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Present state analysis of business performance measurement systems in large manufacturing companies

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Abstract

The purpose of this article is to empirically investigate the present state of the performance measurement systems (PMS) at 7 sites of 6 different large Swedish manufacturing companies. The methodology has both a bottom-up and a top-down perspective. Important findings are that the PMSs are very similar in how they function but differ a lot in what is measured.

Keywords

Performance measurement system, Performance indicator, Daily control, Efficiency

Introduction

Performance Measurement Systems (PMSs) are here to stay. The adoption in the Swedish manufacturing industry, at least when it comes to medium and large companies, seems to be 100%. We have no scientific support for this claim, but the authors have not heard of any manufacturing company that doesn't apply a PMS today 2016. The Swedish industrial application and the wide spread is tightly connected to the adoptions of Toyota inspired lean production strategies and production system models (Åhlström and Carlsson, 1996). This includes using performance indicators (PIs) to align the operation to the company's strategic objectives and for managing the daily operation to meet customer demands and other requirements. Business Performance Measurement System (BPMS) (Franco-Santos et al. 2007) was introduced to indicate that not only production, but also other processes in a business need to be systematically monitored and improved and hence included in the BPMS.

The balanced score card (BSC) model (Kaplan and Norton, 1992) has become the norm and many companies have implemented some kind of interpretation of that concept. There are many variants of BSC, e.g. the Performance prism (Neely et al, 2002) and these have been termed Contemporary performance measurement systems (CPM) (Franco-Santos et al, 2012). The common denomination for the CPMs is the idea of acknowledging more aspects than solely the financial ones. This fits very well with the Japanese influenced production system model (Witcher and Chau, 2007). This is also what has been acknowledged and stressed in the implementation of Lean production variants in the Swedish manufacturing industry. However, the original BSC perspectives have been replaced by different company specific headlines for the grouping of PIs in the PMSs. On a more global scale, the interest in BSC seems to somewhat decline (Bain & Company, 2016). It is however unclear if balanced score cards are replaced by other CPM concept.

The PMS life-cycle can be perceived to have four phases: design, implementation, management, and evolution (Bourne et al., 2000; Neely et al., 2002; Bititci et al., 2004). The first phase deals with the design of the PMS, thus deciding on what shall be measured and how. Once the PMS is designed the implementation phase is initiated; focus is here put on removing the old PMS structure and introducing the new ditto. The third phase deals with the management and how organisations ought to act in order to attain what they set out to achieve with their PMS. The concluding phase of the PMS life-cycle, evolution, deals with keeping the PMS evolving, relevant, and updated over time. Many guidelines are available today for designing an appropriate PMS (Paranjape et al., 2006) or re-designing a PMS (Medori and Steeple, 2000). In relation to the advances made within the frame of the first life-cycle phase, the remaining phases are under-researched (Bourne et al., 2000). There is a limited understanding of how efficient PMSs are in practice, how they are used to manage performance, and how to manage changes (Neely, 1999; Kennerley and Neely, 2003; Barrows and Neely, 2012).

These limitations in present PMSs have pushed the evolution of the field from being occupied with which measures to be deployed, to how to manage measures in order to improve performance and to achieve goals and objectives. Srimai et al. (2011) argue that the field has evolved from being focused on operational and static performance measurement to strategic and dynamic performance management. Neely (2007) concurs and underlines that it is necessary to move from measurement to management in order to create value, as no value will be created unless the management deploys adequate analysis and actions to accompany each indicator.

Further, there is a lack of insight in how different measures affect each other. It is called a performance measurement *system,* but the systemic aspects, i.e. interaction between measures or indicators, are most often missing (Choong, 2014). Choong further concluded that there is a knowledge gap in how the goals of the organisations' stakeholders are connected to the indicators and how the measures are communicated to the stakeholders. However, there are international standardization efforts for specific applications, e.g. ISO 22400 (ISO, 2014) for automation systems in the manufacturing industry, that reach quite far in catching the systemic aspects.

