

From Metrics to Process: Towards a Dynamic and Flexible Performance Measurement System for Manufacturing Systems

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ABSTRACT

Performance measurement systems are challenged by today's rapidly changing and highly competitive markets. Measures and management of these systems often fail to continuously reflect the dynamic business environment. This purpose of this paper is to discuss how to achieve a dynamic and flexible performance measurement system applicable for manufacturing sites. The analysis is based on a literature review on major performance measurement schemes, as well as a problem identified in industry. The paper introduces an industrial case where the current measurement at Operations is briefly evaluated and put in relation to the findings made in the literature study. The industrial challenges and possibilities are set as one basis for a proposed future structure. Important aspects on functionalities/abilities for future research as well as development at the case company when choosing indicators and their implementation are discussed.

Keywords: performance measurement system, productivity, manufacturing.

1 INTRODUCTION

In recent years considerable attention has been given on the design and use of performance measurement systems. As global competition increases and ownership and management has increasingly been separated, financial measures on return of investment have been applied for expanding range of applications, in order to facilitate a monitoring of management and execution from executive levels and owners.

However, as Kennerly and Neely (2003) point out, there is wide documentation on the deficiencies in traditional financial performance measures and their insufficiency for the effective management of businesses in today's rapidly changing and highly competitive markets [1]:

"Authors suggest that traditional financial performance measures are historical in nature (Dixon et al., 1990); provide little indication of future performance; encourage short termism (Hayes and Abernathy, 1980; Kaplan, 1986); are internally rather than externally focused, with little regard for competitors or customers (Kaplan and Norton, 1992; Neely et al., 1995); lack strategic focus (Skinner, 1974); and often inhibit innovation (Richardson and Gordon, 1980)." [2] - [8]

These drawbacks of traditional measures have been especially visible during the latest year of financial crisis and rapid decline in orders, especially for the automotive sector. In addition, in an increasingly complex performance measurement context, the management of performance systems and performance indicators is increasingly important. Companies often fail to continuously reflect the dynamic business environment and their new priorities in their performance measurement systems. One specific aspect is the performance indicator's behaviour in relation to investments. When investing, the

performance measures may in many cases indicate a decline in productivity, while the readiness for change in fact is improved.

With this background, Neely (2005) points out five key research issues for performance measurement [9]:

- How to design and develop enterprise performance management rather than measurement systems?
- How to measure performance across supply chains and networks rather than within organisations?
- How to measure intangible as well as tangible assets for external disclosure as well as internal management?
- How to develop dynamic rather than static measurement systems?
- How to enhance the flexibility of measurement systems so they can cope with organisational changes?

On the basis of an industrial background from a case company, this paper focuses the two latter aspects in the research challenges, to develop a more dynamic and flexible performance measurement system. The objective is to present aspects important for enabling a dynamic behaviour and flexibility within performance measurement schemes and a complementary procedure for a manufacturing context.

The paper is a part of a larger one-year project ambition to explore and develop a dynamic and flexible measurement system applicable for manufacturing sites in today's rapidly changing and highly competitive global market.

2 METHODS AND MATERIALS

The paper is based on an overview of current research propositions and identified industrial schemes for performance measurement systems. As reviewed by e.g. Tangen (2005), the concepts of productivity and performance are often confused and considered interchangeable [10]. By following the description of the terms productivity, performance, profitability, efficiency and effectiveness in [10], this paper discusses alternative performance measurement schemes.

Performance is considered as an umbrella term for all terms covering the success of a company and its activities. When discussing performance of a manufacturing activity, the terms productivity and performance are tightly interlinked. However, productivity is strictly a relation between output and input, while performance covers all aspects of cost, flexibility, speed, dependability or quality [10].

The analysis is based on literature as well as a problem identified in industry. The paper introduces an industrial case where industrial challenges and possibilities are set as one basis for the proposed structure. The current measurement at Operations is briefly evaluated and put in relation to the findings made in the literature study. The analysis is made through interviews and a case description.

Finally, important aspects on functionalities/abilities for future research as well as development at the case company when choosing indicators and their implementation are discussed.

