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Sustainability in performance measurement and management systems for supply chains

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Abstract

Aspects of sustainability – understood as the ability to manage economic, social and environmental performance at the same time – are becoming more important in Supply Chain Management. This is a challenge as sustainability adds less quantifiable aspects to Supply Chain Management than classic process aspects. On the other side measuring sustainability is crucial for the implementation of modern Supply Chains Management and to manage sustainably in the daily business. This contribution discusses the integration of sustainability in performance measurement and management systems (PMMS) for Supply Chain Management. Therefore in the paper firstly an overview of definitions and developments in performance measurement and management systems and a structure for PMMS are given. Secondly guidelines for good and modern PMMS are discussed. Thirdly existing approaches for Supply Chain Management PMMS (e. g. KPIs, TCO, value driver trees and balanced scorecards and maturity assessments) are presented and the suitability for Supply Chain Management as well as the possibility to integrate aspects of sustainability are examined. Lastly the fulfilment of the requirements and the ability to cope with the challenges of the approaches is discussed.

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Keywords: Supply Chain Management; Performance Measurement Systems; Performance Management Systems; Key Perfomance Indicators; Total Cost of Ownership; Balanced Scorecard; Maturity Assessment; Sustainablility.

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1. Performance Measurement and Management Systems (PMMS) – Developments and Definitions

The idea to measure the performance of companies or systems is not new. Also, sustainability becomes more important [20, 24]. Moreover PMMS must become more detailed and action oriented along with better use of IT-systems and the possibilities of big data but also along with higher competition and a higher degree of implementation of state-of-the-art management instruments.

In a general sense performance measurement can be defined as “the process of quantifying efficiency and effectiveness of action” [22] or “the systematic assignment of numbers to entities” [31].

Most of the definitions have in common, that performance measurement refers to the process or the associated activities of evaluating the performance of an entity. In the section on KPIs a more detailed view on different aspects of performance in supply chains with special regard to sustainability is presented, so that the term performance can be defined here in a broader sense – with regard to the definition of quality – as the ability of an organization to fulfil – internally set or externally defined – goals.

A common instrument when assigning numbers to entities are performance measures, that are defined as metrics used to quantify the efficiency and/or effectiveness of actions of part or of an entire process or a system in relation to a pattern or target [22]. When taking into account the fact that performance is not only a single metric but consists of a multitude of dimensions, it is useful to combine several metrics in a performance measurement system that are somehow linked to each other. A performance measurement system can thus be defined as “the set of metrics used to quantify both the efficiency and effectiveness of actions” [22].

But in a comprehensive and modern sense of performance measurement as management support, the sole measurement of performance is insufficient. Instead, the approach should be broadened to performance management [7, 16]. Bredrup uses the PDCA-Cycle to suggest a comprehensive performance management model [4]. In a similar way the holistic approach of Spangenberg consists of the five phases performance planning, design, managing performance and improvement, reviewing performance and rewarding performance. Spangenberg organizes them to three different levels: organizations, processes or functions and teams or individuals. On each level different and interconnecting elements are assigned [26].

2. Guidelines for Supply Chain PMMS

When creating, implementing, or reviewing a PMMS for Sustainable Supply Chains it is necessary to have some kind of checklist or criteria to evaluate whether the PMMS to create or to put in place is or will be suitable and effective. To formulate guidelines, besides an analysis of relevant literature [1, 2, 3, 6, 8, 9, 10, 12, 17, 21, 25] several trends with a high impact on Supply Chain Management and Logistics leading to special challenges for PMMS in Supply Chain Management have to be taken into account:

- Information exchange is an important success factor for Supply Chains to avoid waste. By digitalization information becomes more easily accessible
- In a globalized world value creation processes become more differentiated
- Innovation cycles have been shredded

Guidelines can be grouped into criteria for particular elements, criteria for the Performance Measurement System or Instrument and criteria for the Performance Management Process that aims to align the system with its environment (see figure 1). So, the guidelines are structured according to the above mentioned three elements: Single Performance Element, Performance Instruments/Tools and Performance Management Process.

