# CRITERIA FOR SUPPLY CHAIN PERFORMANCE MEASUREMENT SYSTEMS

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## ABSTRACT
Research on performance measurement has mostly focussed on the single company. However in the last few years focus has shifted to incorporate a supply chain perspective with several supply chain performance measurement systems (PMS) proposed. Implementing such a system proves difficult due to the complexity of supply chains. This paper presents criteria for the development of supply chain performance measurement systems proposed in literature. The criteria are evaluated in two industry cases. Based on findings from the case studies, we discuss the criteria and outline three factors to be dealt with to further enhance the implementation of PMS in supply chains. The factors are: lack of supply chain strategy, lack of implemented supply chain process models and lack of management systems supporting the PMS. We suggest that definition of supply chain strategies and processes along with development of ICT tools for integrated PMS as first steps in addressing these factors.

**Keywords:** Performance measurement, Performance measurement systems, supply chain

## INTRODUCTION
Research on performance measurement (PM) has mostly been focussed on the single company. However in the last few years focus has shifted to incorporate a supply chain perspective, with several performance measurement systems (PMS) proposed (see for example Holmberg, 2000, Van Hoek 1998, Lapide, 2000, and Chan and Qi, 2003). The development of PMSs aim to integrate the critical information of firm's inputs, outputs and actions to better manage its performance and as a result, influence the future by supporting and shaping the further decision and production activities (Chan, Chan and Qi, 2006). Today's PMSs have several shortcomings; i.e. short- term oriented and finance based (Holmberg, 2000) and internal focussed and encouraging local optimisation (Chan, Chan and Qi, op cit). Despite these and other shortcomings, PMSs are widely implemented in industry today.

A key component to successful transformation of individual business units into a fully operational supply chain is to design PMs and a PMS with a holistic supply chain focus. Hence there is now an increasing focus on supply chain measures and the overall performance. This also

implies that each entity will be held responsible for the overall performance and not only own performance (Gunasekaran, Patel, Tirtiroglu, 2001). The arguments for the development of PMS for supply chains are many. Gunasekaran et al. (2004) mentions that control of supply chain processes through measurement is crucial in improving performance and that managers will be more likely to reach overall corporate goals and business strategies with the support of a PMS. Within supply chain management, performance measurement also facilitates inter-understanding and integration among supply chain members. (Chan and Qi, 2003) Another important argument by Lambert and Pohlen (2001) is that supply chain members that are linked through such a system will better respond to customer demand.

Implementation of supply chain PMS in industry has proved difficult due to the complex characteristics of the supply chain, i.e. conflicting objectives and mistrust, multiple tires, incompatibility between ICT systems and lack of understanding of supply chain practices. Several frameworks (i.e. Gunasekaran et al., 2004, Chan and Qi, 2003, Lambert and Pohlen, 2001) for design of supply chain PMS provide a set of criteria or principles as guidelines to the development PM and the PMS. These criteria are important guidelines to help practitioners define and implement PM for management of the supply chain processes. The purpose of the paper is to investigate these criteria in light of the complex characteristics of the supply chain and provide insight into the present challenges and obstacles in designing and implementing performance measurement systems in supply chains.

The research approach for this study has been a multiple case study, together with a literature review. The literature review has involved an in-depth analysis and critical summary of performance measurement literature in general, and more specific of performance measurement in supply chains, for the purpose of identifying a research "gap" that needs to be addressed through future studies (Blumberg et al., 2005, Frankel et al., 2005, Seuring et al., 2005, Fink, 1998). The review identified a set of criteria for designing performance measurement systems, which then were analysed in two case studies. The case study approach was preferred due to the need for a thorough and extensive study of how the set of criteria are applied in industry (Yin, 2003, Eisenhardt, 1998), and due to the fact that a holistic and in-depth investigation was needed (Feagin et al., 1991). The two case studies were taken respectively from the automotive industry and the pharmaceutical industry. The two cases are characterised by both companies which own and have control over large parts of the supply chain and are closely integrated with its suppliers.

