WHY (NOT) MEASURING PRODUCTIVITY IN HOUSE-BUILDING COMPANIES?

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The need for improved productivity in construction, and the continuous tendency of lagging behind manufacturing industries in this respect, is a longstanding theme in the general debate in Sweden. However, there is a lack of consensus in how to understand and measure productivity, as well as in how to assess and compare productivity properly over time, between tasks, projects, companies and industries. This paper presents initial findings from the first step of an ongoing R&D study. The purpose of the R&D study is to develop frameworks for comparisons between productivity in different projects and suggest how these can be used for operational development. In this first step and by lending from two concepts proposed for measuring productivity at different levels in construction, understandings of productivity are identified and problematized together with findings collected during a one-day project-initiation workshop. Results indicate that different stakeholders understand productivity differently and have separate purposes for measuring productivity. The findings also point out that measuring productivity does not seem to be common practice in house-building companies. Furthermore, to measure productivity in ways that allows for relevant comparing of performance between sub-processes and projects seems especially problematic. Findings suggest that further research on how one can tackle differences between house-building projects is needed to understand better how to enable for assessments and comparisons of progress both in and between house-building sub-processes and projects. In addition, further investigation is required to understand how and where to set boundaries for productivity measurement frameworks to enable for meaningful measures without hampering value-adding activities.

Keywords: productivity, house-building, industry levels, productivity performance

INTRODUCTION

The need for improved productivity in construction, and the continuous tendency of lagging behind manufacturing industries in this respect, is a longstanding theme in the general debate in Sweden. However, there is a lack of consensus in whether or not the measurements generally presented by economics to underpin such arguments properly reflect the situation on single industry and project levels and among construction companies in general.

To increase performance, researchers such as Bresnen and Marshall (2001) describe that construction management has adopted different specializations by, for instance, implementing lean production, benchmarking techniques and total quality

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management. Many of these take influence from the manufacturing industry, which has highly standardised, controlled processes that enable for measurements (Bresnen and Marshall, 2001). Yet, measuring productivity is still not a well-established practice among companies in the Swedish house-building industries. Even though construction project inputs are repetitive, to about 80 % according to some researchers (e.g., Egan, 1998) it is frequently suggested that methods and metrics from manufacturing industry do not fit house-building (HB) well due to its project-based nature incorporating multiple goals and purposes from the many stakeholders involved (Vogl and Abdel-Wahab, 2015). There also seems to be a lack of consensus in the fragmented construction sector on how to understand and measure productivity and what methods and metrics to use. For example, there are different definitions of productivity depending on what contextual factors are acknowledged, on the level of analysis and system boundaries currently applied, and what the purpose is of addressing productivity in the first place. Thus, it is inferred that no single framework for measuring productivity can possibly fit all cases (Yang, *et al.,* 2010; Crawford and Vogl, 2006; Huang, *et al.,* 2009). Frameworks also seem to fail in reflecting aspects that might have an impact on productivity, for instance new technologies (Bröchner and Olofsson, 2012). Still, little empirically grounded knowledge exists on how companies do reason and subsequently act in these respects. At the same time, subsequent to trends such as industrialization and digitalization, there is a growing interest among HB companies regarding the use of measurements and metrics for operational and even business performance improvement purposes. This paper presents initial findings from the first step of an ongoing R&D study. The purpose of the R&D study is to identify different productivity measures from the progress of sub-processes in HB projects to suggest frameworks for comparisons between the productivity in different projects and how these can be used for operational development. The research follows a R&D study in which four of the largest Swedish HB companies collaborate with researchers from production management, and construction management and building technology. The aim of the first step of this research is to identify and problematize understandings of productivity by lending from two concepts proposed for measuring productivity at different levels in construction. More specifically, in this paper the understandings of key-representatives at project outset are addressed including their:

- Perceived purposes for measuring productivity,
- Views on how to measure productivity (and not), and
- Challenges associated with measuring productivity for intended purposes.

