chalmers University of Technology, SE-412 96, Gothenburg, Sweden

Since the end of the 1990s, much has been written on construction key performance indicators but little on indicators for building refurbishment, although indicators for road and sewage refurbishment are in use. The purpose of this paper is to formulate principles for developing building refurbishment productivity and environmental performance indicators. When starting from traditional productivity measures, also including effects on client productivity, and from environmental sustainability measures, it is necessary to ask why firms rely on performance measures and why they collect certain types of data. Literature in the areas of performance measurement, key performance indicators, sustainability and productivity has been reviewed and applied to a refurbishment context. When developing new indicators for refurbishment projects, it is important to consider practical issues such as resources required to collect data, including both leading and lagging measures, waste management, local, negative disruptions and effects on user satisfaction, consequences of coproduction, changes in input and output qualities and client productivity.

Keywords: performance measurement, key performance indicator, productivity, environmental sustainability, refurbishment.

INTRODUCTION

Due to the aging building stock in Europe, more attention must be paid to refurbishment of existing buildings. Productivity and environmental performance indicators are developed in various contexts, but seldom with a particular focus on refurbishment. However the nature of refurbishment projects requires new indicators in addition to the earlier, traditional ones for new construction. Issues such as uncertainties in relation to the existing structure, involvement of multiple parties including occupants and a more complex waste handling process make refurbishment differ from other construction activities.

The aim of this paper is to formulate principles for developing building refurbishment productivity and environmental performance indicators. Performance indicators are used at different levels in the construction industry but the focus in this paper is on the project level. Earlier literature in the areas of performance measurement, key performance indicators, productivity and sustainability is reviewed, synthesized and

[1] ahmeta@chalmers.se

Sezer, AA (2013) Indicators of environmental and productivity performance for building refurbishment projects *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 949-957.

applied to the refurbishment context. In general, implications from the performance measurement literature are that practical issues such as resources used to collect data should be recognized and both leading and lagging measures should be included while designing new indicators. Moreover waste appears as a greater challenge in refurbishment projects. Output measurement and especially determination of output qualities are challenges in measuring productivity performance. Local, negative effects of refurbishment processes on user productivity should be recognized in new indicators.

The paper is structured so that the literature is reviewed in three sections, in the order of performance measurement together with key performance indicators, environmental indicators and productivity indicators. Results from these sections are synthesized in a refurbishment context in a following section which formulates principles for developing new indicators. Finally conclusions are drawn in the last section of the paper.

METHOD

This study is based on a literature review in the areas of performance measurement, key performance indicators, sustainability with an environmental focus and productivity. Throughout the review, there is an emphasis on contributions that are relevant in the context of refurbishment processes. Thus, the earlier literature is reviewed, synthesized and then applied to the refurbishment context.

PERFORMANCE MEASUREMENT

Companies measure their performance for a number of obvious reasons including rewards tied to measures, benchmarking to see how they are doing internally and how their competitors do, to develop new company strategies and to evaluate these strategies (Eccles 1991). Instead of developing entirely new performance indicators, there have been attempts to adapt successful benchmarking models from other experienced industries to the construction industry. The nature of construction industry, its projects, participants and methods of execution were the challenges that make such transfers difficult (Lee et al. 2005). Similarly, during the attempts of implementing new performance measurement systems barriers arise for a number of reasons as construction industry is project based and each project is unique, a fairly intense input required to establish a performance measurement system, responsibilities for data collection, processing and analysis are not well defined in the beginning of the project and use of performance measurement system depends on the motivation and capabilities of the managerial team where each project has a different managerial team (Costa et al. 2006).

Although the construction industry is project based, there is a clear link between firms and projects which makes performance measurement more complicated. The project level measures with few indicators clearly do not reflect the performance of an entire firm. Thus El-Mashaleh et al. (2007) emphasize the need for a firm level performance measurement scheme. Vice versa, the firm level policies influence on performance measures at the project level. Additionally, project managers' and executives' perceptions of performance measures vary due to different focuses of these groups (Cox et al. 2003). It would not be unusual to see cases where the link between the firm and the project is weak and project participants disregard a number of important measures for the firm. Hence it should be kept in mind that the results of project

performance measurement might or should be applied at both the project and the firm levels.