The ongoing trend since a couple of decades is that more and more measures are introduced (Radnor and Barnes, 2007; Salloum, 2013). Salloum (2013) investigated the change process of PMS and one conclusion was that the PMS tends to grow at an alarming speed and that the reasons for growth not always are rational. One common reason for introducing a new indicator is for example that a new manager is involved. Due to the fact that the PMSs are growing, there should be an increasing cost associated to the use of the PMSs, due to work time spent on collecting data, analyzing, reporting, presenting, discussing, taking decisions, etc. However, there seems to be a gap in the literature concerning empirical investigations of the increasing amount of PIs used and their associated costs.

This gap is the outset for a research project called "Sustainable and Resource Efficient Business Performance Measurement Systems" (SuRE-BPMS) within the Swedish national research program Production2030. The project involves three universities, one research institute and seven different companies in the manufacturing sector. It started in 2015 and will be concluded in 2017. The goal of the project and the work process of the project are outlined in Figure 1.

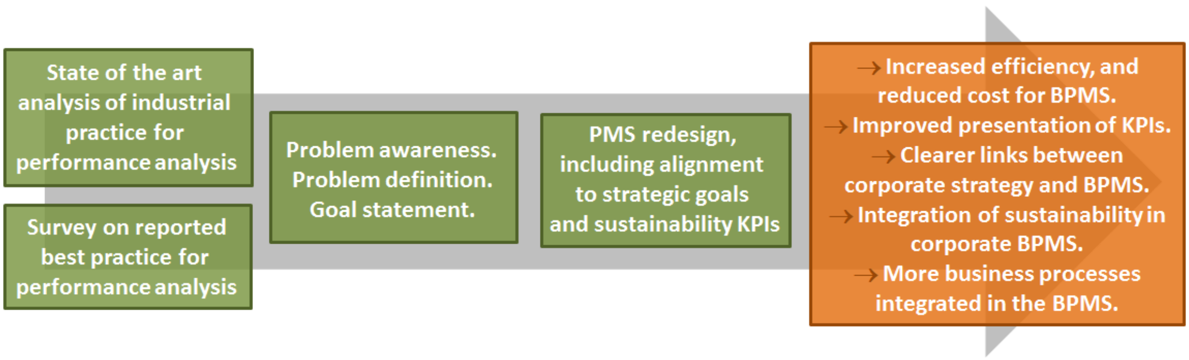

Figure 1: The SuRE-BPMS project process and project goal.

The first step in the project's work process is to make a state of the art or present state analysis of the PMS or BPMS at the participating manufacturing companies. In order to do that a methodology was developed to collect data top-down and bottom-up at these companies. The purpose of this article is to present that methodology as well as the initial result from the present state analysis.

There are three general research questions posed for this stage of the project. The first one is about the method itself while the second and third are about the findings:

1. Is a methodology based on a combined bottom-up and top-down approach for analyzing PMSs applicable on the case companies?
2. What is the management's view of the structure and function of the PMS and how does the PMS life-cycle function at the particular company?
3. What performance indicators are used for operation control and follow-up purposes at different hierarchical levels and what is the associated cost?

The article is structured based on these questions. A positive answer on the first question was obviously a requisite for going ahead with the study. The findings divided into the top-down and the bottom-up perspective is followed by a discussion about the methodology and the results. The article is concluded with brief answers to the research question and the contribution of the research to the industry and to academia.

Methodology

The data collection was divided into two parts, a top-down interview and a bottom-up data collection. The purpose with the setup was to study the differences and similarities between the top management view of PMS and the actual PMS.

Top-down interview

To identify the top management's view of the PMS, an interview with the site manager or another person responsible for the PMS was conducted. It was a semi-structured interview with the following main questions:

- How is the PMS structured at the company?
- How are the results from the PMS used in the company?
- How does the company update the PMS?