3 FRAME OF REFERENCE

Performance measurement literature can be divided into two main phases. The first phase began in the 1880s and lasted for a century. Performance measures were derived from management accounting systems and emphasised cost with a rigid focus on financial measures such as productivity, profit and return on investment. During the end of the 20th century globalisation started to change the rules of making business. Companies started to lose market shares to overseas competitors that were able to offer products with higher quality and wider range for less cost. Trade barriers were torn down and competitive companies started to compete in an international arena and regarded the world, and not only their nations, as their market [11].

In order to adapt and regain competitiveness a change in strategic priorities was prompted for many companies and this marks the start of the second phase of performance management literature. Focus shifted away from cost to more operational indicators such as delivery precision, lead time, flexibility and quality. As strategic priorities shifted new production technologies and philosophies such as just in time, total quality management and optimized production technology were introduced and implemented [12].

The limitations of "traditional" financial metrics were enlightened. Measures derived from management

accounting systems were out of context, lagged, lacked alignment with strategy, not quantifiable in operational terms, expensive and inflexible. New "non-traditional" measures arose with characteristics revolving around: vertical and horizontal alignment between metrics and strategies, focus on operational measures that are useful for everyday decision making (i.e. non-financial measures), guidelines of more specifications the further down the organisation they are broken down, and an ability to adjust to change in the marketplace. [12]

3.1 Balanced scorecard

The balanced scorecard was developed 1992 by Robert Kaplan and David Norton [5]. The authors describe the scorecard as the cockpit of an airplane. In an airplane, the pilots need information about several aspects in order to navigate and fly, in comparison a manager needs to view and gauge performance from several areas simultaneously in order to run a business. The entirety is important and reliance on a single factor can be fatal. The idea of the balanced scorecards is to use a balanced set of measures to allow executive managers to take a quick but comprehensive look at four crucial aspects of business. These aspects are derived to provide answers to four paramount questions illustrated in Figure 1:

- How do we look to our shareholders (financial perspective)
- What must we excel at (internal business perspective)
- How do our customers see us (the customer perspective)
- How can we continue to improve and create value (innovation and learning perspective)

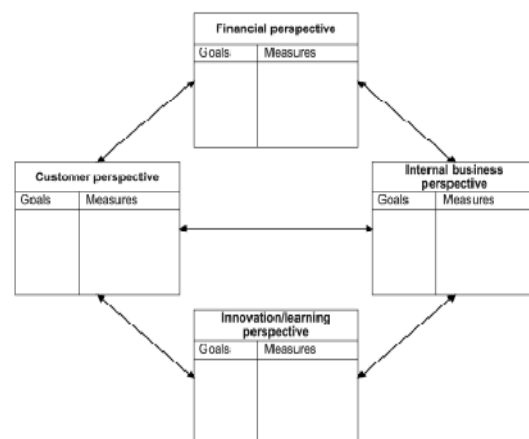


Figure 1. Illustrating the balanced score card [13]

The concept refutes critical voices raised in regards to gauging performance via traditional financial measures. Critics argue that firms should solely focus on operating measures and that the financial numbers will take care of themselves if operations are executed soundly. However, the authors consider the financial perspective to be important because of two reasons. Firstly, well

designed financial measures can amplify quality and secondly because correlation between operational improvements and financial boosts are thin and volatile.

The balanced scorecard uses financial performance measures as tools to display results of taken actions. In addition, the model also uses operational non-financial performance measures to assess drivers of future financial performance [5].

The purpose of streams of information from several directions in combination with a limited set of measures is to guard against information overflow, sub-optimisation and to keep the focus at the most crucial aspects of business.

The balanced scorecard is the most cited piece of work in the field of performance management [14]. At the time of introduction the scorecard was considered revolutionary to the field due to its innovative multi-dimensional approach to performance measurement [15]. According to Rigby (2001) between 30 and 60 per cent of companies has adopted the framework [16]

Even though the balanced scorecard is considered to be the most famous and popular framework it has disadvantages. Ghalayini et al. (1997) argues that the weakness of the scorecard is that it is conceptualized as a tool of controlling for senior managers and not as an improvement tool for factory operation levels [12]. Another weakness is the inadequate instructions on how proper measures can be identified and initiated. Finally the concept lacks a competitor perspective [17].

