Conceptual Framework for Measuring Supply Chain Performance: An Innovative Approach

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Paper prepared for presentation at the 1st International European Forum on Innovation and System Dynamics in Food Networks
Officially endorsed by the European Association of Agricultural Economists (EAAE), Innsbruck-Igls, Austria
February 15-17, 2007

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Abstract

The process of developing appropriate supply chain performance measurement instruments is difficult due to the complexity of supply chains. This paper presents an overview and evaluation of the performance measurement instruments used in supply chain models. As a result it advances a framework for developing an innovative supply chain performance measurement instrument which is generally applicable and which incorporates single organisational measures with inter-organisational and supply chain measures. The instrument distinguishes between qualitative and quantitative performance measures. Finally, it proposes supply chain satisfaction balance/imbalance, as a qualitative supply chain performance measure.

1. Introduction to the research problem

Organisations seeking to achieve high performance have discovered the performance potential of supply chains (Pearson and Samali 2005). They have realized that nowadays' individual organizations no longer compete as solely autonomous entities (Christopher 1998), but as supply chains. Being a member of a well-performing supply chain generates significant performance benefits. Additionally, the way a supply chain is constructed and performing is a potential source of competitive advantage for the participating organisations (Sadeh, Smith et al. 2006). Consequently, participating in high performing supply chains leads to substantial long term benefits for organisations.

As a result, there has been increasing attention placed on the performance of supply chains as a whole (Beamon 1998). Never has so much technology and brainpower been applied to improve supply chain performance as before. Point-of-sale scanners allow companies to capture the customer's voice. Electronic data interchange lets all stages of the supply chain hear that voice and react to it by using flexible manufacturing, automated warehousing, and rapid logistics. And new concepts such as quick response, efficient consumer response, accurate response, mass customization, lean manufacturing, and agile manufacturing offer models for applying the new technology to improve performance. Nonetheless, the performance of many supply chains has never been worse. In some cases, costs have risen to unprecedented levels because of adversarial relations between supply chain partners as well as dysfunctional industry practices such as an over reliance on price promotions (Fisher Marshall 1997).

These examples confirm that today's organisations and managers are at the first place interested in how their supply chain is performing (Geyskens, Steenkamp et al. 1999). Consequently, they use different types of performance measurement instruments to assess their supply chains. The right supply chain performance measurement instrument can tell how the chain is performing, highlight where there is a room for improvement, and help to diagnose problems and decide where to focus improvement efforts (Cohen and Roussel 2005). Contrary to the great need of good performance measurement instruments, early performance measurement instruments of-

ten show significant weaknesses in terms of inclusiveness (measurement of pertinent aspects), universality (allow for comparison under various operating condition) and measurability (data required are measurable) (Beamon 1996).

In the frame of this research paper we aim to present a focused overview and evaluation of supply chain performance measurement instruments and resolve the weaknesses of existing instruments by advancing a framework for developing an innovative supply chain performance measurement instrument. Through this study, we aim to contribute to the supply chain management literature in the following ways: First, we enrich the contemporary state of knowledge about supply chain performance measurement by giving a structured overview about several individual study findings and evaluating the previously used measurement instruments. Second, we provide a framework for developing an innovative instrument that investigates supply chain performance in the way how it has not been empirically investigated simultaneously within an individual study.
The paper is organized as follows: It begins with giving a structured overview about the state of the art in supply chain performance measurement literature. In this section we present and evaluate these instruments in the light of their potential contribution to our innovative performance measurement instrument. Then the article proposes a framework for developing an innovative performance measurement instrument for supply chains. Finally, it concludes with discussion and suggestions for further research.

2. Current state of the art

The previous section presents that the measurement of supply chain performance is a necessity for each chain and participating organisation. There are an increasing number of contributions in the literature to the understanding of supply chain performance. This session gives a broad and structured overview of these contributions making difference between the data collection level, the specificity and the qualitative or quantitative nature.

2.1 Data collection level

The existing supply chain performance measurement instruments are mostly derived following the individual organisation approach, some focus on the dyadic pair of organisations and only a few on the whole supply chain.

