Measuring the Performance of Sustainable Supply Chain Management in the Food Industry

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Abstract

The measurement of the performance of supply chain management in the food industry is mainly focused on the analysis of environmental, social and economic aspects. However, reducing all the dimensions of the sustainable supply chain to a few units of analysis is a task that represents great difficulty in the field of administrative sciences.

In this regard, the central objective of the analytical development presented below is to identify the different dimensions present in the measurement of the performance of the management of the sustainable supply chain in the food industry through the literature review in the field.

As part of the results, four central axes of the analysis were identified: use of raw materials, waste, the measurement of environmental impact and risk management. Each of the identified dimensions is characterized by presenting multiple methodologies and approaches for measuring performance and contributing to the greater and better understanding of the field.

Keywords

Sustainable supply chain management, Sustainability, Performance, Business management

1. Introduction

Currently, there is a trend towards greater responsibility for social and environmental activities. Consequently, companies do not only analyze their financial results, but the need arises to include social and environmental perspectives through sustainable performance.

In addition, the trend in the food industry sector is to recognize sustainability as a central point in the development of operations, due to the high impact on the quality of life of its consumers.

Therefore, there is a growing need to apply sustainable performance measurements that facilitate data collection, analysis and management and facilitate strategic decision making.

However, despite applying some ways to measure the results of sustainability in organizations, the relevance of analyzing sustainable performance is low in business management. Therefore, the main purpose of this document is to identify the different dimensions present in measuring the performance of sustainable supply chain management in the food industry.

To this end, a content analysis is carried out in scientific publications in the field of sustainability, which allow identifying the different study dimensions related to the measurement of sustainable performance, focused on the food industry. This to facilitate a synthesis of the different analysis approaches that contribute to the theoretical and practical development of this topic.

2. Theoretical framework

Sustainability has been defined as the ability to meet the needs of the present without compromising the ability of future generations to meet theirs (WCED, 1987). In recent years, there has been a trend in the business sector to recognize sustainability as a central axis of the development of operations (Aragón-Correa & Rubio-López, 2007; Browne, 2002).

The sustainability approach in the supply chain is the theoretical-practical central axis, where management becomes the nucleus for its definition and adoption (Ashby, Leat & Hudson-Smith, 2012). However, and according to the literature, there is no general definition of Sustainable Supply Chain Management (SSCM); Authors such as Ahi and Searcy (2013) identified the existence of twelve definitions in which a heterogeneity is observed in their conception and development axes.

According to the findings of these authors, the definitions show the incorporation of the objective of sustainability in the activities of the company. However, they do not pose what it means to be sustainable or how it becomes so. The different definitions propose different analysis approaches, ranging from strategic aspects to the incorporation of environmental, social, and economic dimensions.

Liu, Bai, Liu and Wei (2017) considered the incorporation of the Triple Bottom Line (TBL) approach relevant for the definition of the SSCM, which links the analysis of the economic, social and environmental dimensions in the management of production companies. The authors differentiated the types of companies in consideration of the interest groups that each one links and the nature of their economic activity.

The different theoretical approaches presented show the heterogeneity that characterizes the SSCM and the different existing approaches for its analysis. Therefore, the main purpose of this study is to identify the different dimensions present in the measurement of sustainability performance in the supply chain in the food industry. Facilitating the identification of the dimensions involved, the variety of methodologies and approaches for performance measurement, contributing to a better understanding of this developing area.

3. Methods

For the development of the proposed analysis, a qualitative methodological strategy was implemented based on the identification, selection and analysis of scientific documents in the field of supply chain, sustainability, and performance measurement. As a result of the initial search by keywords, 85 documents were identified that met the specifications of the established search.

These selected documents were submitted to review to verify compliance with three criteria of thematic relevance in their content: 1) the central axis of the analysis should be the measurement of performance in management; 2) the development of the analysis should focus on the sustainable management of the supply chain; and, 3) the research field was the food industry.