Different Views on Productivity

Productivity is a slippery term with many interpretations. Tangen (2005) traces the definition of productivity back to Littré (1883) as "the faculty to produce". Parting from that definition, productivity and productivity measurements have been interpreted and evolved in many ways depending on where it has been contextualized and the purpose for measuring productivity. One is the generic term of productivity that refers to the ratio of units of outputs/units of input (Chew, 1988). However, that term is broad and open for interpretations, and in construction, such as Huang, *et al.,* (2009) explain, productivity is measured differently and for different purposes depending on what level one assesses productivity on (industry, project and task).

There is a need to clarify how different understandings of productivity and productivity measures affect productivity in the case of productivity as a performance

measure in HB. Firstly, we need to unravel the different definitions of the methods for measuring productivity in use. Secondly, we need to state the influence on how the different levels (industry, project and task) affect measuring productivity and its influence on different stakeholders.

Productivity Measurement Methods

The generic definition of productivity has been operationalized in two different ways in the case of productivity as a performance measure in construction: Construction or Average Labour Productivity (CLP, ALP) and Total Factor Productivity (TFP) (Vogl and Abdel-Wahab, 2015).

Construction labour productivity (CLP) is a concept with many definitions but is primarily rooted in the belief that firms or industries produce similar products with almost the same capital intensities (Crawford and Vogl, 2006). The concept originates from the relation between labour cost and the quantity of outputs produced (Borcherding, *et al.,* 1986). Both CLP and Average Labour Productivity (ALP) are single-factor productivity measures that assess output by labour input (Vogl and Abdel-Wahab, 2015). As for being single factor measures, they have two main disadvantages; they leave out the importance of a system in its whole and the result is easy to manipulate as one can reach high levels of ALP by substituting capital for labour, neglecting to present the real performance of the process (Crawford and Vogl, 2006). The industry uses CLP for measuring the gross output-based labour productivity while statistical offices tend to set it as value-added labour productivity (Huang, *et al.,* 2009). ALP is commonly used as an indicator of total productivity performance for government policy objectives, as it relates to the income for hours worked and output for a given labour input.

Total Factor Productivity (TFP) is a multi-factor measure that tries to take into account the impact of inputs (labour, material, energy, technological progress, quality, etc.) on output (Crawford and Vogl, 2006). This could, in theory, give evidence for a more in-depth analysis of productivity changes (Chau and Walker, 1988; Crawford and Vogl, 2006; Bröchner, 2010; Wang, *et al.,* 2013). However, TFP does not come without disadvantages. Firstly, it needs a large amount of data, some of which difficult to measure that need qualitative expert assessment. Secondly, the different contexts of each construction project give unfair results if comparing the TFP between different projects.

CLP/ALP and TFP can be used for comparing performance (benchmarking) between projects, organizations and industries (Bresnen and Marshall, 2001). A common measure of inputs is key performance indicators (KPIs). KPIs are quantitative indicators hard to generalise from one context to another as they are based on company accounts and do not provide holistic explanations of the link between practice and performance (Fernie, *et al.,* 2006). However, Bröchner (2010) suggests that KPI based measures can be carried out for comparisons if done on component or task level.

Different Levels with Different Productivity Purposes

If construction performance measurements are carried out, they are performed differently depending on if it is done on industry, project, stakeholder or task level (Yang, *et al.,* 2010; Huang, *et al.,* 2009). As there are different purposes with the measurements on each level and the understanding of performance vary, the boundary of the production system - the base for productivity measures -is different in each

case, which in turn results in different frameworks for measuring performance. Thus, measurements are carried out on what can be called a system with many subsystems and parts from systems or systemic thinking (Atwater, *et al.,* 2008). Since construction is fragmented with multiple stakeholders on each level (industry, project and task), the goals for productivity measures might therefore be different for each stakeholder depending on the level studied which complicates for defining and comparing measures even more.