2.1.1 Single organisations

Data collected at the level of a single organisation can differ in terms of its focus. Four main categories of measures can be distinguished, such as **functional focused, process focused, enterprise focused and cross-enterprise focused measures** (Cousins and Hampson 2000; Cohen and Roussel 2005). **Functional focused performance measures** at the level of a single organisation are useful in case of problems caused by a specific function/department, such as purchasing, manufacturing, sales, marketing, finance etc. (Ghosn 2002). Some measures for purchasing performance can be errors per purchase order, average time to fill emergency orders or total purchase dollars by the purchasing department (Easton, Murphy et al. 2002). Manufacturing performance measures can relate to total productivity, total quality and total flexibility of manufacturing operations (de Ron 1995). Actual sales compared to forecast, sales growth, sales intensity or sales profitability are possible measures for sale performance (Cooper and Kleinschmidt 1985). Spekman et al. (1998) conducted a study focusing on different functional departments (operations, procurement, materials management or marketing) in the same time.

Process focused performance measures are useful if the performance of specific processes within or beyond a functional area needs to be investigated, such as the product development process. Measures of product development can relate to design and process time (Cohen and Eliashberg 1996). **Enterprise focused performance measures** should be used if organisational processes are integrated and aligned across all sub processes and functions. Enterprise focused measures frequently relate to productivity, profitability, export activity, or innovation (Jefferson, Hu et al. 2003). **Cross-enterprise focused measures** integrate both internal and external processes and focus on dyadic relationships between the organisation and its customers, suppliers, other supply chain partners or competitors (Cohen and Roussel 2005). One frequently used way for cross-enterprise analysis is the stakeholder analysis (Mitroff 1982; Cousins and Hampson 2000). Another popular instrument is the balance scorecard, in which the customer dimension is represented by measures such as on-time delivery to commitment, order-fulfillment cycle time, fill rates, and perfect order fulfillment. Most frequently these cross-enterprise measures collect data only from the perspective of the organisations (Anderson and Narus 1990; Kumar and Stern 1992; Morgan and Hunt 1994; Mohr, Fisher et al. 1996; Doney and Cannon 1997), and only rarely from both organisations. When it collects data from both sides of the dyad, we refer to it as an inter-organisational measure.

2.1.2 Inter-organisational analysis

Although cross-enterprise focused measures can collect data about the stakeholders of an organisation, the data collection is one-sided. The difference between the cross-enterprise focused measures at the level of a single organisation and the inter-organisational measures is the direction of the data collection. In contrast to single organisation measures the direction of data collection of inter-organisational measures is two-sided. Compared to the amount of cross-enterprise studies, fewer studies studied both organisations in the dyad (Ganesan 1994; Lindgreen 2001; Clare, Shadbolt et al. 2002; Claro, Hagelaar et al. 2004; McDermott, Lovatt et al. 2004). A very popular instrument for inter-organisational analysis is the Supply-Chain Council's SCOR model, in which each measure is considered from the perspective of the organisation as well as from the perspective of the customers and suppliers. This means that the reported performance by the organisation and by the customers/suppliers is compared and the discrepancy between them is analysed. This makes the SCOR model to be a valuable tool for inter-organisational analysis, though many organisations do not use the instrument for inter-organisational analysis, but for cross-enterprise analysis.

2.1.3 Supply chains

Although there are several publications in the last four years, which looked at the performance of the chain and focus on three or more organisations (Spekman, Jr et al. 1998; Trienekens 1999; Van der Vorst 2000; Clare, Shadbolt et al. 2002), these studies used single organisational or inter-organisational measures and aggregated them as supply chain performance. In supply chain analysis, there are only a few measures, which are focusing on the whole supply chain. One of these measures is e.g. the activity cycle time, which refers to how much time it needs to take a supply chain activity such as order fulfilment or product design. Another measure is the upside flexibility, which refers to the ability of a supply chain to respond quickly to additional order volume for the products they carry (Hugos 2003). These examples are rather logistical focused, and one could hardly find supply chain performance measures from other areas.

2.1.4 Evaluation

Existing supply chain performance measurement instruments are often focusing on individual organisation measures, some on inter-organisational ones and only a few on supply chain measures. Performance measurement instruments which incorporate selected single organisational measures can hardly provide a clear picture of the overall performance of the chain. At the level of the supply chains, there exist no such instruments yet, which do it either. The reason is simple: Establishing a robust -and useful- performance measurement instrument for the supply chain is difficult (Cohen and Roussel 2005). Despite the vast empirical research attention devoted to supply chain performance measurement, this issue remained unresolved. Consequently it is a real research challenge to develop an instrument, which collects data from all the three levels of data collection. The innovative performance measurement instrument pays careful attention to the balance between these three levels.