The structure of the paper is as follows; first a list of the supply chain performance measurement criteria is presented. Thereafter the case studies are introduced, followed by an analysis and discussion of the PMS in the cases against the criteria. Finally, findings are summarised and further research suggested in the conclusion.

## SUPPLY CHAIN PERFORMANCE MEASUREMENT CRITERIA

A well-designed PMS should help supply chain managers understand and improve performance of supply chain operations (Chan, Chan and Qi, 2006). Reviewing the existing literature on supply chain, PMS reveal a set of criteria or principles that serve as guidelines when designing PMS. Restricting this to PMS for supply chains Takle and Gabrielsen (2006) propose a set of criteria and principles for supply chain performance measurement systems. The following list is a summary of the criteria and principles presented in Takle and Gabrielsen (2006):

- *Holistic approach* – Performance measurement in the supply chain should take a holistic system perspective beyond the organisational boundaries (Chan and Qi, 2003). The performance of supply chains needs to be assessed across the organisations in order to encourage global optimisation along the supply chain channel.
- *Process-based* – Successful supply chain management requires a change from managing individual functions to integrated activities within key supply chain business processes

(Lambert and Cooper, 2000). Supply chains metrics should reflect this change and focus on supply chain processes rather than functions.

- *Aligned with strategy* – The performance measurement system must be consistent with the overall strategy of the supply chain. For instance, if the overall supply chain objective is short delivery times, logistic strategies that emphasise low cost could be in conflict (Coyle et al., 2003, Keebler et al. 1999).
- *A dynamic system* – An important criterion for performance measurement system is that the system needs to be dynamic (Folan and Browne, 2005). The supply chain is a dynamic system that evolves over time, and the performance measurement system must have the ability to change over time to incorporate the changes in the supply chain and to continually remain relevant (Kennerly and Neely, 2003).
- *Balanced approach* – The purpose is to distribute performance measurement on a set of parameters that is representative for the most part of the business/supply chain. Supply chain performance measurement systems should provide a balance between financial and non-financial measures (Gunasekaran et al., 2004, Chan and Qi, 2003, Lambert and Pohlen, 2001). Financial measures are important for strategic decisions and external reporting, while non-financial measures handle the day to day control of manufacturing and distribution operations (Gunasekaran et al., op cit).
- *A managerial tool* – The performance measurement system is supposed to be a managerial tool, and the system must be able to arrange the transition from "measurement" to "management" (Basu, 2001). As a result, the performance measurement system needs to be simple to understand and provide timely and accurate feedback.
- *Cover strategic, tactical and operational level* – The performance measurement system should assess and give relevant information to the appropriate level of management. Strategic level measures influence the top level management decisions, tactical level deals with resource allocation and operational level measurements and metrics assess the results of decisions of low level mangers (Gunasekaran et al., 2004).
- *Provide a forward looking (leading) perspective* – the performance measurement system should capture trends rather than snapshots of the business (Busi, 2005)
- *Tool for improvement* – The performance measurement system should focus on improvement. New methods and concepts like TPM (Total Productive Management) and TPS, emphasise continuous improvement, which should result in raising the performance expectation over time (Coyle et al., 2003, Kennerly and Neely, 2003, Basu, 2001).
- *Provide drill-down functionality* –The performance measurement system should give the managers the ability to pinpoint distinct areas for improvement (Lapide, 2000).
- *Handling conflicting objectives* – The performance measurement system should assess the different trade-offs within a supply chain and visualise the results to prevent sub-optimisation (Lambert and Pohlen, 2001).
- *Simple* – The performance measurement system should be easy to understand at all levels in the organisations and it should contain a limited number of relevant measures (3-7) (Busi, 2005, Lapide, 2000, Neely et al., 1997).
- *Comparability* – The performance measurement system should enable the supply chain to benchmark its performance to a set of standards (Gunasekaran et al., 2004, Coyle et al., 2003).
- *Relevant metrics* - The performance measurement system should only use relevant metrics that enable appropriate decision-making (Coyle et al., 2003).