3.2 The performance prism

The performance prism [13] is a framework designed to assist performance measurement selection – the vital process of picking the right measures. It suggests that the performance measurement system should be focused around five distinct but linked perspectives, illustrated in Figure 2;

- Shareholder satisfaction – Who are the important stakeholders and what do they want and need?
- Strategies – What are the strategies we require to ensure the wants and needs of our stakeholders are satisfied?
- Processes – What are the processes we have to put in place in order to allow our strategies to be delivered?
- Capabilities – What are the capabilities we require to operate our processes?
- Stakeholder contributions

Stakeholder satisfaction is seen as the first facet. Instead of deriving measures from strategy as other the framework argues that a strategy is a plan for delivering value to a set of stakeholders and hence measures need to be directly derived from the wants and needs of the stakeholders. When the wants and needs are mapped out the second facet starts, the exploration of what strategies to put in place to ensure their satisfaction begin.

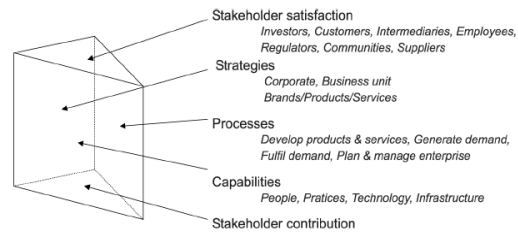


Figure 2. The performance prism. [18]

The third facet of the framework is the processes. The common generic business processes needed in order for organizations to follow and fulfil strategies are enlightened. These are: develop new products and services, generate demand, fulfil demand and finally plan and manage enterprise. Specific measures within each process should be identified and generated in order to allow managers to track performance. The fourth facet is capabilities; they are defined as the combination of people, practices, technology and infrastructure that together allow execution of business processes. The last facet of the performance prism is stakeholder contribution. The authors argue that organizations and stakeholders enter a relationship with mutual demands. Just as the first facet lists the wants and needs of the stakeholders the last facet addresses the wants and demands of the organisation towards the stakeholders [18].

The framework is unique with the broad focus on stakeholders. The strength of the prism is that it questions before selecting and hence ensuring that solid measures are generated [13].

3.3 The Performance pyramid

Cross and Lynch's framework: "the performance pyramid" puts corporate vision in focus [19]. It is considered one of the earliest approaches to advocate integrated measurement systems [15]. The framework addresses internal and external effectiveness and links corporate strategy with daily operations through a pyramid consisting of four levels:

- Corporate vision – The "heart and soul" of the company defines its markets and how to compete – on price, breadth of product line and quality of sales force. The strategy is translated into business unit objectives.
- Business Units – Comprises key results, objectives and measures. Most business units define success as reaching short-term goals of cash flow and profitability and long-term goals of growth and market position.
- Business Operating Systems – Bridges the gap between top-level, traditional indicators and new day-to-day operational measures.
- Key Performance Measures – Integrated and balanced set of performance measures that are controllable on daily basis for managers and

workers alike. Measures consist of; quality, delivery, cycle time and waste.

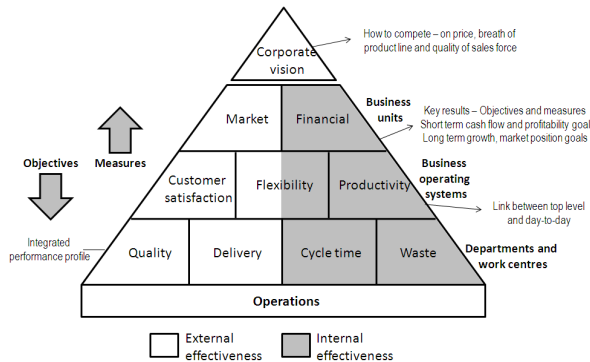


Figure 3. The performance pyramid [19]

The Performance pyramid focuses on the paramount requirement of a performance measurement system, a clear link between performance measures at different hierarchical levels within a company so that goals are aligned. The pyramid links corporate strategy to operations by translating objectives top down and measuring bottom up.

Continuous improvement is discussed but no implicit process exists for implementation. The authors suggest that continuous improvement is triggered by the state of improvement of the competitors and that their achievements should be a point of reference for what the company must overachieve. For example, a goal of 95 per cent delivery precision says nothing without knowing where the competition is heading [19].

Ghalayini et al. (1997) argues that the main strength of the concept is the integration of corporate objectives with operational performance indicators [12]. Further, the vertical and horizontal alignment of strategies is another strength that ensures correct direction. The concept lacks a mechanism for identifying key indicators of performance. Further, the lack of a process for continuous improvement is also seen as a disadvantage.