Bottom-up data collection

In the bottom-up study all performance indicators in the PMS were identified and analyzed according to a set list of questions based on the performance measurement record sheet (Neely et al., 1997):

- Title – The title of the indicator set by the company.
- Explanation if needed – Clarify the purpose of the indicator if needed.
- Company topic – how does the company categorize the indicator?
- Formula/Definition – What does the indicator measure? For a numerical indicator the formula for the calculation should be documented and for status indicators the different statuses should be documented.
- Frequency – How often is the result of the indicator documented and analyzed?
- Who measure – Who collects the data?
- Who analyses – Who analyses the data?
- Visualization – How is the result of the indicator presented?
- Target - Does the indicator have a target? (Yes/No)
- How is the indicator used? – Is the indicator used for reporting, decision making or both?
- Hierarchical level - The hierarchical level categorization is based on ISO 22400-2:2014 (ISO, 2014) (see Figure 2). If the indicator is measured in a level below enterprise level, the name of the unit should be specified according to the organization map, e.g. Area (Assembly) or Work center (Assembly line 1).

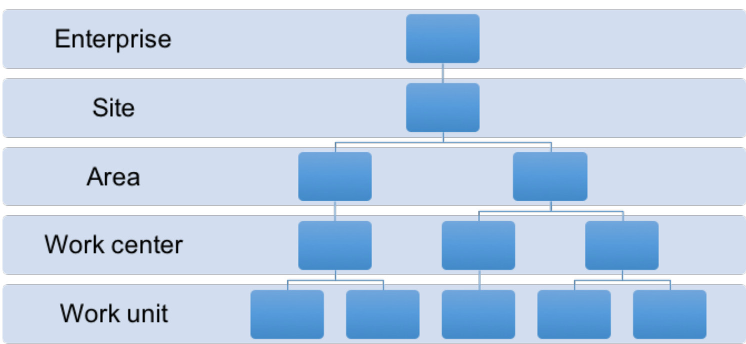

Figure 2 – Hierarchical levels.

The collection of the daily production control indicators was mainly done by studying the documentation at meeting areas where the indicators were presented and by attending some daily production control meetings. In order to deepen the understanding of the performance measurement system, interviews with the area managers and some work center managers were conducted. To collect the indicators used for strategic decision making the interviews with the area managers also included questions about which indicators they used outside the daily production control. An interview with the site manager was conducted to identify the indicators used on site level and which indicators that were reported to the enterprise.

In order to compare the companies, the performance indicators were categorized according to the list below which is based on Galbraith (2014) and Salloum (2013).

1. Financial indicators – Indicators measuring cost and other financial aspects of production.
2. Human resource indicators – Indicators related to employees and staffing.
3. Research and development indicators – Indicators measuring both larger development projects and continuous improvement work.
4. Productivity indicators – Indicators measuring the productivity and efficiency of the production processes.
5. Quality indicators – Indicators measuring the quality of the products and quality activities.
6. Flexibility indicators – Indicators measuring the flexibility in production processes.
7. Delivery reliability indicators – Indicators measuring the delivery quantity as well as the ability to deliver on time.
8. Speed indicators – Indicators measuring the lead time aspects of production processes.
9. Equipment indicators – Indicators measuring the availability of the equipment and maintenance issues.
10. Supply chain indicators – Indicators connected to suppliers and customers.
11. Safety indicators – Indicators measuring safety and safety improvement work.
12. Environmental indicators – Indicators measuring the environmental impact of production.

The time spent on daily production control and more strategic meetings with discussions about the result of performance indicators was also measured and calculated. This was done by identifying an approximate time for each meeting, how often they had the meeting and an average number of participants at the meeting and calculating the total meeting time using the formula:

Total meeting time = time for each meeting × frequency of meetings × number of participants (Eq. 1)

The case companies

The methodology was applied on seven different sites located in Sweden of six large multi-national companies. The selection of companies was based on their participation in the research project SuRE-BPMS. They all entered the project with the intention of improving different aspects of their PMS. The case companies are described briefly in table 1. Site F and G are part of the same enterprise and site F was used as a pilot study to test and improve the method.

Table 1 – Information about the companies.

Site	*No. of employees*	*Product*	*Manufacturing processes*
Site A	1000	Machines and Tools	Machining, assembly

Site B	1200	Aero space components	Machining, welding, surface treatment, testing
Site C	270	Vehicle components	Machining, surface treatment, assembly
Site D	380	Machines and tools	Machining, heat treatment, assembly, surface treatment
Site E	1800	Machines	Machining, assembly
Site F	1000	Heavy vehicle	Machining, welding, painting, assembly
Site G	800	Heavy vehicle	Machining, welding, painting, assembly

Findings

In this section the findings from the top-down interview and the bottom-up data collection will be presented.