A common problem in current performance measurement systems is that they lack preventive measures that can be used during a refurbishment process. While designing a new performance measurement system, both leading and lagging measures should be developed. Lagging measures are the most common measures used in performance measurement systems and they measure outcomes whereas leading measures are preventive and provide information during the projects (Anderson and McAdam 2004). The ideal proportion between leading and lagging measures for refurbishment projects is difficult to estimate, however the need for leading measures is obvious due to the high level of uncertainty concerning the existing structure. Moreover clients or at least building users are negatively influenced by the short term, local effects of refurbishment such as dust and noise (Holm and Bröchner 2000); therefore client satisfaction cannot be measured only in the end of the refurbishment project, something which is often adequate in new construction.

Many attempts to introduce new performance measures fail because both implementation and in use phases of performance measures are disregarded during the design phase. Problems related to in use and on-going management of performance measurement systems are resources required, simplicity, validity and reliability of the indicator, compatibility with other indicators, risks of leaking sensitive company information, and managers that are insufficiently capable and motivated. This can be seen in several studies of benchmarking schemes in other industries (de Bruijn et al. 2004; Francis and Holloway 2007; Maleyeff 2003; Neely et al. 2000). In his performance measurement manifesto, Eccles (1991) mention the importance of top management commitment to ensure continuous evolvement of the performance measurement system.

ENVIRONMENTAL INDICATORS

Environmental assessment tools are used in many industries including construction and they offer a number of obvious benefits. Frequent purposes are to compare, communicate (de Bruijn et al. 2004), help consumers to understand what is environmental and orient them towards buying such products or services (Crawley and Aho, 1999; Schweber, 2013). In the absence of environmental design guidelines, environmental assessment tools implicitly offer guidance. Cole's list (1998) covered most of these benefits though he was able to add other ones: they provide a common and verifiable set of criteria and targets, they gather and organize detailed information on the building and they can be used by building owners to identify priorities for future administration measures.

In the construction industry, environmental assessment tools fail to reflect a number of aspects or do so only partially. Limitations of these tools have been identified in two similar studies. Ding (2008) presents that current environmental assessment methods are dissatisfactory in eight aspects: usability as design guideline, usability for selection of optimum project options, financial aspects, recognizing regional variations, complexity (input), evaluation of qualitative and quantitative data, weighting and measurement scales. Haapio and Viitaniemi's (2008) list of limitations covers user based problems are ignored, reusability of the building products are not considered, a predicted service life is used, ambiguities in utilization of the results and also that economic and social aspects of sustainability are not considered. However both

studies neglect specific challenges of different types of construction activities, such as refurbishment.

Problems related to separation of design and on the other hand implementation and in use phases of indicators are not limited to performance measurement systems. In a recent attempt at monitoring the environmental performance of the Swedish building and real estate management sector with a top-down approach by using national statistics, Toller et al. (2013) developed six indicators. They report difficulties to apply two of the indicators due to unavailability of data, namely use of hazardous chemical products and generation of waste. This shows that implementation and practicality of an indicator must be kept in mind while developing new indicators.

The BREEAM Refurbishment Domestic Buildings is today the only environmental assessment tool that has its focus specifically on the refurbishment process (BREEAM Refurbishment Domestic Buildings 2012). LEED for New Construction & Major Renovations has a longer history but it has little that is specific to refurbishment processes. The Ska rating tool in the UK is another environmental assessment tool which is clearly useful while dealing with fit-out projects; however, its application is limited to offices and retail space. When the BREEAM Refurbishment Domestic Buildings tool handles refurbishment separately from new construction, more attention is paid to the energy section whereas sections such as waste, materials and pollution are given less weight than for new construction. Efficiency is partly included in the tool in the section dealing with refurbishment site waste and efficient use of resources. However since this BREEAM version is the first attempt to evaluate the environmental performance of refurbishment projects, it can be questioned considering fundamentals of sustainability and also relations between the aspects of sustainability and productivity.