2.2 Specificity

Performance measures included in an instrument can vary depending on several factors (Cousins and Hampson 2000), such as the structure of the supply chain, the environment of the chain, the sector, or the type of products. Stanely (1993) developed a model which describes how the structure of the supply chain depends to a great extent on the variability of the environment in which the supply chain operates. Consequently the nature of the environment can contributes to the nature of the performance measures employed. As a result, Counsins and Hampson (2000) state that in designing new performance measurement instruments, this need to be understood and the performance measures need to be designed according to the environment and the structure of the supply chain in order to ensure that they are directly relevant and useful to the needs of the supply chain (Stanely 1993; van Weele 1994; Ghorpade and Chen 1995). There are several studies, which followed these guidelines, and as a result existing supply chain performance measurement instruments are often too specified and focus on a particular case, a particular supply chain or a specific sector. Cousings and Hampson (2000) use balance scorecard for supply chain performance measurement and tailor it for focusing on purchasing measures and purchasing performance. Leong *et al.* (1990) and Maskell (1991) investigates the performance of manufacturing tasks. In the supply chain positioning matrix of Kraljic (1983) special attention is paid to supply chains of specific products and services. Van der Vorst (2000) and Trienkens (1999) focused on the food, while Womack et al. (1990) on the motor vehicle manufacturing industries. As a result of the huge difference between these sectors and cases, the performance measurement instruments applied in these studies are highly tailored to the characteristics of a given sector or case.

2.2.1 Evaluation

Performance measurement instruments can be useful for comparison with other supply chains, and help to identify supply chain improvement opportunities. Internal comparison inside the supply chain helps to identify which organisation/link are the best performers (Cohen and Roussel 2005). This is only possible, if the measures in the instrument are general applicable among supply chains and along the chain between the participating organisation.

Existing performance instruments often show significant weaknesses in terms of universality because of their specificity (Beamon 1996). As a result, they do not allow comparison under various conditions or between sectors. Therefore it is a great challenge to find the balance between developing a more general applicable and systematic approach to performance measurement

(Beamon 1999) and in the same time not to hamper its accurateness. Despite the importance of and the vast empirical research attention devoted to supply chain performance measurement, this issue also remained unresolved and this is the task of the research to develop an instrument, which fit these requirements.

2.3 Qualitative or quantitative nature

Supply chain performance measurement instruments should capture both economic and non-economic aspects. The proportion of economic and non-economic measures, however, varies considerably across existing instruments. In this paper two types of performance measures are distinguished, it is performance measures focusing primarily on economic aspects (labelled as quantitative performance measures) and performance measures focusing primarily on more non-economic aspects (labelled as qualitative performance measures).

2.3.1 Quantitative measures

Quantitative performance measures are those measures that may be directly described numerically. Most measures of performance belong to this group and focus on quantitative/financial aspects as quantitative measures are easy to obtain from books of an organisation (Cohen and Roussel 2005). Quantitative performance measures may include cost measures such as inventory costs and operating costs (Neely, Gregory et al. 1995) and customer responsiveness measures such as lead time, stock out probability, and fill rate (Ishii, Takahashi et al. 1988; Newhart, Stott et al. 1993).

2.3.2 Qualitative measures

Beamon (1998) defines qualitative performance measures as those measures for which there is no single direct numerical measurement, although some aspects of them may be quantified. Some managers may feel uncomfortable about assessing the performance in ways which are not entirely quantitative, and in which there is perhaps greater potential for error in measuring. Often quantitative measures continue to be used, simply because managers do not feel they have an acceptable alternative or complement with which to measure the qualitative side of performance, although they recognize the limitations of the measures in which they are involved (Cousins and Hampson 2000). As a result, though qualitative performance measures have been identified as appropriate for including them into supply chain performance measurement instrument, they have not been used frequently in supply chain research. Although these measures may be important characteristics of a supply chain, their use in supply chain models is challenging, since the qualitative nature of such measures makes them difficult to incorporate into quantitative models. Examples of such measures are: Flexibility (Voudouris 1996), customer satisfaction (Christopher 1994) or information flow (Nicoll 1994).