Although these criteria are all useful to practitioners it must be noted that they are a collection of criteria presented by different authors and in different models, and not meant to be accomplished in one PMS. However it is still important to consider and discuss these criteria thoroughly among the

actors when designing a PMS for the supply chain. In the following case study two supply chain PMS are presented and analysed against the criteria listed above.

## CASE STUDY

Two cases studies from the automotive and the pharmaceutical industry are presented here. First a brief introduction to the supply chain and the existing PMS is given. Thereafter the PMSs are analysed against the presented criteria.

*Case study one*

The first case study addressed in this paper is from the automotive industry. The supply chain provides crash management systems, bumpers and crash boxes to first tire system manufacturers, third party suppliers or directly to the OEMs. The five tier supply chain consists of casting house, extrusion plant, bumper plant, crash box plant and assembly plant. The casting house, extrusion plant and the bumper plant are located in Norway only a few hundred meters apart, the crash box plant is located in Sweden. Finally, the assembly plant is located in Germany. In 2006, they delivered 4.6 million bumpers. The five plants are organised in the same company, but are individual business units responsible for costs and profits.

Today's performance measurement system is hierarchic structured from single line level in each factory to the top corporate level. Some KPIs are decided from top management and are the same in all units, i.e. within Health Security and Environment (HSE). Apart from this, the companies themselves decide which areas are critical to measure. A few chosen measures are reported from line to unit level and then from unit to corporate level. These chosen measures from each unit are those most critical for the specific unit. For the extrusion plant, cost pr kilo produced is the chosen parameter while for the bumper plant this measure is cost pr piece sold. Measures are developed based on the unit's vision and strategic business goals. Information about the KPIs are gathered in an excel-sheet where each KPI has its own page for KPI definition, result reporting and follow up. Data is manually inserted in the excel-sheet. The KPI sheet is used actively in the continuous improvement work in the organisation and all actions to improve KPIs are listed and assigned to the responsible person.

*Case study two*

The second case study is from the pharmacy industry in Norway. The supply chain consists of a wholesaler and a pharmacy retail chain. The pharmacy industry in Norway is dominated by intense competition due to the new pharmacy law enforced in 2001 that is more liberal and led to increased integration both vertically and horisontally. The wholesalers primarily deliver goods to their own pharmacies (retail chain) in spite of the multiple channel system allowing each wholesaler to deliver pharmaceuticals to all pharmacies in the market.

The wholesaler and the retail chain operations are separated into two individual companies. However these are owned by the same company group. Even though the companies are closely linked with interdependent operations, they have separate performance measurement systems with individual follow-up and reporting to the group. The companies are hence evaluated separately based on different parameters. For the overall evaluation of the two companies' performances, a large set of indicators is applied. There are further various measurements reporting routines and measurements which are followed up at various levels in the two companies. A large number of parameters are reported on a monthly basis to the group headquarters, with focus on financial results and market figures. Several of these measures are influenced and decided by the company group and are in some cases perceived as unnecessary, irrelevant or with a wrong focus from the single unit's perspective. Follow up of logistics operations are carried out primarily at the wholesaler on a daily basis and a few of these are selected for the monthly group reporting. Monthly follow up of the retail chain operations is primarily based on more general indicators focusing on

financial results and market figures. Measurements for follow up on a daily basis include mainly financial indicators such as sales figures but also pharmacy stock levels. Tools used for follow up include ERP-systems and excel-sheets.

## ANALYSIS

The criteria presented earlier in the paper will now be analysed and discussed with regard to the two case studies. The cases give examples of how the criteria are applied and provide some indications of the challenges in design of these systems and the practical implementation in the different cases.