Firstly, Huang, *et al.,* (2009) define productivity on the industry level as "the amount of output produced per unit of input", which should provide a measure of industrial efficiency. At this level, one seeks to measure productivity for making comparisons between industries at the national or global market (Yang, *et al.,* 2010; Huang, *et al.,* 2009). These measurements show that construction is low productive when comparing with others such as the manufacturing industry; it is lagging behind (The Economist, 2017). However, when making the comparisons one neglects the increasing project complexity and the heterogenic nature of construction, and even if there are some measurements that have applied TFP, the most common way of measuring is by CLP or ALP (Crawford and Vogl, 2006). For instance, in Sweden, the industry level is assessed by an index based on the difference between the produced volume of value and working hours required to produce the output. What this measure actually shows is the change in economic activity within construction.

Secondly, at project level one looks at the collection of all tasks performed to construct new buildings or to renovate existing ones (Huang, *et al.,* 2009). The measure is used for comparing the project to an overall average in the reference data set or to identify productivity changes over time. The level includes different processes, aspects and stakeholders (Yang, *et al.,* 2010); and different tasks have different inputs and outputs. Huang, *et al.,* (2009) state that "each component of the project productivity metric contains a task weight, a raw task productivity baseline value, a raw task productivity value for the project, and a measure of the task mix". The result is an index value from a function of the individual components/tasks together. However, task level productivity does not count for factors such as regulation, idle time and managerial coordination and planning, which affect project-level productivity. There is no standard practice for measuring project-level productivity nor a standard database with metrics that cover the overall project-level productivity, which complicates the analysis of productivity and its driving factors. Another challenge in the analysis of project productivity is that used measures rather reflect changes in the composition of projects instead of productivity changes per se (Huang, *et al.,* 2009).

Thirdly, the stakeholder level refers to the measurement of a single stakeholder/company from the industry. Even if a construction project normally includes many stakeholders, productivity measurements on the stakeholder are rare or none. Instead, one looks at the overall stakeholder performance, which can have many different purposes besides productivity (Yang, *et al.,* 2010). However, depending on the stakeholder, the business, the contract and the mission, the stakeholder will affect or be affected by other stakeholders' productivity to a smaller or greater extent.

Lastly, the task level considers single activities for specific elements, such as the construction of a wall. Task level type of productivity measurements are more common and often in the form of single factor measures that focus on labour

productivity (Huang, *et al.,* 2009). There are different metrics depending on how one defines and measures task level productivity and thus different outputs depending on what one considers relevant in the context and for what purpose one measures productivity. However, tasks are isolated events within a process. Hence, as Huang, *et al.,* (2009) explain, they do not capture the whole process, failing to reflect a complete picture of industry and project level productivity. In addition, some methods include value-added inputs such as prefabrication of materials, while others do not (Huang, *et al.,* 2009).

METHOD

The first activity in step one of the research process, was a one-day project-initiation workshop. The general intentions of the workshop were to provide the opportunity to share and discuss understandings on productivity and to guide the design of the R&D study. The workshop gathered four key-representatives of the HB companies, i.e. managers in charge of production development, and an economist (invited as expert) representing a Swedish research institute that work with productivity measurements on national level. From here on, the four representatives from the Swedish HB companies are referred to as "industry practitioners 1-4 (IP 1-4)", and the expert representative of the Swedish research institute as the "researcher".

The workshop included semi-structured discussions and unstructured dialogues on "what is productivity", the purposes of measuring productivity, how the representatives' organizations work with/measure productivity, and participant's experiences and views of challenges associated with measuring productivity. Two researchers observed and took notes of the workshop. The semi-structured discussions were recorded in full.

Workshop observations were analysed parting from the generic definition of productivity operationalized in two concepts (CLP and TFP) acknowledging also viewpoints from different levels (e.g. industry, project, stakeholder, and task level).

FINDINGS

Perceived Purposes for Measuring Productivity

From the economist side, the researcher at the workshop indicated that productivity is a measure of industrial efficiency. The measure is based on the price of the product or value-added productivity and is measured at industry level and carried out with single factor measurements such as CLP.

> Gross-value is the ultimate measure of productivity and should in theory relate to the costs in HB. - Researcher

The industrial practitioners instead viewed productivity as a measure of progress in work.

> Productivity is progress in work. - IP 1

That is, a purpose for measuring productivity is that it should reflect the progress of operational work when constructing buildings. However, when discussing about the stakeholder and industry level, productivity is perceived as a measure that should reflect performance.

