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Integrated performance measurement system in a Dutch tomato supply chain

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Abstract

Measurement of entire supply chain performance is an important issue, because it allows for 'tracking and tracing' of efficacy and efficiency failures and leads to more informed decision-making with regards to chain organization. The choice of appropriate supply chain performance indicators is rather complicated due to presence of multiple inputs and multiple outputs in the system. This issue becomes even more problematic in the field of food and agribusiness due to specific characteristics of agri-food supply chains. This paper presents a conceptual framework for selecting a performance measurement system for agri-food supply chains. Four main categories of performance measures are identified as necessary components in agri-food supply chain performance measurement system. Each category contains set of performance indicators. Case study research has been designed in the Dutch tomato supply chain to test the proposed conceptual framework.

Key words: agri –food chain, indicator, performance, case study

Introduction

In order to be able to assess the success of supply chains an adequate performance measurement system needs to be developed. The basic purpose of any measurement system is to provide feedback, relative to the set of goals that increases organizations' chances of achieving these goals efficiently and effectively. Recent studies have shown that performance indicators to measure supply chain performance that includes the characteristics of inclusiveness, universality, measurability and consistency are not available (Beamon, 1998). Evaluation of an organisation's performance is complicated in the presence of multiple inputs and multiple outputs in the system. These aspects require a shift in the focus of performance evaluation and benchmarking from characterizing performance in terms of single measures to evaluating performance as a multidimensional systems perspective (Zhu, 2003). Lee and Billington (1992) found that supply chains do not have an adequate performance metrics and firms only aim at achieving their own performance standards. There is less agreement, however, on the matter of what such a system should look like. According to Bunte et al. (1998) performance indicators should relate to both effectiveness and efficiency of the supply

chain and its actors. Van der Vorst (2000) makes a distinction for performance indicators on three main levels: supply chain level, organization level and process level. Beamon (1999) suggests a system of three dimensions: resources, output and flexibility.

Measuring the performance of chains and networks received little attention in the field of food and agribusiness. Agri-food supply chains have many specifications, which set them apart from other types of supply chains. Examples are: 1) Shelf life constraints for raw materials and perishability of product, 2) Long production throughput time 3) Seasonality in production 4) Physical product features like sensory properties such as taste, odour, appearance colour, size and image 5) Requires conditioned transportation and storage; 6) Product safety issues and many more.

Recent socio-economic developments have resulted in a change in performance requirements for food supply chains as a whole and for all stages in the supply chain (Van der Vorst, 2000). This change is the result of the variation in buying behaviour of consumers. Besides the consumers' preference variation, environment plays a vital role in agri-food supply chain performance assessment. The environmental variability affects the quantity and the quality of the farm products. The perishability of products put strains on logistics and quality management. Given these facts it is obvious that food quality and environmental issues have a great impact on agri-food supply chain performance. Thus, when developing a performance measurement system for agri-food supply chains, the indicators that reflect the quality aspects of product and processes are important (freshness, food safety, environmental issues, etc.) and together with other indicators, should be included into a performance measurement system.

Recently Aramyan et al. (2005) developed a conceptual framework of performance measurement system for agri-food supply chains, which captures the characteristics of agri-food supply chain as well as other financial and non-financial indicators. In this study we hypothesize that that four main categories of performance measures suggested in the conceptual framework are the necessary components in agri-food supply chain performance measurement system, however different indicators within these categories can vary between different links of the chain given different objectives of different links in the chain. The goal of this study is to test the conceptual framework of Aramyan et al.(2005) using data from Dutch tomato supply chain.

The paper is organized as follows. In the next section the details of the conceptual framework are briefly discussed followed by the methods used to carry out the research and case study description. Next, the results of the case study are analysed for each member of the supply chain separately. The paper ends with conclusions and discusses areas for future research.