Top-down

The findings from the top-down interview will be divided into the three main questions.

Structure of PMS

The performance indicators at all sites are structured in different categories (see table 2). Site A has two different categorization systems, one for their scorecard (B) and one for daily production control (A). As shown in table 2, the most common categories are safety, quality, delivery, cost, people, and environment. For site D the safety, environment and people categories are combined into the safety, health & environment category, and for site E the safety and environment categories are combined into a sustainability category.

Table 2 – Categories used by the sites.

Site\Category	Safety	Quality	Delivery	Cost	Results	People	Processes	Innovation	Customer	Commercial	Environment	Lean	Productivity	Value stream	Safety, health & environment	Economics & Productivity	Finance	Improvement	Sustainability
Site A (1)	✔	✔	✔	✔															
Site A (2)					✔	✔	✔	✔	✔										
Site B	✔	✔	✔	✔		✔				✔	✔	✔							
Site C		✔				✔							✔	✔					
Site D		✔	✔												✔	✔			
Site E		✔	✔			✔											✔	✔	✔
Site F	✔	✔	✔	✔		✔					✔								
Site G	✔	✔	✔	✔		✔					✔								

All sites have scorecards on site level and site A, C, D, and E have scorecards on area level. All scorecards are reported and analyzed once a month. One of the sites (E) has scorecards on all levels in the organization. The scorecards are organized according to the categories in table 2.

Site A focus their daily production control on safety, quality, delivery, and cost, site D focus on Safety, quality, and delivery, and site E focus on safety, quality, delivery and finance while site B, C, F and G uses the same categories for daily production control as the scorecards. Site A and D have standardized whiteboards for status indicators and additional indicators chosen by managers. At site B, C, E, F and G the manager for the organizational unit decides which indicators to address during daily production control meetings.

Usage of results of PMS

Site F and G are compared with other sites within the enterprise based on the results from the scorecard. In site D the enterprise compares sites based on a separate report which was excluded in the bottom-up approach. Site A is not compared with other sites based on their performance indicators. Whether or not site B, C and E are compared to other sites are unknown due to lack of sufficient information.

All sites have daily production control meetings where the data for chosen indicators are reported and analyzed. During these meetings deviations from the targets are discussed and based on the deviations decisions about actions are taken. The results from the daily production control are also used as a base for continuous improvements. All hierarchical levels within the organization have daily production control meetings and the meetings have the same structure and purpose, however the indicators discussed varies depending on the organizational unit. Some indicators are reported less frequently on monthly or weekly meetings where more long term decisions are taken. Long term decisions on site level are taken by site management and are often based on indicators used in the scorecards.

Update of PMS

Four of the sites review their PMS once a year and all sites set new targets once a year. The choice of performance indicator is affected by different factors for the different sites. At site A, the performance indicators are set by the need of information to be able to manage operations according to their strategy. Site B creates new performance indicators based on export compliances and site C creates indicators based on problem at the site and new goals from the enterprise. Site D and E decides which performance indictors to use by breaking down goals from the enterprise level. At company F and G, the indicators are created based on what they need to know in order to be able to meet the goals from the enterprise.

Bottom-up

The bottom-up study was limited to the production operation and the production support functions: quality, maintenance and internal logistics. Only the indicators that were visualized in the production or at the offices of the selected functions were included, hence indicators only existing in computer systems or written reports were excluded.

In Figure 3 the total amount of performance indicators per site is presented. This is not the amount of unique measures, since a lot of the measures were measured at more than one organizational unit. The total amount of indicators collected and systematically categorized in the study was 3151.