Developing indicators for waste from the refurbishment process is challenging. When looking at the fundamentals of sustainability, two common views should be distinguished: the conservationist and preservationist views (Passmore 1980) and waste could be analysed differently according to these two views. The conservationist view draws optimistic conclusions in terms of substitutability of social capital and the main concern is to achieve intergenerational equity. However, in the preservationist view the main concern is nature, where intergenerational equity among human beings is totally disregarded. Hence according to the preservationist view, the aim is to keep the species and wilderness as they are even if they are harmful to human beings. Unlike the conservationist view, conclusions from the preservationist view can be drawn in a refurbishment context, namely that resource use and waste management should be highlighted due to their potential negative influences on nature. Moreover, Toman (1994) identifies three common views of sustainability: neoclassical presentism, neoclassical egalitarianism and ecological organicism. In the ecological organicism view, the focus is on ecological systems and humanity as a whole and natural resources are accepted as limited. The basis of this view is the idea of an ecological system breakdown due to a chain of activities. Again in a refurbishment context, resource use is hardly expected to cause an ecological breakdown whereas waste from the refurbishment process might be different and more threatening due to uncertainty and problems often faced in recycling (Sezer 2012).

Also in another way, refurbishment presents a greater challenge than new construction, because of stakeholders particularly those present in the building during the refurbishment. Taking office refurbishment projects, building user satisfaction is

decreased temporarily due to local disruptions such as noise and dust (Holm and Bröchner 2000) and it is easy to find links between office user dissatisfaction and lower productivity.

Thus local, short term and negative effects of the refurbishment process may create particular challenges while dealing with environmental indicators. Todd and Geissler (1999) note also regional limitations of environmental assessment tools. They claim that regional differences such as having land or water as scarce resources should be reflected in environmental assessment tools. This requires that a tool gives enough flexibility to adapt criteria to local, regional and national differences. In refurbishment projects, local, negative effects have a greater impact than for most new construction and therefore more precise measurement of such effects should be encouraged while designing new environmental indicators.

PRODUCTIVITY INDICATORS

Productivity is the ratio between output and input and it is defined in different ways, as partial or total factor productivity. In the construction industry the use of labour productivity as partial productivity is more common since it demands less data which makes it less costly but also less informative as a measure (Sudit 1995). Moreover labour productivity does not reflect the input quality changes such as due to heterogeneity of the skills of workers (Schreyer 2001). Relying on total factor productivity by including several inputs such as labour and equipment was suggested by Chau and Walker (1988) despite the challenge of data access and representing changes in input qualities.

One of the problems associated with the current productivity indicators is thus that quality changes in inputs and outputs are not covered adequately for construction in general. In refurbishment projects, the difficulties of determining both output and input qualities appear to be even worse. This also implies that existing productivity measures fail to reflect how refurbishment processes affect customer productivity. Having analysed six types of new construction and repair projects, Bröchner and Olofsson (2012) propose a number of non-traditional quality categories in addition to traditional productivity measures. These measures are intended for prioritizing innovation projects and recommended to be applied differently to different types of projects, such as in repairs of plumbing, the useful area of the existing facility might be less relevant and this requires other measurement units. Moreover, as already mentioned, reduced disruption of user activities is often more important in the context of repair projects.

Considering both the short and long term effects of refurbishment brings the potential conflict between productivity (efficiency) and economic sustainability to the surface. While efficiency reflects the short term productivity (productivity during the refurbishment process), economic sustainability refers to long term consequences. Most probably, efficiency will appear to be lower in refurbishment, partly owing to the problems related to output measurement (Sezer 2012).

Client involvement and coproduction is typical of the services sector and can be observed in the production processes of construction, creating further challenges to productivity measurement. Djellal and Gallouj (2013) identify three consequences of coproduction in services: defining the "product" becomes more difficult since the product is always different and tailored to specific needs; assigning the labour and capital input is difficult when measuring productivity, and the quality of the customer

(understood as an input!) strongly influences on the productivity of the service provider. More specifically in refurbishment projects where service characteristics are more obvious compared to other construction activities (Holm 2000), what is hidden by the term "client" appears to be more complicated, because it may include both clients who own the property and end users who may be customers of the client or occupants. Turning back to Djellal and Gallouj (2013), it is evident that client involvement and co-productive nature of refurbishment projects cannot be disregarded while designing productivity indicators.

Once again, design and implementation of performance indicators should not be separated and there are a number of challenges related to current productivity indicators. Nasir et al. (2012) noted several problems in the implementation of the indicators with a focus in infrastructure sector. First of all, using work breakdown and measuring productivity of the each subgroup was difficult. A similar problem appears in refurbishment projects where a predetermined list of activities, suitable for new construction, does not include typical refurbishment activities, nor the unexpected activities that may occur during the refurbishment such as asbestos removal. Second of all, inadequate resources to collect data is a well-known problem in performance measurement. Including many subcategories and assigning subcontractors to different subcategories makes it even more difficult to collect data and aggregate it. Finally, confidentiality concerns related to actual productivity data were reported as the final challenge; however this is more of an organisational issue which is out of the context of this paper.