1. *Holistic approach* - In case one the measures at corporate level mostly reflect company specific features, apart from measures of HSE and capital days that are common. In the second case, measures are primarily concentrated on the individual companies while measurements reflecting the inter-organisational performance between the companies seem to be less prioritised. Common for the two cases is the lack of a true holistic view of the supply chain, as one entity. Instead, focus is on each individual company.
2. *Process-based* - In both cases, the PMSs are primarily concentrated to internal company processes and include only a few integrated processes between the companies and in the interface between them. As there is no common supply chain processes defined in the systems, measurements reflecting performance in supply chain processes are lacking.
3. *Aligned with strategy* - In case one the measures are derived from each unit's vision, and strategic business goals. Their vision is however quite "wide" and can fit all measures. In case two, the companies have strategies that are aligned but still separate for each company. Hence, there is no strategy representing the supply chain and KPIs are primarily reflecting performance of the individual companies. In both cases the individual companies have strategies with linked KPIs, but on the supply chain level, both the strategy and link to KPIs is unclear or missing.
4. *A dynamic system* - In the automotive supply chain, measures are updated through yearly strategy discussion and development of each unit's business plan. This is also done in the pharmaceutical supply chain. Using the PMS as a dynamic system to change focus according to changes in the market and constraints is demanding and requires active involvement and a PMS which is easy to access and update. The frequencies of such updates will vary according to industry and company.
5. *Balanced approach* - The top three KPIs in case one are related to Cost, HSE and Quality. The overall distribution is balanced between financial and non-financial. Focus on cost and quality reflects important factors to achieve customer satisfaction in the automotive industry. KPIs in case two have a major financial and market focus, especially in the pharmacy retail chain. Balancing measurements seem difficult as some aspects are considered more important to the company than other, resulting in over focus on some dimensions.
6. *A managerial tool* - In case one, the PMS is used in weekly/monthly meeting to assess performance and define actions supporting the achievement of the agreed targets. In case two, financial measures are primarily used for monthly control. Some measures are also used for daily follow-up, i.e. to support and control logistics operations at the wholesaler. Moving from performance measurements to performance management require timely and accurate feedback and focus from top-management. An important requirement for achieving this is efficient tools, presenting information in a visual and simple manner, for communication and follow-up.
7. *Cover strategic, tactical and operational level* - Inherent from the hierarchic structure, the measures cover strategic, tactical and operational issues in case one. However with the manual data collection the data is not used for operational real time control, but more as follow up and reporting. In case two, the measures also cover all levels, but with a major focus on financials for follow-up and reporting. Measuring at different levels is important,

but is also challenging as the relationship between the measures can be hard to establish. Different tools for data gathering are required at the different levels.

8. *Provide a forward looking (leading) perspective* - In both cases the system only reports on past performance which makes it possible to analyse trends. However, the systems do not provide any measures that indicate future trends. Providing leading measures when gathering data from several sources is hard and demands integrated ICT systems or solutions.
9. *Tool for improvement* - In case one, the PMS is actively used for continuous improvement work. This is probably due to the strong focus on lean principles in the organisation and the automotive industry. In case two, the system is mostly used for follow up, and not actively used for improvement work. Using the PMS for active improvement requires a strong organisational focus and dedication to improvement work and allocation of time to meetings etc.
10. *Provide drill-down functionality* - The hierarchic structure in case one provides drill-down functionality on some measures. The drill down must be done manually by navigating through different excel files and is not user friendly. The situation is similar in case two, as data is manually extracted from various business information systems and entered in excel sheets. Drill down functionality can be enabled through an ICT implemented PMS, where the user can navigate and analyse measures at different levels.
11. *Handling conflicting objectives* - In case one the conflicting objectives are clear, for example between inventory and cost pr kg produced in the extrusion plant. This is not properly dealt with since responsibility and authority over inventory and production is split between the specific business unit and the logistics department. In case two, attempts are made to find a proper balance between objectives at the wholesaler and the pharmacy chain. However, conflicts regarding for instance pharmacy and wholesaler stocks and delivery frequencies need to be further dealt with. Dealing with conflicting objectives requires a common view of the customer requirements and the supply chain processes.
12. *Simple* - In both cases, the structure is simple and measures are organised according to the areas they want to measure, i.e. financial information and productivity, and it has developed over time. The structure is however designed from a single company perspective and is not intuitive from a supply chain perspective. The amount of KPIs pr unit is a high ranging from 10 - 30 KPIs. Tools contributing to creating a simple system can be different ICT systems with logical structure and possibilities for easy updating.
13. *Comparability* - Key measures in the two cases can be benchmarked to industry with similar processes. For example, in case two, measures are regularly benchmarked to other companies with similar operations within the same company group. This can however only be done on process level and not on a supply chain level since supply chain processes are not defined.
14. *Relevant metrics* - Measures in case one is relevant to each unit's processes, but are traditional and not reflecting the supply chain processes. This is similar to the situation in the second case. Defining relevant measures require a good understanding of the processes and a clear strategy which often is lacking in the supply chain.