3.4 Sink and Tuttle model

A classic performance measurement system is the Sink and Tuttle model [11] [13]. The model defines performance as a complex interrelationship between seven criteria, illustrated in Figure 4;

- Effectiveness – Which involves doing the right things at the right time with the right quality. Expressed as the ratio of actual output divided over expected output.
- Efficiency – Doing things the right way, expressed as the ratio of expected consuming of resource over actual resources consumed.
- Quality – A wide concept, therefore this criterion is measured through six checkpoints; quality management process, inputs, outputs, downstream systems, upstream systems and transformation value adding process.

- Productivity - Defined as the traditional input to output ratio.
- Quality of work life - An essential contribution to a high-performing system.
- Innovation - A key element in sustaining and improving performance
- Profitability / budgetability - Represents the ultimate goal for any organisation.

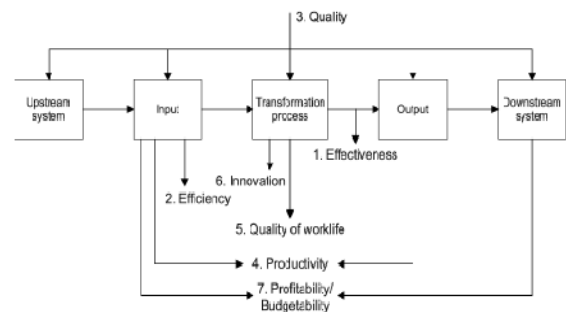


Figure 4. Sink and Tuttle model [13]

Having the first three performance criterion in place is a prerequisite for a productive organisation. Further, quality of work life and innovation are moderators. They can either decrease or increase performance. Producing high level performances at these criterions amplifies profitability in short-term and supports the long-term goals of survival, excellence and growth.

The industry and business environment has changed since the release of the model. However the above criteria are still deemed important to business.

The model has several limitations. It does consider the need for flexibility, which is considered to be a strategic priority. Further the model lacks consideration for the customer perspective [12].

3.5 TOPP performance model

A framework constructed within the TOPP Project views performance as an integration of three dimensions, illustrated in Figure 5:

- Efficiency
- Effectiveness
- Adaptability

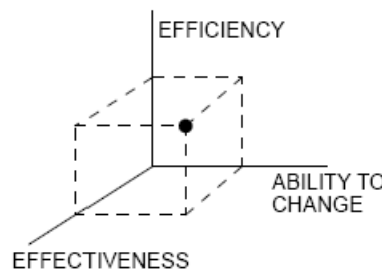


Figure 5. Illustrating the TOPP Model [11]

The first two dimensions have the same definitions as in the Sink and Tuttle model. The additional adaptability dimension gauges the extent to which a company is equipped for future changes [13].

TOPP was a productivity study carried out in the Norwegian manufacturing industry between 1992 and 1996. The study was sponsored by the Norwegian Research Council and had as overall goal to focus on the total productivity for the whole enterprise and stimulate an industrial climate that improves competitiveness. The key objectives of the study were time to market, quality, flexibility and total cost [20].

3.6 Medori and Steeple's framework

The Medori and Steeple's framework is based on a research programme executed at four medium- to large-sized manufacturing organisations. The purpose of the research programme was to identify actual industry requirements for a performance measurement framework [21].

The concept is designed to either audit or enhance an existing performance measurement system or to create a brand new one. The framework is designed as a process consisting of six detailed stages:

- Defining manufacturing strategy and success factors
- Matching strategic requirements with the six defined competitive factors
- Selection of the most suitable measures
- Auditing existing measurement systems to identify which existing measures are to be kept
- Implementation of measures based on eight elements
- Periodic review of the measurement system

The starting point is to define the manufacturing strategy. The purpose of the step is to ensure that measurements are related to the company's strategy. The second stage matches the requirements derived from the strategies to six competitive priorities: quality, cost, flexibility, time, delivery and future growth. Once stage 2 is completed the competitive priorities become clear in the area of measurement for the company. After identifying priorities the most suitable measures are then chosen out of a spectrum of 105 well defined measures in stage three. The fourth stage is to audit the existing performance measurement system. The measures of the existing system are compared with the ones picked in stage three. Old measures that are aligned with the new ones are kept, the rest are scrapped. Stage five is of essentiality and contains the implementation of the measures linked to eight elements: title, objective, benchmark, equation, frequency, data source, responsibility, improvement. Finally, the last stage of the framework is revolved around periodic maintenance of the system. Periodical reviews are a part of the framework and serve as a guard against redundancy and obsolescence [21].