PRINCIPLES FOR DEVELOPING NEW INDICATORS

As we have found in the literature review, refurbishment projects present different challenges than new construction and other construction activities. Therefore while benchmarking internally (benchmarking among projects), it is doubtful to compare different types of construction projects such as comparing a new construction project with a refurbishment project. Traditionally in the construction industry, performance measurement is done with a predetermined list of activities derived from new construction. Very often the list may not cover specific activities of refurbishment or extra activities may occur during the refurbishment process including asbestos removal, additional demolition work and complicated waste handling. Therefore specific challenges of refurbishment should be recognized while developing new indicators.

While designing new indicators, the implementation and in use process of the indicators cannot be disregarded. One of the major problems reported in current performance measurement systems is resources required to collect data. The problem is practicality of indicators including data collection is sometimes overlooked in the design of the indicators. Practical issues should be recognized in the design of new indicators such as if this type of data can be collected easily. Moreover developing new indicators is a continuous process which requires updates depending on new conditions. Nevertheless, the number of indicators should be reasonably small and they should be kept simple if possible.

In relation to project completion, two types of measures are mentioned in the literature: leading and lagging. It might be excessive to fix an optimal proportion between these two types of measures for refurbishment projects but clearly both are required. During the refurbishment process, leading measures can be used to reflect extra work caused by uncertainties associated with the existing building structure.

Moreover due to local, negative disruptions of refurbishment process, client satisfaction should not be measured only in the end of the process. Therefore, client satisfaction should be a leading measure for refurbishment projects.

Waste from refurbishment processes is clearly different from new construction and more threatening owing to uncertainties associated with existing building structure such as a need for asbestos removal. Therefore the need for precise indicators related to waste management in refurbishment processes is clear.

According to the literature, local and negative disruptions such as dust and noise caused by refurbishment processes have negative influences on users. The relation between local, short term and negative effects of the refurbishment and user satisfaction should be recognized in the new indicators. A problem identified in critical analyses of current environmental assessment tools is regional limitations and in refurbishment projects, local effects are more problematic. This is partly because of consequences for stakeholders, particularly occupants that are involved in the refurbishment projects.

From the productivity measurement perspective, the co-productive nature of refurbishment is challenging. Output is produced together with the client and therefore both input and output qualities are more difficult to measure. Client satisfaction, client productivity and coproduction should be reflected while devising new indicators in relation to productivity.

CONCLUSIONS

Performance measurement linked to productivity and environmental sustainability is challenging in the construction industry. In order to provide guidance for developing new environmental and productivity indicators for building refurbishment projects, literature in the areas of performance measurement, KPIs, sustainability and productivity has been reviewed here. Refurbishment presents a greater challenge than new construction and in current performance measurement systems, these challenges are overlooked or inadequately met. Clearly, more research is needed to understand different challenges of refurbishment and to improve productivity and sustainability of the refurbishment process. In this paper the need for new productivity and environmental indicators for refurbishment projects is presented together with a number of principles for developing the new indicators. Future research should include testing these principles with a set of indicators applied to the monitoring of actual refurbishment projects.

The design and implementation of a new performance framework should ensure that obstacles in data collection are recognized and simplified indicators to evaluate the productivity and environmental performance are produced. Including both leading and lagging measures is an important task.

Waste should be highlighted as a greater challenge in refurbishment projects and while designing new indicators. Moreover the local negative effects of refurbishment processes such as dust, noise and lack of information exert an influence on user satisfaction, constituting a relation which should then be mirrored in new indicators of refurbishment performance.

Productivity measurement in the construction industry suffers in general from problems in measuring output and input qualities and also from the co-productive nature of construction projects. Clearly, measuring output in refurbishment projects is a greater challenge than for new construction. Users being involved in refurbishment

projects is only one argument for the need for developing different indicators for refurbishment.

REFERENCES

Anderson, K and McAdam, R (2004) A critique of benchmarking and performance measurement: lead or lag? "Benchmarking: An International Journal", 11(5), 465-483.

BREEAM Refurbishment Domestic Buildings (2012) BREEAM. Available from: http://www.breeam.org/domrefurbmanual/ [Accessed 2 May 2013].