**DISCUSSION**

Analysing the two cases against the presented criteria provide insight into the present challenges and obstacles in designing and implementing performance measurement systems in supply chains. Based on the previous analysis three important reflections can be observed in the following areas:

- Supply chain strategy (1,3 and 5)
- Supply chain processes (2, 11, 12, 13 and 14)
- Management system (4, 6, 7, 8, 9, and 10)

The figures in brackets refer to the criteria listed in the analysis.

*Lack of supply chain strategy*. The increasing focus on cost and efficiency has lead companies to seek closer cooperation and collaboration with suppliers, customers and even competitors. This collaboration can be formalised in a supply chain strategy that typically consists of a number of decision areas such as transportation, customer service, supply chain design and control, and ICT (Fauske et al., 2006). The strategy should clearly define the supply chains objective in these areas. Analyses of the two cases show however that the supply chain approach and strategies are lacking. Even if the two companies' emphasis the supply chain interfaces they still act and operate as if they where single companies, and not influenced by the supply chain processes. This has to do with tradition and practice, and that companies operate in a competitive environment where business to business competition still is the most common way to think (Arnulf and Dreyer, 2005). Another explanation is partly that goals and objectives of the supply chain actors are different which makes it hard to agree on a common supply chain strategy and supply chain measures aligned with this strategy. Mistrust between supply chain partners can explain why it can be difficult to share information, collaborate and commit to a common strategy. Commitment to strategy from the individual manager is also difficult as the manager experiences a lack of control over the supply chain performance processes and measures that he is evaluated on (Brewer and Speh, 2000). Overall the commitment to the supply chain is lacking and the purpose of supply chain measurements is not fully understood. These arguments underline the fact that focus is still on the individual company and not the supply chain as a whole.

*Lack of defined supply chain processes.* A supply chain performance measurement system can align processes across multiple firms, targeting the most profitable market segments and obtaining a competitive advantage through differentiated services and lower costs (Lambert and Pohlen, 2001). Without cross-process and cross-organisational metrics, each company will continue to maximise the achievement of its own objectives; potentially at the expense of the system's overall performance (Stallkamp, 2005). The measures in the two cases are primarily concentrated on the individual company processes while the inter-organisational processes seem to be less prioritised and have a clear functional design. Due to this functional orientation the performance measurement system is also developed to serve the individual companies needs. This has to be seen in light of the lack of supply chain strategy and company focus tradition. An important reason for this is the lack of defined supply chain processes (i.e. order fulfilment). A common understanding of processes and how they are linked to the customer are crucial in choosing relevant measures that are aligned with the supply chain strategy and developing a measurement system capturing the whole supply chain. An understanding of the supply chain processes will also make it easier to handle conflicting objectives among the actors. The lack of holistic and common supply chain processes defined in the systems results in few measurements that reflect performance in the supply chain as a whole. It also makes comparability and benchmarking with other supply chains difficult.