3.7 The performance measurement matrix

The performance measurement matrix is one of the older systems existing. Performance is here measured by a four dimensioned matrix [22]. The matrix is split into four cells: external/cost, external/non-cost, internal/cost and internal/non-cost. The system is founded on four pillars:

- Performance measures must be derived from strategy
- Performance measures must be integrated vertically and horizontally
- Performance measures must be supporting the multidimensional environment
- Performance measures must be based on a thorough understanding of cost relationships and behaviour.

The authors argue that performance measurements trigger actions from management and therefore it is of utmost importance that measures are derived from corporate strategies and are integrated vertically and horizontally.

Metrics need to be measurable on each hierarchical level and the further measures extend down the organisation the more specific they need to get. Telling an operator at the factory floor to increase return on investment will not generate anything but setting up measures of scrapings per unit and delivery precision for each factory cell or work centre will trigger actions that in the long run will amplify return on investment.

The system need to measure the whole multidimensional environment with indicators both internally and externally. The purpose of the design of the performance measurement matrix is to give a holistic view of the overall performance of the company. Finally focus should be on cost drivers and generated measures need to be based on a sound and thorough understanding of cost relationships and behaviour. This is because cost, according to the authors, is the most important basis of performance measurement [22].

4 CURRENT SITUATION IN AN INDUSTRIAL CASE

The case company has several manufacturing sites in Sweden. One site has been of particular focus in this study, producing components for the automotive sector. During the last years an extensive project with the purpose of implementing a company specific production philosophy has been executed at the site. The project was estimated to a staggering 1.2 billion SEK and is the largest investment ever made at a production site by the corporate group. Within the company specific production philosophy, goal and result orientation is highly rated and therefore focus has been concentrated on generating a culture that fosters results.

The top managerial body at the site have been able to create a result oriented culture and make it an integral part of the way of working. In order to create the culture of result orientation the managerial body involved an external management consulting team with the purpose

to implement tools that would enhance result culture throughout the organisation.

4.1 The result plan structure

The external team implemented result plans. The purpose of the result plan as a tool is to enhance result culture and ensure that goals and objectives are met within an organisation. It is designed to follow up organisational and departmental goals and individual tasks and objectives. In order to assure alignment result plans are synchronized vertically throughout the hierarchy (see figure 6). The idea is to ensure fulfilment of overall goals through a process of weekly follow up of the individual tasks and objectives. The weekly follow-up-process is executed by result meetings throughout the organizations managerial bodies. During the result meetings status and progress is reported and deviations to plan are scrutinized.

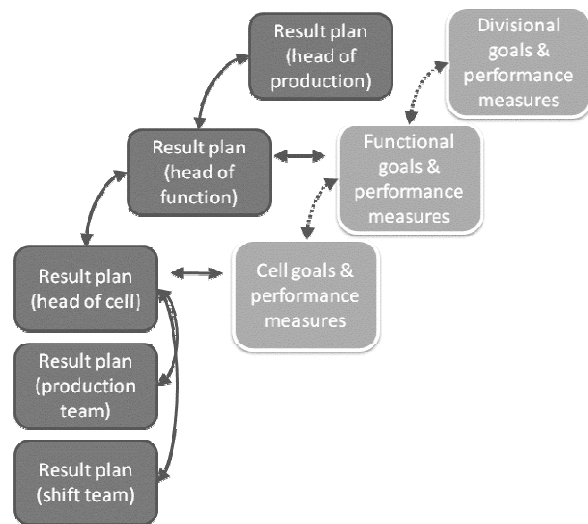


Figure 6. Plans and goals synchronisation.

The result plans are seen as a vital part of the way of working at Operations and the follow-up-meetings are considered to be of high importance. The acceptance of the result plans has pushed the integration of performance measures. The implementations of performance measures have become a part of the day-to-day operations since every head of function and cell have their own set of metrics to report. Just as figure 6 illustrates, in addition to goals, performance measures are vertically aligned to respective function and cell. Further, the same procedure of follow-up applies to measures, status is reported and deviations scrutinized on a weekly basis.