As a result of the content verification process, according to the criteria of relevance, 30 articles were selected for the formation of the corpus of articles that would allow the development of the proposed analysis. With the identification of the scientific corpus, the content analysis technique (de Burgh-Woodman and King, 2013; Higgins and Coffey, 2016; Onn and Woodley, 2014; Verbruggen and Laes, 2015) was implemented in which, with a qualitative approach, the main elements associated with the management and measurement of sustainability in the sustainable supply chain were identified.

4. Sustainable supply chain management performance measurement

From the literature review, four central axes were identified in measuring sustainability performance in supply chain management in the food industry: a) use of raw materials; b) waste; c) the measurement of environmental impact; and d) risk management. To expand on each of them, the main findings are presented below.

4.1 Use of raw materials

For Dale et at (2013), indicators are needed to assess the economic, social, and environmental sustainability of energy systems (especially bioenergy). Effective indicators can help identify and quantify the sustainable attributes of alternatives in bioenergy uses. 16 socioeconomic indicators were identified that belong to the categories of social welfare, energy security, trade, profitability, resource conservation and social acceptance. The set of indicators is based on the existence of legal, regulatory and compliance institutional frameworks, as well as basic governance.

Taken together, this set of indicators is assumed to reflect the main socio-economic effects of the entire supply chain, including raw material production and logistics, conversion to alternative energy, among others.

Trienekens and Wognum (2013), analyze the importance of Quality Management Systems to integrate supply chains and improve consumer confidence. They found innovations from information systems, which allow aligning the exchange of information in the supply chain and in logistics management, based on novel measurement technologies within the production stage, in the food industry.

In contrast, Bourlakis et at (2014) analyze sustainable performance gaps within the Greek food supply chain and provide numerous statistical comparisons of its key members (producers, manufacturers, wholesalers, and retailers) against company size. To do this, they examine micro, small and medium-sized companies against a set of performance measures, using a survey in which they evaluated sustainable performance measures (consumption, flexibility, responsiveness, product quality and total performance of the supply chain. supply).

Among their findings, they identify food supply chain participants who outperform or underperform relative to size, providing specific reasons for these sustainability performance differentials, including the role of locality, usage, and resource intensity in operations (eg, Manufacturing). Another key finding relates to small businesses that do best in terms of sustainability performance measures, especially in the areas of flexibility and responsiveness.

Sparovek et at (2018), through methods to model the flows of materials and energy along the supply chains to produce agricultural products from 1975 to 2006 in Brazil, identified a group of important sustainable measurement variables located throughout the production system. It is concluded that the improvements in the results of this chain are derived from a combination of the intensification of the animal husbandry systems, the feeding systems, and the increase in the consumption of proteins through cultivation.

Shashi et at (2018) investigate how the overall performance of the food supply chain (FSCP) often depends on the performance of suppliers in a sustainable and energy-efficient supply chain. To do this, they propose and formally test a five-stage performance measurement model. The results highlight the direct and indirect and significant positive performance relationships between the different stages of the system along the chain.

The analysis of the model highlights that the performance of the producer is positively affected by the performance of the supplier and the distributor. On the other hand, supplier performance has a positive impact on producer, distributor, and retailer performance.

Lastly, the performance of the distributor has a positive impact on the performance of the retailer. The authors suggest that regular performance improvement in each stage of the FSCP would improve the performance of the players in the next stage. Most importantly, the direct impact of each partner's performance is comparatively high on the immediate performance of your next partner. Additionally, this study will help professionals understand various FSCP measurement issues and make significant improvements to their energy efficiency and sustainable supply chain practices.

4.2 Waste management

Xue et at (2017), through the review of 202 publications on food loss and waste (FLW) in 84 countries and through 52 years between 1933 to 2014, identify that most of the existing publications They are conducted for a few industrialized countries (for example, the United Kingdom and the United States), and more than half of them are based only on secondary data, indicating great uncertainty in the existing global FLW database. Despite these uncertainties, the authors indicate that per capita household food waste increases when there are improvements in per capita GDP.

Eriksson et at (2017) analyze how food waste is a major problem that must be reduced to achieve a sustainable food supply chain. Since food waste valorization measures, such as energy recovery, have limited possibilities to fully recoup the resources invested in food production, there is a need to prevent food waste.