> There are both internal and external efficiency and effectiveness. Productivity relates to the internal efficiency and effectiveness, that is productivity; the external is the price we can sell the product for. - IP 3

The external efficiency view is expressed as a measure to assess performance within and between organizations.

Views on How to Measure Productivity (and Not)

On the national or the industry level, economists measure productivity to report the results to the ministry of finance. The purpose is to evaluate and compare productivity between industries based on value added productivity to report if there is any need for improvement. Based on the price, one should be able to analyse the results and connect them to how HB companies perform seen as an industry.

> On the industry level, one measures productivity on the different partitions in HB added together as one single industry. The purpose is not to steer the organization, it is to compare how the numbers evolve with respect to other industries. - Researcher

All IPs participating in the workshop did not see the point in using gross-value measurements for assessing and working with productivity. Production related costs are reported to higher organizational levels for evaluating the economic progress of projects and the company, serving for accounting purposes. Instead, the industry representatives expressed a desire for having methods using many sources in the measures for assessing productivity to primarily improve progress in activities or sub-processes in projects.

> One can have done a great project that still turned out very expensive. One can manage and use resources excellently and still not get effective results. - IP 2

However, the workshop also resulted in a common view that productivity measurements also should be a tool with potential to steer towards increased productivity. The perceived purpose was to improve not only progress in work but also performance to be able to evaluate and compare between tasks, projects and with other companies.

> If we do not measure at every level, we cannot really improve. - IP 2

> Comparing productivity between projects would be good. Also, between regions within an organization or between organizations. As for now, we cannot get a measure on whether we are good or bad. We can see what costs and income we have, but not if we are productive. - IP 1

Challenges Associated with Measuring Productivity for Intended Purposes

On the industry level, the main challenge voiced at the workshop had to do with the use of gross-value productivity as a measure working on the other levels. The existing measures on the industry level have their base in market prices and not the actual costs of the company. In addition, when measuring productivity at industry level, different sections from the construction sector are added together to produce a final measure. In this way, HB productivity and e.g., infrastructure productivity are lumped together.

> One studies how productivity in construction evolves as a whole in relation to other industries, but is it really meaningful to compare HB to other completely different industries? - Researcher

> In order to make comparable measures, one has to divide construction into smaller partitions." - IP 3

The matter of cost, in itself, and as intervened in the gross-value productivity, was another challenge mentioned. Costs are accounted for differently between projects and between the participating companies, and do not necessarily need to reflect the progress in work.

> One can build something with low costs but meet the client's expectations on many other levels to increase the price, which does not really reflect the costs. The price reflects willingness-to-pay, not productivity - IP 1
>
> We do not book costs in the same way between projects - IP 3

Another challenge mentioned at the workshop was that the HB companies often estimate task level progression but not task level productivity per se. The first part of the challenge had to do with problems of comparing progression. The second part of the challenge had to do with not measuring productivity as such but using other proxies.

Firstly, it appeared that there was always a contextually "clouded" blame so that no one could really explain why the task level results and results on the project level were different in each case and why they were not comparable from case to case.

> Sub-processes are measured, but there are problems in comparing between projects, even harder between regions and companies. - IP 1
>
> Requirements change due to variations in regulations; it is difficult to find point-zero. - IP 3

Secondly, instead of assessing productivity the findings indicate that industry focus on production pace, -disturbance and -waste. By following up active working time, idle times or unnecessary work can be identified and eliminated which, according to the workshop, can be understood as to increase productivity.

> One seldom talks about productivity on site, one can rather talk about pace as in manufacturing. There is a baseline for pace-schedules, but somehow, we do not manage to compare them between projects due to exceptions and external influences. Somehow there is always an excuse to focus on exceptions instead of what is actually produced. - IP 1
>
> There are measures of disturbance and waste, that is, how much we work and how much disturbance we have. If we decrease disturbances and waste, productivity should increase. - IP 4

The last major challenge evident from the workshop had to do with project type productivity measurements and, again, how costs and unit time is defined. The common ground for production planning is founded on unit time for each task, which is connected to piece rate. The piece rates are often developed from KPIs that are rooted in past and project-based negotiations with labour unions. Even if adjustments based on project leaders experience may be possible, the studied companies do not have full control over piece rates and thus do not normally change the unit times.