4.2 Towards global key performance indicators

The case company has, in the moment of writing, created a taskforce with the purpose to construct a scorecard with 11 global key performance indicators that are to be reported by all sites.

The idea behind the initiative is to support the wanted position of the company and to create alignment with the corporate group's specific group definitions

regarding Key performance indicators of the order-to-delivery and sourcing processes. The order-to-delivery process involves all steps from the customer order to delivery of the vehicle. The process of uniting the sites has been conducted through local and global workshops where the managerial bodies of the various sites have had a chance to influence the proposed definitions of the Key performance indicators. The global workshops have also been a chance for the sites to propose supporting measures to the all-embracing 11 indicators. In order for the measures to be of help for management the taskforce has concluded that they will be automated from underlying common systems to maximum extent possible to provide real time data.

The set of measures are chosen from the appropriateness of a high level summary and are mainly divided between four aspects: **quality** (two measures), **delivery** (two measures) **cost** (four measures) and **safety/other** (three measures). The measures are both financial and non-financial and the thought is that the overall measures shall be broken down and cascade throughout each organization to cell levels.

Inevitably, parallels can be drawn between the company's scorecard and Kaplan and Norton's framework [5]. The biggest difference however is that the company scorecard has not adopted the four "critical" aspects of business (financial, internal business, customer, innovation) instead the metrics are divided among the aspects deemed important for the order-to-delivery and sourcing processes (safety, quality, delivery, cost and other).

5 COMPANY SPECIFIC DISCUSSION ON FUTURE DEVELOPMENT

As discussed, both macro and micro levels processes for performance management is in existence at the case company. The result plans ensure alignment and involvement of measures in daily operations, the global key performance indicator initiative covers the breakdown of corporate strategies to functional and divisional goals.

5.1 The missing link between micro and macro

However, as illustrated by figure 7, the vital process between top- and bottom levels is currently not intact.

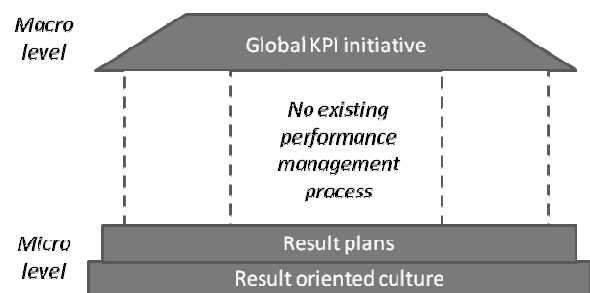


Figure 7. Illustrating the missing performance management process.

The absence of a performance management process is a result of the organizational restructuring that the studied site went through in the aftermath of the 2008 financial crisis. During the restructuring, departments vanished and were consolidated. Unfortunately, among the vanished departments were the responsible department for the performance management process. The department administrated information regarding definitions of measures, ownership, cascading of measures, auditing routines, evaluation, synchronization and the function of reviewing, modifying and deploying performance measures.

5.2 *Long and short term consequences of the missing link*

Ever since, the studied site has suffered from a missing link between the macro and micro levels of performance management. The short term consequence has been lagged decision making and the long term consequence is the risk of extraordinary costs of restructuring. Decisions have been lagging due to the absence of a functional performance management process. Blurriness and ad-hoc solutions have been surrounding decisions taken in regards to performance. The restructuring costs will be a direct consequence of the absence of maintenance of the measurement system. The restructuring will involve actions to update information systems for data collection and actions to revise measures due to strategic and organizational change. Otherwise, the system will become obsolete and not up to date. Just like an automobile, a measurement system needs maintenance and just like an automobile, a measurement system will break down if not maintained.

5.3 *The risk of biased measures*

The short and long term consequences are discussed above, however, there is additionally one more aspect that needs to be enlightened, the risk of steering the organisation with biased measures. As illustrated by figure 6, initially overall performance measures are broken down to site levels. The next step is cascading the measures down to function and cell levels so they become contextual. The last part is the result plans and the weekly deviation follow up. If the linking process is not functional the cascading of overall measures will be biased and misleading measures will be generated. In an organisation that appreciates and values results this is risk of magnitude. As literature has frequently pointed out, measures are to be derived from strategies. Strategies are dynamic and change after the preferences of the customer and the market, hence the need for a reactive link between top- and bottom levels.