A Conceptual framework

This section develops a conceptual framework for measuring performance of agri-food supply chains. Based on the literature review on existing performance indicators a conceptual framework for measuring performance of agri-food supply chains has been developed (Aramyan et al., 2005). The framework takes into consideration specific characteristics of agri-food supply chains. The agri-food supply chain performance indicators are grouped in four main categories: efficiency, flexibility, responsiveness and food quality. These main categories contain more detailed performance indicators (Figure 1). Efficiency aims to maximise value added by the process and minimise the cost absorbed in inventories. It includes several measures, but the most important ones are cost minimisation, profit maximisation and return on investment maximisation. Flexibility indicates the degree to which the supply chain can respond to a changing environment. It may include customer satisfaction, reduction in the number of backorders, lost sales, late order. Responsiveness aims at a high level of customer service and may include fill rate maximisation, product lateness minimisation, customer response time minimization, lead time minimization, shipping errors and customer complaints.

The specific characteristics of agri-food supply chains are captured in the measurement framework in category "food quality". The latter is based on the framework of food quality developed by Luning et al. (2002). Food quality is divided into product and process quality. Product quality in its turn is divided into 1) Food safety and health, 2) Sensory properties and shelf life 3) Product reliability and convenience. Process Quality is divided into 1) production system characteristics, 2) environmental aspects and 3) marketing.

Adding the category "food quality" to the three other categories completes the conceptual framework (Figure 1).