Bröchner, J and Olofsson, T (2012) Construction Productivity Measures for Innovation Projects. "Journal of Construction Engineering and Management", 138(5), 670-677.

Chau, K W and Walker, A (1988) The measurement of total factor productivity of the Hong Kong construction industry. "Construction Management and Economics", 6(3), 209-224.

Cole, R J (1998) Emerging trend in building environmental assessment methods. "Building Research & Information", 26(1), 3-16.

Costa, D B, Formoso, C T, Kagioglou, M, Alarcón, L F and Caldas, C H (2006) Benchmarking initiatives in the construction industry: lessons learned and improvement opportunities. "Journal of Management in Engineering", 22(4), 158-167.

Cox, R F, Issa, R R and Ahrens, D (2003) Management's perception of key performance indicators for construction. "Journal of Construction Engineering and Management", 129(2), 142-151.

Crawley, D and Aho, I (1999) Building environmental assessment methods: applications and development trends. "Building Research and Information", 27(4-5), 300-308.

de Bruijn, H, Van Wendel De Joode, R and Van Der Voort, H (2004) Potentials and risks of benchmarking. "Journal of Environmental Assessment Policy and Management", 6(3), 289-309.

Ding, G K C (2008) Sustainable construction – The role of environmental assessment tools. "Journal of Environmental Management", 86(3), 451-464.

Djellal, F and Gallouj, F (2013) The productivity challenge in services: measurement and strategic perspectives. "The Service Industries Journal", 33(3-4), 282-299.

Eccles, R G (1991) The performance measurement manifesto. "Harvard Business Review", 69 (1), 131-137.

El-Mashaleh, M S, Minchin E J R and O'Brien, W J (2007) Management of construction firm performance using benchmarking. "Journal of Management in Engineering", 23(1), 10-17.

Francis, G and Holloway, J (2007) What have we learned? Themes from the literature on best-practice benchmarking. "International Journal of Management Reviews", 9(3), 171-189.

Haapio, A and Viitaniemi, P (2008) A critical review of building environmental assessment tools. "Environmental Impact Assessment Review", 28(7), 469-482.

Holm, M G (2000) Service management in housing refurbishment: a theoretical approach. "Construction Management and Economics", 18(5), 525-533.

Holm, M G and Bröchner, J (2000) Office conversions: the effects of craftsman-user interaction. "Facilities", 18(13/14), 535-545.

Lee, S H, Thomas, S R and Tucker, R L (2005) Web-based benchmarking system for the construction industry. "Journal of Construction Engineering and Management", 131(7), 790-798.

Maleyeff, J (2003) Benchmarking performance indices: pitfalls and solutions. "Benchmarking: An International Journal", 10(1), 9-28.

Nasir, H, Haas, C T, Rankin, J H, Fayek, A R, Forgues, D and Ruwanpura, J (2012) Development and implementation of a benchmarking and metrics program for construction performance and productivity. "Canadian Journal of Civil Engineering", 39(9), 957-967.

Neely, A, Mills, J, Platts, K, Richards, H, Gregory, M, Bourne, M and Kennerley, M (2000) Performance measurement system design: developing and testing a process-based approach. "International Journal of Operations and Production Management", 20(10), 1119-1145.

Passmore, J (1980) "Man's responsibility for nature". London: Duckworth.

Schreyer, P (2001) The OECD productivity manual: a guide to the measurement of industry-level and aggregate productivity. "International Productivity Monitor", 2, pp. 37-51.

Schweber, L (2013) The effect of BREEAM on clients and construction professionals. "Building Research and Information", 41(2), 129-145.

Sezer A A (2012) Environmental assessment tools and efficiency in housing and office refurbishment. In: Smith, S D (Ed.), "28th Annual ARCOM Conference", 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 1331-1341.

Sudit, E F (1995) Productivity measurement in industrial operations. "European Journal of Operational Research", 85(3), 435-453.

Todd, J A and Geissler, S (1999) Regional and cultural issues in environmental performance assessment for buildings. "Building Research and Information", 27(4-5), 247-256.

Toller, S, Carlsson, A, Wadeskog, A, Miliutenko, S and Finnveden, G (2013) Indicators for environmental monitoring of the Swedish building and real estate management sector. "Building Research and Information", 41(2), 146-155.

Toman, M A (1994) Economics and "Sustainability": Balancing trade-offs and imperatives. "Land Economics", 70(4), 399-413.