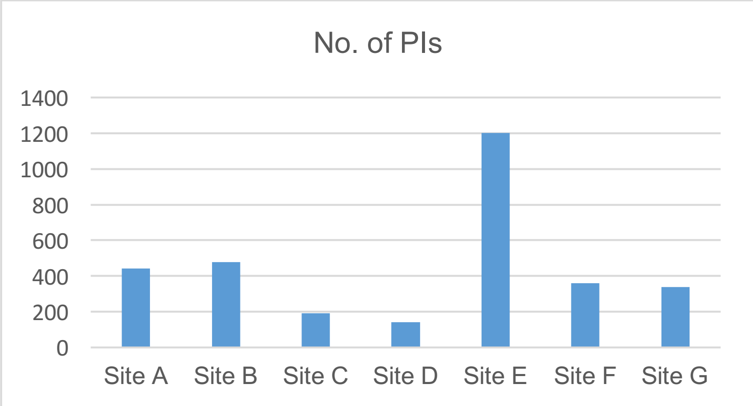

Figure 3 – Number of performance indicators at the studied companies.

To be able to compare the sites despite their size difference, figure 4 and figure 5 were created. Figure 4 shows the number of indicators in relation to the number of organizational units and figure 5 shows the number of indicators in relation to the number of employees.

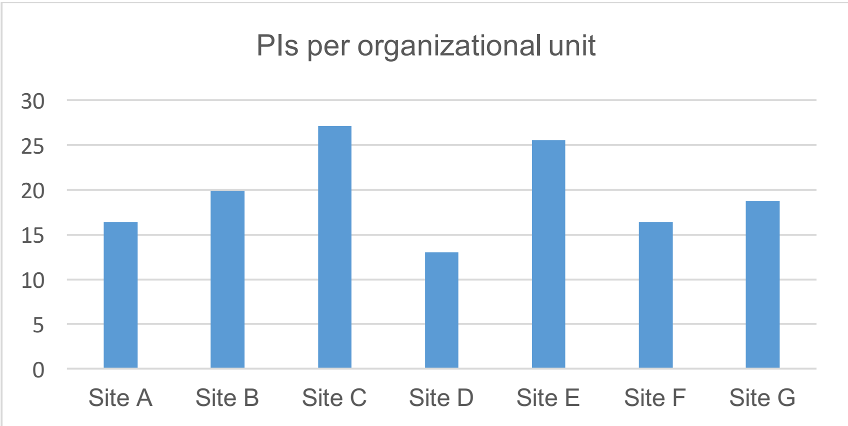

Figure 4 – Number of performance indicators divided by number of organizational units.

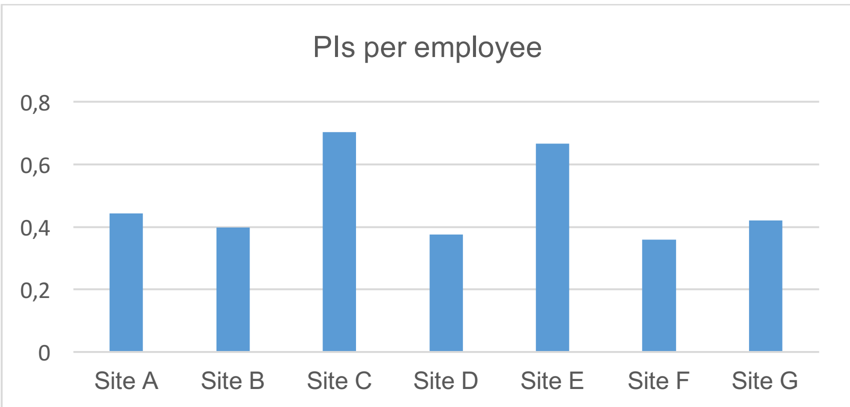

Figure 5 – Number of performance indicators divided by number of employees.

Categories

Figure 6 shows the distribution of indicators between the categories. The categories with most indicators were: quality, delivery, safety, and human resources. These are common on every level at all sites. Very few indicators (>0.1%) measuring flexibility were identified during the study. Another interesting result is the quite low amount of environmental indicators. That can be explained by the limitations of the collection method. Environmental indicators are mostly found in environmental reports and not displayed in the operation.