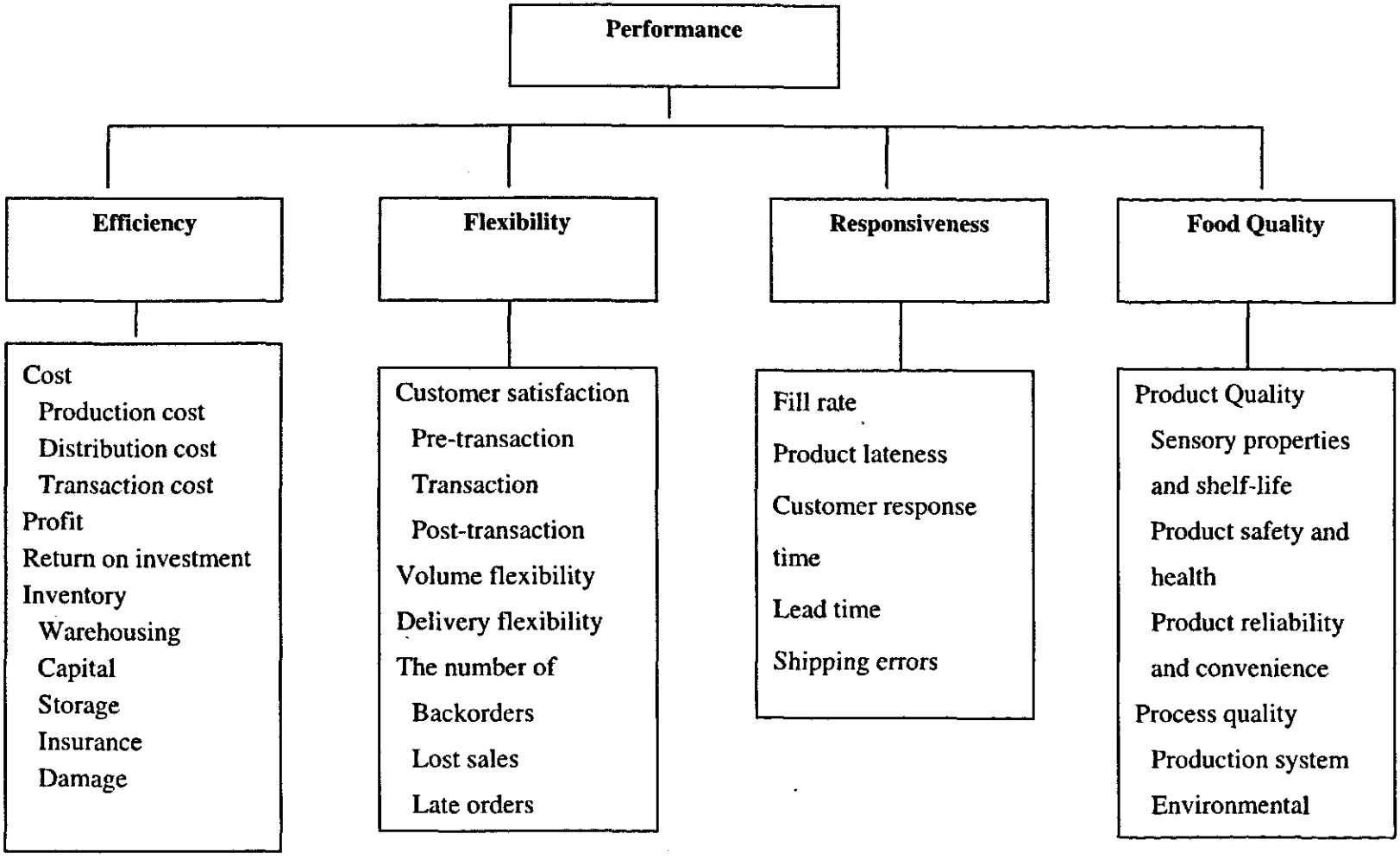

Figure1. Conceptual framework of agri-food supply chain performance indicator

Method

The case study is applied to the Dutch tomato supply chain. The source of information are interviews with 1) a chain manager in a breeding company 2) owner-growers in seven tomato producing firms, 3) wholesaler in wholesale company. The type of interview is a focused interview (Yin, 1994), in which the interview consists of open-ended questions and a set of questions in the form of questionnaire. The first part of questionnaire includes general open-ended questions to become familiar with the firm. In the second part of the questionnaire respondents were given definitions of possible performance indicators that can be integrated into a performance measurement system. Respondents were given the opportunities to suggest new indicators and/or to reject the proposed ones and to provide suggestions for better (practically possible) ways to measure the suggested indicators. Next, the respondents were asked to rank the listed indicators of performance according to the perceived importance for their firm. The used ranking method is interval ranking (Churchill, 1999). A Likert scale of 1 to 5 was used with 1 being not important at all for measuring performance and 5 being very important.

Case Study Description

The choice of this specific tomato supply chain was conditioned upon the fact that it is one complete chain starting from breeder till the end consumer.

The supply chain in this case is the integral chain management for tomatoes on the vine and consists of one breeder, 12 growers in the Netherlands, one wholesaler in Germany, 13 distribution centres and multiple retailers in Germany.

Breeder

In this chain there is one breeder, situated in De Lier, the Netherlands. The company is specialised in breeding, production and selling of many different vegetable seeds. The company activities are based on a number of quality control systems such as ISO 9001 norms, NAL system (specific tests for seed characteristics, e.g. germination, purity of seeds). In cooperation with ECAS (European institute for certification for the agricultural sector), the company developed the integral chain management system to guarantee product quality.

Growers

In this chain there are 12 tomato growers who grow tomatoes situated in the South of the Netherlands. Together they add up to an area of 24.35 hectares of tomatoes. In total 7 growers agreed to participate in interview. All interviewed growers cultivate 100% tomato except for one grower who cultivates 50% tomato. Quality standards used by the growers are integral chain management, Integrierte Anbau (German control system of integrated cultivation) and Eurep GAP.

Wholesaler

The wholesaler involved in this supply chain is located in Weeze, Germany. The company is working on certification according to the International Food Standard (IFS). The use of this certificate is conditioned upon the fact that the company wants to gain trust from the consumer, which will eventually lead to a higher price (Disco, 2004). The company delivers half of the production to supermarkets in Germany. The share of tomatoes in total sales is 25%.