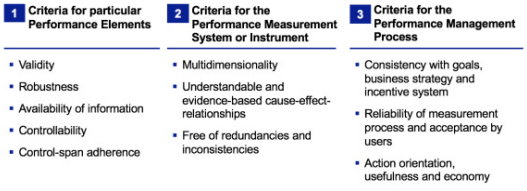

Fig. 1. Guidelines for Performance Measurement and Management Systems.

3. Approaches for Supply Chain PMMS and the Integration of Sustainability

There are different approaches to support Supply Chain Management to achieve a better performance. Some of the most commonly used ones are Key Performance Indicators (KPIs), Total Cost of Ownership and Life Cycle Assessments (TCO/LCA), Balanced Scorecards (BSC) and Maturity Assessments.

3.1. Key Performance Indicators

In addition to the above given definition of Performance Measures and Performance Elements companies often use the term Key Performance Indicators (KPIs). KPIs are a few strategically important metrics that often represent a balanced set of aspects such as productivity, utilization, or performance in general. Empirical surveys show that there are some commonly used KPIs for the measurement of the Supply Chain Performance. The following table shows the results of three surveys.

Table 1. Results of empirical surveys on Supply Chain KPIs.

Study	Metrics area/ In-formation aspect (avg. capture)	Capture over average	Capture under average
Keebler 1999	Involved Trading Partner (59%)	Customer complaints, On-time delivery, Over/ Short/Damaged, Returns&allowances, Order-cycle-time, Overall Customer Satisfaction	Days sales outstanding, Forecast accuracy, Invoice accuracy, Perfect order fulfilment, Inquiry response time
	Internal Focus (61%)	Inventory account accuracy, Order fill, Out of stocks, Line item fill, Back Orders, Inventory Obsolescence, Incoming material quality	Processing accuracy, Case fill, Cash-to-cash cycle time
	Cost (61%)	Outbound freight cost, Inbound freight cost, Inventory carrying cost	3rd party storage cost, Logistics cost per unit vs. budget, cost to serve
	Productivity (44%)	Finished goods inventory turns, Orders processed/labor unit, Product units processed per warehouse unit	Units processed per time unit, Product units processed per transportation unit
	Utilization (42%)	Space utilization vs. capacity, Equipment downtime	Equipment utilization vs. capacity, Labor utilization vs. capacity
Liebetruth 2005	Financial metrics (70%)	Actual cost vs. budget	Cash-to-cash cycle, company value
	Strategic level (40%)	Accuracy of planning systems, degree of uncertainty, cooperation need, power distribution	Compatibility of data-standards, Data-transparency, Compatibility of IT-systems, Trust, Quality of interfaces, Supply Chain Complexity (involved companies)
	Operative level (63%)	Inventory, Delivery reliability (on time, in full), Capacity utilization vs. capacity, Order lead time, Customer satisfaction, Network complexity	Geographical distribution, Efficiency potential, Lead time potential, Time-to-market, Reaction time to inquiries
Weber et al. 2012	Financial metrics (60%)	Freight cost, Total logistics cost, Inventory carrying cost, Cost of administration in logistics	Cost of mistakes, Customer profitability, Turnover per working hour
	Customer metrics (50%)	Customer complaints, Customer satisfaction	Returns, Reaction time to inquiries, accuracy of billings
	Process metrics (58%)	Delivery reliability (on time, in full), Turn rate, Inventory account accuracy, Labor utilization vs. capacity, Space utilization vs. capacity	Order lead time, downtimes, orders processed per time unit, units processed per time unit, Equipment utilization vs. capacity, Units processed per employee
	Financial metrics (70%)	Actual cost vs. budget	Cash-to-cash cycle, company value

The survey of Keebler was conducted in 1999 and sponsored by the Council of Logistics Management. 355 US-companies participated, that could select from a list of 70 metrics, which metrics they used. A strong focus on external and internal metrics as well as on cost was found and a low coverage of metrics to control operative logistics. A delimiting factor for low coverage was a missing IT support or missing information in IT systems [14].