2.3.3 Evaluation

Focusing entirely on quantitative performance measures may be counterproductive (Cousins and Hampson 2000). Yet, while quantitative measures can help to gauge the impact of process changes on an organisation's economic health, they are inadequate when organisations are seen as the part of a supply chain. It is because most financial measures do not provide insight into indicators such as order-delivery performance and customer service levels, and they do not consider the organisation as being part of the supply chain (Cachon and Lariviere 1999).

It is highly important to select performance measures in the broader context and to develop qualitative measures to complement the quantitative ones (Beamon 1999). An innovative performance measurement instrument must find the balance between the qualitative and quantitative measures.

3. Development of an innovative performance measurement instruments

One of the most difficult areas of performance measurement is the development of performance measurement instruments. This section gives a framework in developing an innovative performance measurement instrument along the previously introduced categories. Developing the instrument one has to keep in mind that a good supply chain performance measurement instrument needs to include a balance of: **organizational measures, dyadic measures and supply chain measures**. It should be **general applicable** and incorporate **qualitative and quantitative** performance measures as well (Figure 1). A good performance measurement instrument cannot be too complicated, so the amount of measures must be limited and only a few key variables can be used in each category in order to maximize simplicity (Cousins and Hampson 2000).

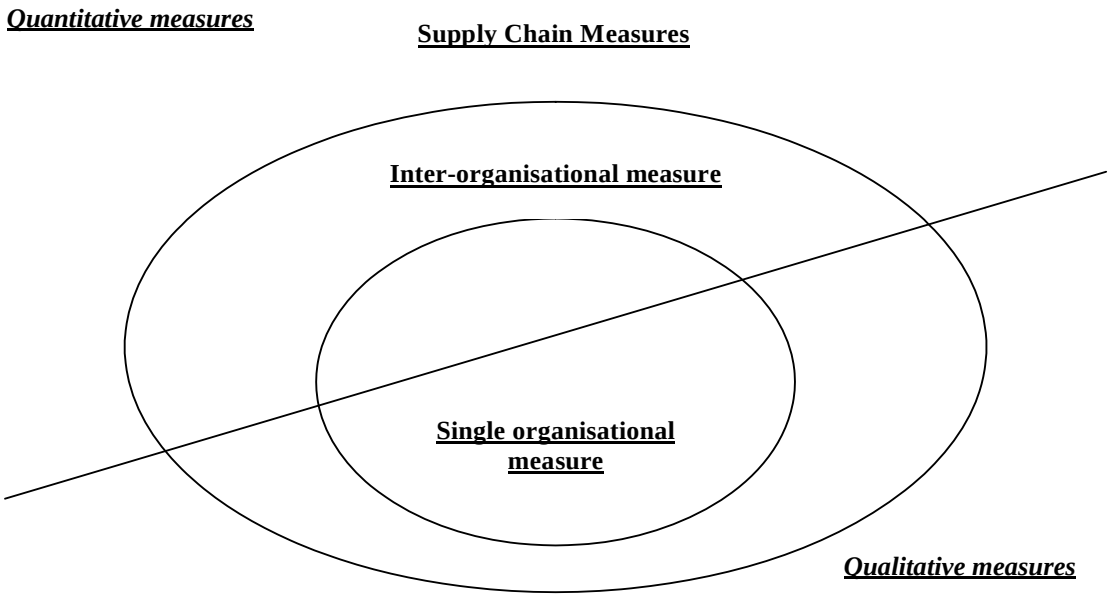

Figure 1. Supply Chain Performance Measurement Instrument

The question arise which measures should be used for analysis of individual organizations, for inter-organizational analysis and for the entire supply chain. Regarding the measures at the level of an organisation in a general applicable instrument it is difficult to use **process** or **function** focused measures, as they can be highly different in different context. **Cross-enterprise** focused measures should also be avoided, in case the instrument will further include inter-organisational measures. In this case the inter-organisational measures characterise better e.g. a possible organisation-customer relationship, as they collect data from both side. Consequently it is highly suggested that at the level of an organisation, **enterprise focused measures** should be applied, such as productivity, profitability, or innovation. The measures for inter-organisational analysis and supply chain analysis will be discussed later, under session 3.1.