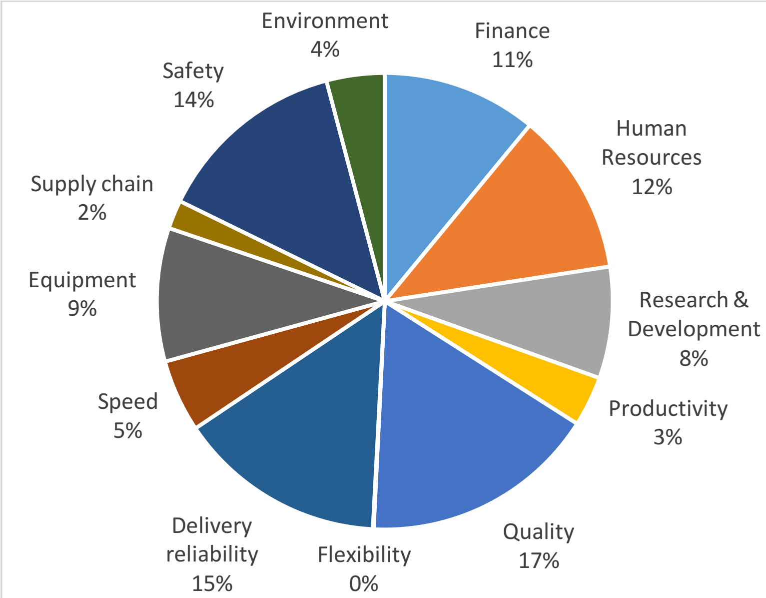

Figure 6 – Distribution of performance indicators between the categories.

The distribution of indicators between the categories at the different sites is shown in table 3. Site D has much smaller share of quality indicators than the other sites and a larger share of safety indicators. Site C and D have a larger share of indicators connected to supply chain. Site F and G have smaller share of equipment indicators and larger share of environment indicators. The larger share of environment indicators is because they measure environmental accidents on all levels in the production.

Table 3 – Distribution of performance indicators between the categories at the companies.

Site	Financial	Human resources	Research and development	Productivity	Quality	Flexibility	Delivery reliability	Speed	Equipment	Supply chain	Safety	Environment
Site A	9%	3%	5%	7%	15%	0%	21%	9%	13%	2%	12%	1%
Site B	7%	10%	10%	4%	13%	0%	22%	5%	11%	0%	17%	1%
Site C	12%	2%	2%	2%	24%	0%	11%	4%	19%	8%	14%	3%
Site D	16%	8%	6%	5%	8%	0%	17%	5%	10%	8%	29%	0%
Site E	16%	14%	10%	2%	18%	0%	10%	2%	10%	2%	10%	5%
Site F	2%	21%	6%	4%	19%	0%	16%	6%	2%	1%	16%	8%
Site G	6%	13%	7%	4%	17%	0%	14%	9%	1%	2%	18%	9%

Production control meetings

Figure 7 shows the total hours spend on production control meetings and the time divided between monthly, weekly and daily meetings. Most time is spent on the daily production control meetings which is held at all levels at the sites. Weekly meetings are held at only four sites while the monthly meetings are held at all but one site. It is also worth noticing the different sizes of the sites, Site E is the biggest site with most organizational units, hence the highest amount of meetings and site C and D are the smallest sites with the least amount of meetings.