The survey of Liebetruth was executed in 2004 on the basis of 19 expert interviews with responsible Supply Chain Managers of selected companies in Germany. The aim was to find out which elements formed the information basis for Performance Measurement in Supply Chains. It was found that even though the focus was on Supply Chain

Performance Measurement "classical" logistics Performance Elements such as inventory, delivery reliability, and accuracy of planning systems were the most used Performance Elements in the surveyed companies [18].

The survey of Weber et al. was conducted in the period between July and September 2011 and sponsored by the German Logistics Association. With a return rate of 37% respectively 44% 180 answers from logistics service providers and 251 industrial and trading companies were recovered. It was found that progressive companies achieved better results in forming a consistent system of KPIs integrating the operative and strategic level as well relating its own performance to that of their most important external partners. Also successful companies focus on few important KPIs report them timely to the responsible managers and adapt the KPIs when new challenges in the companies' context arise [29].

From the methodological point of view, it is easy to integrate "sustainable" KPIs in a KPI system as they can be simply integrated in the system as new KPIs. But from the point of view of the fulfillment of the above mentioned requirements there are some challenges arising, especially in the field of availability of data and robustness.

Measures of corporate sustainability performance are highly variable across published studies, and are mostly limited to the availability of quantitative data. They can be based on the amount of information disclosed (disclosure-based), or actual environmental, social, and governance performance. Other measures of business sustainability are for example input-output life cycle analysis, hybrid life cycle analysis, and "environmetrics" [15].

Sustainable metrics in a Supply Chain context are not yet covered in literature to a great extent. An overview of existing literature give Hassini et al. [11]. In a comprehensive framework they propose to use metrics that are firstly collected by every Supply Chain Partner in the three dimensions economy, environmental and society and that are chosen based on an alignment with each partners own strategic goals. Possible metrics include: Percent of suppliers with an up-to-date sustainable development policy, Percent of contracts with provincial suppliers, Percent of purchase orders placed with aboriginal companies, or Level of stakeholder trust by category.

3.2. Total Cost of Ownership and Life Cycle Assessments

Total cost of ownership or Total landed cost or total lifecycle cost [15] is a method to analyze how other qualitative and quantitative factors than just the purchasing price of a product can affect the cost of a product over its acquisition process or even its lifetime [30]. The total cost of ownership is "the process of identifying cost considerations beyond unit price, transport, and tooling." It can lead to better decision making in Supply Chain Management as it considers all relevant cost components in the Supply Chain ranging from packing requirements to supplier nonperformance. Total cost can be grouped into the categories purchasing price, acquisition cost, usage cost and end-of-life-cost.

Total cost of ownership is a good instrument for Supply Chain Management as it covers cost of the whole process and the whole lifespan of a product or service. It is also excellently suitable to integrate aspects of sustainability as it is looking at the whole lifespan of a product, which includes also its end-of-life-cost. Also possible ethical aspects such as child labour can be integrated in the analysis at they might entail risks of lost sales due to reputation problems. Approaches that aim to assess environmental impacts along a supply chain and minimizing them are called 'lifecycle based approaches'. Nevertheless it can be problematic to integrate non-financial effects in the model. Solutions include Multi-Criteria Decision Making or Analytical Hierarchy Process [23].

3.3. Balanced Scorecards

The balanced scorecard as a top down instrument for defining an organization's goals and objectives was introduced by Kaplan and Norton [13] with the key notion that firms must go beyond financial measures as they are lagging indicators and utilize leading indicators of performance to enable strategic feedback and learning. Therefore they included four key performance measurement areas that are linked to each other: financial, customer, internal operations and innovation and learning perspective. Another aspect and focus of the balanced scorecard is the strategy map where cause-and-effect-relations between the different objectives are shown to illustrate how the ultimate financial goals can be met. From the strategy map a balanced scorecard and an implementation plan can be derived.