Distribution centres

The next link in this tomato supply chain are the distribution centers in Germany. With a net of return 32.16 billion Euros in 2003, the company is one of the biggest European food trading companies. The share of fruits and vegetables in total sales is 12% from which tomatoes are 6-7%. The Quality standards used by the firm are Integrierte Anbau and HACCP.

Retail

The last link in the chain before the end-consumer are the retailers, which are part of the same group as the distribution centres. It is a group of 15 cooperatives composed of many largely independent retailers supplied by its own regional food wholesalers. The company offers organic fruits, vegetables, dairy products, and cereals.

Results of Case Study

Table 1 presents perceived importance scores of indicators for all members of tomato supply chain. In the category efficiency chain members jointly appear to be indifferent about two indicators such as transaction costs and inventory (except for breeder). The possible explanation can be that this particular chain is structured as such that transaction

Table 1. Perceived importance scores of indicators for all members of tomato chain

	Breeder	Growers	Wholesaler	DC	Supermarkets	Mean	SD
Indicator							
Efficiency							
Production costs	4	4.86	4	5	4.5	4.47	0.47
Transaction costs	3	3.86	3	3	3.5	3.27	0.39
Profit	4	5.00	5	5	4.5	4.70	0.45
ROI	4	4.71	4	4	3.5	4.04	0.43
Inventory	4	3.14	3	3	3.5	3.33	0.43
Flexibility							
Customer satisfaction	5	4.86	5	5	5	4.97	0.06
Delivery Flexibility	4	4.29	5	4	2.5	3.96	0.91
Volume Flexibility	4	3.71	4	4	4.5	4.04	0.28
Backorders	3	2.43	3	1	1.5	2.19	0.90
Lost Sales	4	3.14	3	1	1	2.43	1.36
Late Orders	4	3.43	4	1	1.5	2.74	1.43
Responsiveness							
Fill Rate	4	3.57	5	5	3	4.11	0.88
Product Lateness	5	3.57	5	5	4.5	4.61	0.62
Customer Response Time	4	3.86	5	5	4.5	4.47	0.54
Lead time	4	4.00	4	5	4.5	4.30	0.45
Customer complaints	4	4.43	3	4	5	4.09	0.73
Shipping Errors	3	3.86	4	4	4	3.77	0.44
Product quality							
Appearance	5	4.71	5	5	5	4.94	0.13
Colour	4	4.57	5	5	4.5	4.61	0.42
Firmness	4	4.57	5	5	4	4.51	0.50
Size and Form	4	4.00	5	5	4	4.40	0.55
Taste	5	4.71	5	3	4	4.34	0.85
Shelf Life	5	4.71	5	5	4	4.74	0.43
Salubrity	4	4.00	5	3	4	4.00	0.71
Safety	5	4.43	5	5	4	4.69	0.46
Certified Product	4	4.43	4	4	4.5	4.19	0.26
Product Reliability	5	4.71	5	5	5	4.94	0.13
Convenience	4	4.14	4	3	4	3.83	0.47
Process Quality							
Traceability	5	4.57	5	5	3.5	4.61	0.65
Storing and Transport	5	4.29	5	5	3.5	4.56	0.67
Working Conditions	4	4.14	4	5	3.5	4.13	0.54
Energy Use	5	4.71	4	2	5	4.14	1.27
Water Use*	4	4.00	2	2	-	3.00	1.15
Packaging	4	3.00	4	2	4.5	3.50	1.00
Reuse	4	3.57	3	4	4.5	3.81	0.56
Pesticide Use*	4	4.14	-	-	-	4.09	0.10
Emissions	3	2.57	3	2	1.5	2.41	0.66
Promotions	4	4.00	5	4	5	4.40	0.55
Services	5	4.14	3	5	5	4.43	0.88
Display in Stores	3	3.71	5	5	5	4.34	0.93