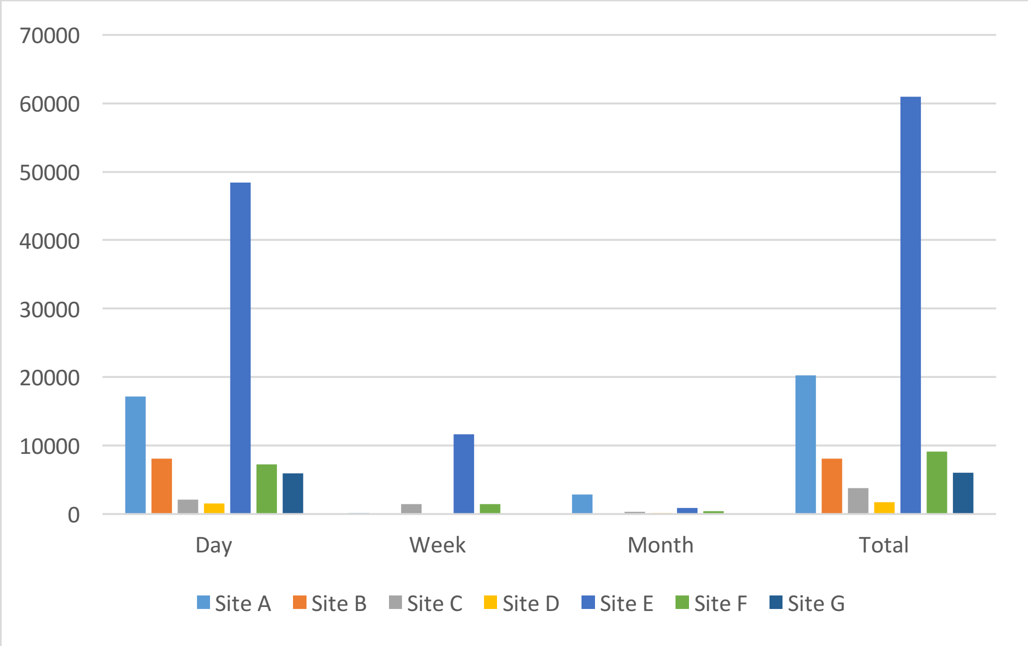

Figure 7 – Hours spent on production control meetings.

As shown in figure 8, site A and site E spend more hours on production control in relation to total work hours compared to the other sites. One reason for this is that they are the only sites that have more than one daily production control meeting at work center level. Site A has three, 10-minute-long meetings (one for each shift) per day and site E has a 2-minute-long meeting every two hours. The site with shortest meetings is site D with only a 5-minute meeting each day while the rest of the site has one daily production control meeting which take between 10-15 minutes.

On the area level have all sites one meeting per day accept site F which has two meetings per day. All sites accept site D and E has meetings that take about 10-20 minutes every day. At site E they have one additional organizational level. To be able to compare the site E with the rest of the sites are the two levels combined into the area level. The meetings on site E take 45 minutes (higher level) or 20 minutes (lower level). Site A has the shortest meeting on the area level with only 5 minutes a day. On the site level have all sites one meeting per day accept site A which has two meetings each week. The meetings take 10-20 minutes accept for site D which has a 5 minutes meeting and site E which has a 30 minutes meeting.

Only site A, C, E and F has weekly meetings and as can be seen in figure 7, site E stands out with the most time spent on weekly meetings. One reason for this is that they have weekly meetings at all levels, which is not the case for any other site. When it comes to the monthly meetings it is worth noticing that site A has a one-day meeting with approximately 30 employees which is unique since the other sites accept site B has shorter meetings with the top management of the site. Site B doesn't have any production control meetings on weekly or monthly basis since they discuss their more long term indicators during the daily meetings, a few selected long term PIs each meeting. Only three sites (C, E and G) also have monthly meetings at area level.

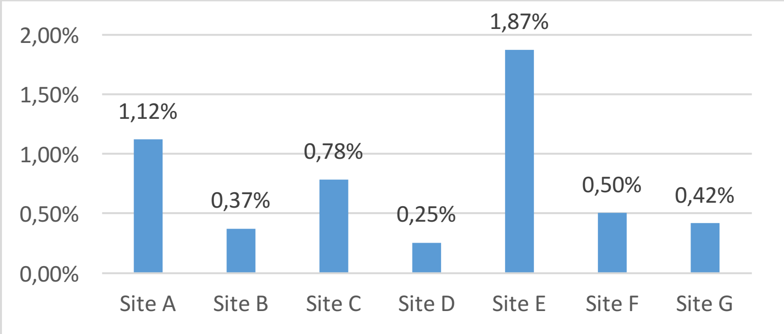

Figure 8 – Hours spent on production control meetings / Total working hours.

Discussion

The methodology is discussed first followed by a discussion about the findings.

Methodology

The methodology results in a snap shot of the present state of the PMS at the sites. The data collection and documentation was led by one person at all sites which ensured that the same methodology was used, thus strengthening the reliability of the results. To make sure that the results are comparable between different sites it is important to set the limitations of the study before the data collection begins. During this study the limitations were set to the production and the support functions: quality, maintenance and internal logistic, as well as to only include indicators that were visualized in production or offices related to the chosen support functions. However, since the method is general it would be possible to use this method for a more comprehensive study containing more organizational functions and indicators from computer systems and various reports.