In order to avoid too much specificity and to develop a general applicable instrument, one has to eliminate function, sector, case or process specific measures.

Besides, the instrument should apply qualitative and quantitative measures in a balanced way. Cousins and Hampson (2000) suggest including qualitative measures of such activities as buyer behaviour, supplier development, interdepartmental relationships, and negotiation skills in every performance measurement instrument. These qualitative measures of inter-organisational or supply chain relationships have not yet been included into previous performance measurement instruments. The next session proposes and explains a qualitative performance measure for supply chain analysis.

3.1. chain satisfaction balance, as a qualitative supply chain performance measure

For the purpose of measuring supply chain performance, we introduce the construct: supply chain satisfaction balance and imbalance. Satisfaction is an important measure of an inter-organisational relationship (Robicheaux and El-Ansary 1975; Anderson and Narus 1984), which can be further developed in order to be appropriate for supply chain analysis as well. Based on Anderson and Narus (1984), we define satisfaction as "supply chain member's affective state resulting from his overall appraisal of his relationship with his supply chain partner". Our definition of satisfaction measures the supply chain partner's perceptions related to its relationship with another partner (Figure 2).

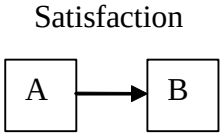

Figure 2. Satisfaction of supply chain partner "A" with "B" (AB)

Based on the above given definition we define the aggregated satisfaction of the two partners in the supply chain as relationship satisfaction (Figure 3).

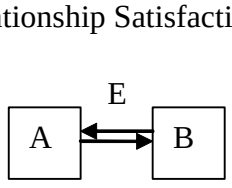

Figure 3. Relationship satisfaction among supply chain partner "A" and "B" (AB+BA=E)

If we define supply chain relationships as all relationships among all the organisations involved in all the upstream and downstream relationships in the supply chain, then supply chain satisfaction refers to the aggregated upstream and downstream relationship satisfactions (Figure 4).

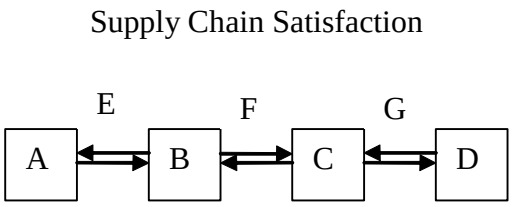

Figure 4. Supply Chain Satisfaction (AB+BA+BC+CB+CD+DC) (E+F+G)

In the frame of the paper we further improve the measure of supply chain satisfaction and introduce the concept of supply chain satisfaction balance and imbalance. Based on the definition of satisfaction we talk about satisfaction imbalance at the level of the supply chain when relationship satisfaction (dyadic) significantly differs along the chain. Consequently, we talk about supply chain satisfaction balance, when relationship satisfaction (dyadic) significantly not differs along the chain.
Identifying the supply chain satisfaction imbalance/balance is very important. After evaluating which links cause imbalance in supply chain satisfaction, problem areas can be more easily highlighted. Next, solving the problem should lead to improvements in the overall performance (Whipple and Frankel, 2000). Consequently we found supply chain satisfaction balance/imbalance as a good measure of supply chain performance.

4. Discussion and future research

The present research paper shows evidence of the necessity of supply chain performance measurement for each chain and participating organisation. Given the importance of supply chain performance measurement and the current status of research, we structured and evaluated the available research contributions and build an overview on supply chain performance measurement from the impressive body of literature available. We concluded from this overview that existing supply chain performance measurement instruments use mostly single organisational measures and little of them even attempts to establish supply chain focused measures. In the frame of this research paper we proposed guidelines for choosing appropriate performance measures from each category. Finally, we developed and introduced a new construct, namely supply chain satisfaction balance and imbalance for measuring supply chain performance.

The limitations of our study are recognized. The performance measures presented in each category are only a proportion of the potentially relevant variables that might have been included. Moreover they sometimes are not the focal interest of researchers as well as practitioners. These measures only serve as examples and special attention is rather paid for structuring the vast major of measures.

Overall, the proportion of qualitative and quantitative performance measures included in an instrument can lead to varying results. The appropriate combination of these measures has to bee addressed in future research, with special attention to the role of supply chain satisfaction balance and imbalance, as a qualitative supply chain performance measure.

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