> Unit time is based on piece work and negotiated with labour unions. We do not control the time units by ourselves. - IP 1
>
> "Unit times are often old, from the 60s. - IP 2

From the organization's perspective, they adjust these union negotiated KPIs to fit the company based on strategy reasoning and market situation in procurement and to win contracts but also control task and project costs. This apparently creates a situation where project managers steer towards a project final cost instead of towards productivity improvements.

> Nowadays, one steers towards a final cost. If that is achieved, one seldom do any adjustments. - IP 1
>
> KPIs are not used for increasing productivity; they are rather used for cutting costs. - IP 4

DISCUSSION

Generally, the findings concur with what literature, e.g., Huang *et al.,* (2009) and Naoum (2016) indicate; that there are different understandings and therefore disagreements related to what productivity is. On the one hand, the economist understand productivity as a number based on gross value-added measures. On the other hand, the IPs understand productivity as progress in work, unrelated to gross-value or prices.

The IP's seemingly argue that single factor productivity leaves out many driving factors of productivity, much in line with observations in Crawford and Vogl (2006). What the studied HB companies seem to ask for are measurements for improving and evaluating their progression and performance in all levels. The CLP measure commonly used on the industry level does not serve for that purpose. Following the reasoning in Crawford and Vogl (2006), TFP could be more appropriate than CLP when looking for improvements in work progress. Results also indicate that measurements and active actions to reduce disturbances and waste are in use by the companies. However, literature does not define waste and disturbance as measurements of productivity. Thus, based on the preferences expressed by the four company representatives in this initial step of the research, the multi-factor TFP method seems to be in favour to incorporate these managerial actions.

The representatives further state that their companies perform task level progression measurements from time to time. However, they also state that there are challenges in comparing productivity between different projects and stakeholders due to exceptions, different ways of booking results, variations in project requirements, changes in regulations, etc. These notions adhere to those presented by Huang *et al.,* (2009).

Fernie *et al.,* (2006) state that KPIs are hard to generalize from one context to another. Still, production planning in Swedish HB is based on unit times from predetermined piece rates developed from KPIs and past negotiations with labour unions. As this is the agreement, the studied companies state that actions to improve work progress or productivity in and between projects to change the frame of the unit times are scarce. Thus, instead of steering projects towards productivity improvements, the companies steer projects towards a planned final cost, which is controlled by using KPIs.

CONCLUSIONS

The findings indicate that productivity as a performance measure is understood and assessed differently depending on the context, level and purpose. There seems to be a conflict between economists on national level and IPs regarding the understanding and interpretation of the broad definition of productivity. Besides, the findings and discussion suggest that the companies find existing measures to be inappropriate for improving what they define as productivity. The studied IPs and economist disagreed on what productivity is and what measurements actually should include and measure. Thus, one next step in the following R&D study will be to reach a common ground on what productivity is and should measure in order to proceed in developing a method for measuring productivity with suitable purposes throughout the levels. Acknowledging this, future research will treat the dilemma of what to take into account or not and how when measuring productivity in HB. Of especial importance will be to understand where one should set the boundaries of the system to measure in order to produce meaningful measures without hampering value-adding activities. Better understanding is needed regarding how one can tackle differences between

projects to enable for assessments and comparisons of progress both in and between HB sub-processes and projects, which will be investigated in future steps. Lastly, recent developments in digitalization and industrialization might have potential in acting as possible facilitators for gathering comparable data. The authors will explore this further in the following R&D study.

From these first findings and discussions, one can conclude that measuring productivity does not seem to be common practice. Even if it is measured on industry-level and for some activities on the task level, it is rarely found on stakeholder and project level.

Tentatively and on a more general level, the results point out that measuring productivity for relevant comparison between industries, tasks, organizations and especially projects is problematic due to different ways of working, conditions and contexts between each HB project.

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