*Indicators Water and Pesticide Use were left out from the questionnaire as not applicable for some members of the chain based on results of pre-test

costs (e.g. searching costs, transportation costs, etc.) are kept to a minimum. Growers are not allowed to sell their products to wholesalers outside of the chain. Growers do not seek other marketing channels such as e.g. marketing via auction or direct marketing. The explanation of this is that growers benefit from the arrangement with the wholesaler since they have no transportation costs and saving time for marketing their products. On the other hand the wholesaler relies on the growers and is assured of a constant supply of products. Therefore, we assume that there is a high level of trust between chain members. This fact is reflected in mutual agreement upon e.g. delivery of products, customer response time or delivery flexibility, where many transactions are based purely on telephone calls. The fact that transaction costs appeared to be not interesting indicator for all chain members once again shows that there might be a high level of trust between chain members. Inventory costs are important for breeder given a large amount of expensive seeds kept in the storage for long time-period, which increases the costs of warehousing. The wholesaler or the distribution centre sells its whole stock within one day. There is a high level of agreement between chain members on cost and profit indicators on category efficiency. Agreement among chain members in category efficiency one more times shows that the costs remain one of the major concerns for measuring supply chain performance.

There is less agreement between chain members on importance of category flexibility, responsiveness and process quality. Indicators in these categories such as e.g. fill rate, product lateness, customer complaints, water use, packaging, display in the stores, etc. (see table 1) received different importance perception in different links of the chain. Fill rate is not very interesting for growers, because wholesaler is responsible for transportation. The same goes for product lateness. Surprisingly customer complaints received low score at wholesaler, while breeder and growers find this indicator more important. During the interview growers explained that they would appreciate to have feedback information about customer complaints. Obviously growers lack information from the end of the chain. Water use and packaging received different scores in different links, because of differences in use of these indicators in different links. Emissions perceived to be as indifferent to not important at all across entire supply chain. One explanation could be that there are no direct restrictions from the government to reduce emissions. In average three indicators of flexibility (Backorders, Lost sales, Late Orders) are perceived to be not important. The argument of the majority was that it does not happen, thus is not important to measure.

Results show that there is a joint agreement between supply chain members on category product quality, where all indicators (except for Taste and Convenience) received high score of importance in all links of the supply chain. This may imply that product quality is one of the most important aspects of the chain performance. The high level of agreement in product quality category can also be explained by fact that the breeding company developed the integral chain management system to guarantee product quality down the supply chain.

Conclusions and Discussion

This paper tests a conceptual framework for selection performance measurement system for agri-food supply chain. Note that the framework was tested in the Dutch tomato chain that is one complete chain starting from breeder till the retailer. Summarizing all results it became obvious that the hypothesis that efficiency, flexibility, responsiveness and food quality are the necessary components in agri-food supply chain performance measurement system is supported by case study. As was expected the different indicators within these categories vary for different members of the supply chain. Some the suggested indicators within these categories such as e.g. transaction costs, backorders or emissions are perceived to be not important for measuring the performance of the chain. Some of the suggested indicators e.g. production costs, profit, customer satisfaction and product quality indicators are very important for all members of supply chain. Chain members disagree about the importance of several indicators, e.g. fill rate, water use. Therefore, the framework can be adjusted to each member of the chain, based on the importance of the given indicators for each chain member. Namely, by using four main categories (efficiency, flexibility, responsiveness and food quality) integrated into one measurement system, chain members have the choice to include/exclude suggested indicators in the system based on their own perceptions about the importance of these indicators. The measurement system can be designed for each link of the supply chain, where the main four categories must be the same for each link, while some indicators within categories can vary given different objectives of the firms. The system allows making a comparison between the categories to evaluate the performance of the firms and a chain (e.g. if efficiency rises what happens to the flexibility).

In order to test the applicability of this framework to real world, for the future research, an empirical research needs to be carried out. One of the suitable methods of analysis could be Multi Criterion Decision Making approach.

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