Even though several process models are developed, only few are implemented in supply chains. The primary reason for the limited success of these models on a large industrial base is that the models are generally very elaborate and require acute expertise to be used effectively (Delen and Benjamin, 2003). This is supported by Bolseth (2005) who claims that there is a lack of holistic, consistent and comprehensive process models that at the same time are simple, easy to use, time saving, intuitive, and easily recognisable for the user. Gardner and Cooper (2003) also point out that there is not yet a universal set of models (e.g. process models) to represent a supply chain.

*Lack of management system.* Finley and Srikanth (2005) points out that performance measurement and management is one of the imperatives for successful supply chain collaboration. This is supported by Stallkamp (2005) who stress that measurement and tracking systems are of importance to show sceptics that collaboration is actually working and producing results. The use of measurements for management and collaboration in the supply chain requires a management system to support the managers in collaborating. However in supply chain collaboration, no company any

longer posses control over all processes and are dependent on its partners in order to provide the customer with the desired value. Lack of control, limited access to information and poor visibility are often quoted as important problems with such collaborations (e.g. Christopher, 2005, Boyson et al. 2004, Handfield and Nichols Jr., 2002). These problems can be addressed through access to a common management tool that would enable information exchange and visibility. The challenge is to have a system that is flexible and dynamic and enables proactive management of the processes. In the two cases, measures are only used for follow-up and reporting past performance to management. The systems found in the two cases reflect this use as they are static and require manual data processing in excel sheets. Possibilities for analysis through visual representations and drill down functionalities are limited or non-existent. This cumbersome system limits the use of the PMS as a day to day managerial tool and it does not help the managers to define forward looking (leading) measurements and managing processes in real time.

The discussion underlines some of the challenge and complexity when designing PM and PMS for the supply chain. Overcoming these challenges is not easy as they affect both inter- and intra-organisational processes and organisations. We suggest the following actions as a first step in addressing these challenges.

- *Definition of supply chain strategies and processes*. Defining supply chain strategies and processes require a common understanding of the supply chains objectives. An important part in realising this is increased understanding and knowledge to performance measurement and management practices in a supply chain perspective. In addition further development of more suitable process models is also required. With this understanding and suitable models we believe supply chain partners can sit down and together define strategies and processes that support the entire supply chain.
- *Development of ICT tools for integrated performance measurement systems*. An important enabler for effective supply chain PMS is integration in an ICT system to support the PMS. Providing better ICT tools require further development of technical solutions beyond today's ERP and business intelligence systems solutions that are mainly designed for the single company. An ICT integrated PMS in the supply chain would be a driving force for implementation of PMS as they would enable the use of PMS as a dynamic managerial tool.

Addressing these areas will be an important step in enhancing the implementation of performance measurement systems in the supply chain.

## CONCLUSION

In this paper we discuss the complexity of PMS for supply chains. Based on findings from two industry case studies, we discuss a set of common criteria, identified in the literature review, for PMS in supply chains. The criteria serve as guidelines for developing PM and PMS in supply chains, but have proved difficult to implement in practice. The paper outline three factors that need to be further dealt with to enhance the implementation of PMS in supply chains. The factors; lack of supply chain strategy, lack of implemented supply chain process models and lack of management systems supporting the PMS clearly hinder the supply chain actors in developing and managing their PMS. Addressing these three factors will greatly aid the development and implementation of supply chain performance measurement systems. We suggest that definition of supply chain strategies and processes along with development of ICT tools for integrated performance measurement systems as a first step in addressing the factors that hinder PMS implementation in the supply chain. They will not in themselves ensure that the criteria will be addressed, but it will provide practitioners with tools and knowledge to better handle and control the complexity of supply chains.

Further research should both target a further development of the criteria for designing supply chain performance measurement systems and at the same time more thoroughly investigate the requirements necessary to implement such a system.

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