The company needs to recreate an efficient process that supports the whole spectra of performance measurement and involves the mechanics missing in the measurement system. As the company is in a market that is highly affected by the turns of the business cycle, the process needs to be efficiently reactive to long and short term contextual change.

6 GENERAL DISCUSSION ON REACHING A PERFORMANCE MANAGEMENT PROCESS

Literature regarding performance management lists the search for a dynamic and flexible measurement system on the future research agenda in the field. [9] However, globalisation has amplified the rate of speed in which business environment and demands change and with it, the rate of change in strategies and goals. Change has become more frequent and at a broader horizon, putting pressure on more dynamic and flexible solutions. The need is therefore also found in practice for a dynamic (long term response to contextual change) and flexible (short term response to contextual change) performance measurement system that is to be characterized by the ability to cope with rapid organizational and business cyclical changes. The system should be robust for irrelevant disturbances and sensitive for relevant changes. Furthermore, the continuous management of a performance measurement system is vital, not only adding extra indicators and measures as priorities change, but in fact removing old priorities.

As sound measures are derived from either corporate strategies or stakeholder interests the solution lays in designing a reactive and efficient performance management process linking top and bottom levels. A reactive process will anticipate contextual change and an efficient process will trigger rapid change throughout an organization as strategy change. An efficient performance management process will create a measurement system that is robust to irrelevant disturbances and sensitive to relevant changes.

Hence, future research must focus on deriving a process, not a measurement system, which is dynamic and flexible. Measurement systems have their relative benefits and limitations, however the most common limitation of the frameworks listed in this paper is the lack of guidelines for the actual selection and implementation of the measures selected [21]. Focus on the process is therefore inevitable. The process involves all the guidelines and supporting infrastructure that is missing in the frameworks as illustrated in the industrial case in figure 8. The dynamical and flexible ability of the measurement systems becomes a direct result of the abilities of the process.

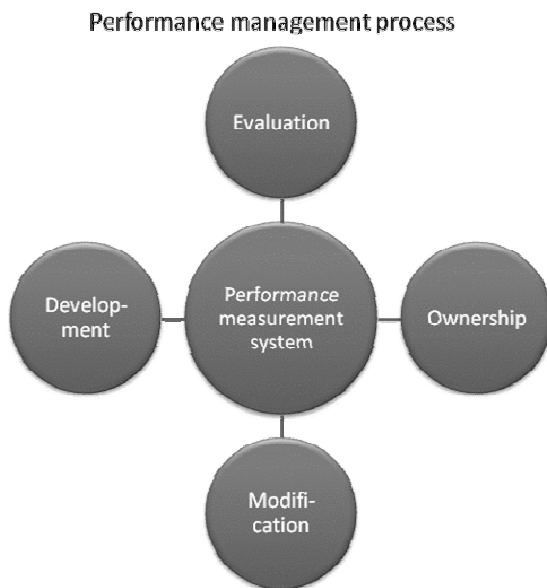


Figure 8. Vital abilities in a future performance management process.

7 CONCLUSIONS

During the recent year's rapid decline in orders for especially the automotive sector, performance measures have been put to test. In many cases indicators fail to reflect the dynamic and flexible behaviour of the manufacturing activity.

The measurement frameworks from literature described in this paper have their respective capabilities and limitations. Some frameworks, such as the performance matrix and Sink and Tuttle model, highlight important aspects but are deemed obsolete due to change in business nature since their introduction. Others systems are contextually relevant but lack to integrate crucial supporting functions such as the balanced scorecard and the performance pyramid. The most common limitation of performance measurement frameworks is the lack of guidelines for the actual selection and implementation of the measures selected.

In a sense, the same limitation is seen as crippling in the industrial case. An all-embracing global measurement initiative exists in combination with a result culture and result plans. The process of integration between macro and micro levels is however missing, and with it, the guidelines and functions needed.

As globalization has changed the rules of business and amplified and broadened the rate of change demands has emerged from both academia and practice for a dynamic and flexible measurement system robust for irrelevant disturbances but sensitive for relevant changes.

The main thesis of this is paper is that the future research agenda in the field of performance management must focus on deriving a dynamic and flexible process due to the general limitations of

measurement frameworks and the broadened horizon of change in context.

The final objective of the project is to support manufacturing industries on choice of measurement scheme, the implementation and management. The next step in this work is to benchmark the findings against a market competitor and the other operative manufacturing units in Europe.

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