The method is cost efficient since it took 2-4 days to perform the study at one site depending on the size of the site. However, it could be beneficial to spend more time for data collection, depending on the purpose. About a week on each site would give time to do more interviews to get a better understanding of the PMS. This was tested at the pilot study at site F where the researcher was present for a week and performed interviews with most of the area managers.

During the pilot study the method was tested and improved. The time spent on collecting and analyzing data were excluded after the pilot study, since it was very time consuming to collect that data and hard to make distinct definitions. The problem was to determine if an activity was performed to collect the result for an indicator or if that activity would have been done anyway with another purpose, e.g. tracking quality problems due to regulations. However, during the pilot study, some extreme cases of the time it takes to collect data were found. For example, to collect the data for the measure Inventory reliability, had the site 4,5 full time employees to check the inventory, while for other indicators, the data collection was done automatically by a computer system.

A similar problem was identified when collecting the data for how much time that the sites spent on using the PIs. The collected data is an approximation of both the time spent on each meeting as well as the number of employees participating. The only data available was a planned meeting time as well as the assumption, made by the manager or one of the participants, of the average number of participants.

Findings

The structure and use of the PMSs were quite similar at the different sites, with smaller differences in the review process and level of standardization. However, the number of performance indicators per organisational unit varies between 13-27 indicators at the studied sites, this is mostly influenced by the variations in use of scorecards on different organisational levels and the structure of the organisation. The time spent on production control is not only affected by the number of indicators but mostly by the number of meetings and the number of participants, hence a reduced number of indicators might not decrease the time spent on production control meetings.

The most used categories at the sites: safety, quality, delivery, cost and people, correlate with the categories with largest share of indicators. This is not surprising since most companies develop their indicators to fulfil the goals set in the scorecards which in most cases are organized by the categories. This structure is closely related to the CPM. The site wants to make sure they cover all perspectives that are important for the company and therefore ensure that they are measuring it on all levels within their site. The choice of categories is in most cases connected to the long term goals or strategy of the company.

One other relation to the balanced scorecard is the amount of financial and non-financial indicators. In this study there are a large majority of non-financial measures which is explained by the focus on operational indicators. All financial reports were excluded in the study.

The limitations had a large impact on the results of this study. It explains the low amount of environmental and financial performance indicator since they are measured in reports and is in most cases a separate function at the company. Therefore, it would be interesting to look into more functions in the organization, to get an even deeper understanding of the system. If for example the sales functions or the procurement function were included, the supply chain category would increase. It would also be interesting to look outside the site and compare the indicators and PMS at enterprise level with the site level. There are not great differences between top-down and bottom-up at site level. However, the authors got the impression at the pilot study that there were more differences between the enterprise and site levels.

Conclusion

The methodology is applicable for the purpose of gathering data of the present state of manufacturing companies. However, a few changes in the work procedure are needed to improve the efficiency of performing the methodology as well as improving the accuracy. A detailed standard procedure can be formulated and analysts need to been trained in the procedure to ensure reliability and validity of the data.

The participating sites are similar in that they all are part of large multi-national groups that have adopted some variant of lean production, where the PMS is a central part of their production system. They differ on the top level of their PMSs, where they have different top categories of PIs. The maturity of the PMS life-cycle differs also, where some sites have very mature routines for revision of PIs, while other only have routines for goal setting.

From a bottom-up perspective it differs in the amount of PIs, the time spent on production control and in the distribution of the PIs between the categories. However, the categories with largest share correspond to the most used categories by the companies.

The contribution of this research to industry is foremost that it lays the foundation for the future work in the project that will entail redesign of the PMSs for several of the companies. A more general contribution is the methodology itself. It can be used by manufacturing companies or consultants to efficiently and in a standardized fashion get valid data about a complete PMS.

The academic contribution is the systematically collected empirical data about the PMSs of the case companies. The generalizability of the results is limited since the sampling of the cases was not made randomly to represent a larger population. The methodology is also an academic contribution, since it's generally applicable for all companies with a PMS and a production system where production control meetings are a central part.

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