The balanced scorecard can also be used to measure the performance of supply chains. Some authors argue that the integration of supply chain oriented measures requires an adaption of the perspectives. This is due to the fact that supply chains do not only concern one company but a chain or a network of companies:

- Brewer/Speh state that the process perspective has to be complemented by interfunctional and partnership aspects and in the innovation and learning perspective aspects of Improving the Supply Chain should be included [5]
- Weber/Bacher/Groll propose that two new perspectives should be integrated in a Supply Chain Balanced Scorecard: the quality of cooperation and the intensity of cooperation [28].

Similar adaptations can be made to integrate aspects of sustainability that are not covered yet, such as the environmental perspective and the social perspective as Verdecho et al. propose [27].

3.4. Maturity Assessments

A comprehensive methodology for measuring and managing the performance in a specific field are maturity assessments. They offer a framework to firstly assess the effectiveness and efficiency of those organizational units with a special focus on the alignment with the overall strategy and to secondly to contribute to the active management by developing measures to improve the alignment and the effectiveness and efficiency.

Measuring processes on the basis of maturity levels has its origins in quality management but assessing the maturity level of a process is a next development step. Maturity models assess the performance by means of benchmarking: based on a comparison with the best known way to perform a process, a classification of the maturity on a defined maturity-scale is set. So, maturity models are made to describe, assess and compare the quality of different examined objects. Therefore an integrative maturity assessment model has to cover the aspects structure (framework within which the content has to be filled in), content (criteria that separate a good and a poor execution of the focal function) and method of the assessment process (process how a maturity assessment is conducted) [19].

Maturity assessments are a very powerful and flexible tool for Supply Chain PMMS. Besides a structured methodology to measure and evaluate the performance it focuses very much on the process and is therefore useful to manage the performance actively. As it is very flexible it is able to integrate easily aspects of Supply Chain Management and Sustainability.

4. Summary and Outlook

The presented approaches can be evaluated with regard to firstly whether the mentioned guidelines and secondly whether they are able to cover sustainability in an appropriate way. In summary, maturity assessments seem to be a good choice for PMMS in Supply Chain Management to integrate aspects of sustainability. But there is a substantial risk of ‘over engineering’ the instrument. Therefore especially for smaller organizations “leaner” instruments such as single KPIs that focus on a specific aspect might be more useful.

Table 2. Evaluation of PMMS approaches with regard to the fulfilment of guidelines.

	KPIs	TCO	Balanced Scorecard	Maturity Assessments
Multidimensionality	Yes, KPIs can be very diverse	No, only focus on cost and cost-evaluated effects	Yes, idea of instrument	Yes, instrument is flexible enough to cover many dimensions
Understandable and evidence-based cause-effect-relationships	Not necessarily	Only with focus on cost and cost-evaluated effects	Yes, possibly based on empirical evidence	Yes, possibly based on empirical evidence
Free of redundancies and inconsistencies	High risk	Limited risk as only cost are calculated	Preparation of strategy map limits the risk	Possible, but it has to be addressed in the process of designing
Consistency with goals, business strategy and incentive system; esp. capture of SCM and Sustainability aspects	Special KPIs on SCM and Sustainability can be defined, Consistency has to be assured for each KPI „outside“ the system	Instrument can be used to support SCM and Sustainability but is not comprehensive; TCO can be one aspect to align actions with goals, strategy and incentives	Alignment with incentive system can be established and aspects of SCM and Sustainability actively integrated	Instrument is very flexible but time-consuming, it can be linked to the incentive system
Reliability of measurement process and acceptance by users	Originally no reference on the measurement process; has to be established for each KPI separately	Originally no reference on the measurement process and thus on the acceptance	The process of designing the Balanced Scorecard ensures a high acceptance of stakeholders and users	The process of designing the structure, content and process ensures high acceptance of users; measurement process should be well defined

Action orientation, usefulness and economy	Depends on the fulfillment of the above stated guidelines	Should be able to support decisions on sourcing and logistics	Due to consistency a good chance to induce action; risk of dilution	Good chance of a high usefulness as processual aspects are integrated; risk of "over engineering"

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