The authors highlight the importance of prevention at the end of the production chain, where the greatest number of sub-processes have already been carried out and are produced in vain if the food is not used for consumption. Since the first step in waste reduction is to establish a baseline measure to identify problems and solutions, the authors focus on quantifying food waste in schools, pre-schools, and nursing homes in a Swedish municipality.

As a result, the level of food waste was quantified as 75 g of food waste per serving served, or 23% of the mass of food served. However, there was a large variation between kitchens, with a level of waste ranging from 33 g of waste per serving served (13%) to 131 g of waste per serving served (34%). Food wasted consisted of 64% service waste, 33% dish waste, and 3% other food waste. Preschools had a lower level of waste than schools, possibly because preschool caregivers ate together with children.

Kitchens that received food prepared in another kitchen (satellite kitchens) had a 42% higher waste level than kitchens that prepare all foods (production units), possibly because the latter have greater flexibility to cook the correct amount of food and to be able to cool and store surplus food. The large variation between kitchens indicates that they have different causes of food waste, but also different opportunities to reduce it. Therefore, detailed waste quantification for each kitchen can be the first step in the waste reduction process.

Strotmann et at (2017) focus on analyzing how to reduce food waste in a hospital, a cafeteria, and a residential home by applying a participatory approach in which employees were integrated into the process of development and implementation of measures. Initially, a process analysis was carried out to identify the existing processes and structures in each institution.

This included a 2-week measurement of the amounts of food produced and wasted. After implementing the measures, a second measurement was performed and the results of the two measurements were compared. The average waste rate in the residential home decreased significantly from 21.4% to 13.4% and from 19.8% to 12.8% in the cafeteria. In the hospital, the average waste rate remained constant (25.6% and 26.3% during the baseline and control measurements). However, the average amounts of daily food provided and wasted per person in the hospital decreased.

Minimizing overproduction, that is, aligning the number of meals produced with that required, is essential to reduce service losses. Meeting the quality and quantity of meals with customer expectations, needs and preferences, that is, individualizing the food supply, reduces dish waste. In addition, the establishment of an efficient communication structure that involves all actors throughout the food supply chain contributes to reducing food waste.

Redlingshöfer, Coudurier and Georget (2017) inquire about the methodological problems of quantifying food loss relevant to the previous stages in food supply chains. For this, food loss is defined as discarded or lost food products, initially intended for human consumption, unless they have been used for animal feed (excluding pet food).

The results indicate that food loss occurs in the pre-production phases, where the role of the different stages of the supply chain varies between food sectors. According to the results, in 2013, between 3 and 11% of food was lost and up to 12% for fruits, vegetables and potatoes, considering production to processing (up to retail sale in the case of fruits and vegetables). Recycling, including reusing discarded food directly or indirectly as animal feed, plays a moderate role in reducing waste during production and processing.

Johnson et at (2018) describe a simple methodology for measuring waste at the field level and demonstrate its usefulness in 6 vegetable crops harvested in 13 fields of a 121-hectare vegetable farm in North Carolina (US). Concluding that, on average, approximately 65% of the unharvested crop that remained in the field was of healthy and edible quality, although the appearance may not meet buyers' specifications for certain markets.

4.3 Management of social, environmental, and economic impact

Egilmez and Park (2014), through a hierarchical two-step methodology, quantify the carbon, energy and water (FP) footprint related to transportation of the US manufacturing sectors and evaluate the environmental performance versus the economic one based on eco-efficiency scores. The methodology consists of an integrated application of the Product Life Cycle Assessment (LCA) and Data Envelope Analysis (DEA) approaches.

Based on the results of the DEA-based sustainability performance assessment, the authors found that most manufacturing sectors in the United States are inefficient.

Iriarte, Almeida and Villalobos (2014) evaluate through the carbon footprint methodology of the Ecuadorian premium export banana (Musa AAA) using a considerable amount of field data. In their results, the authors focused on oscillations between 0.45 and 1.04kgCO2 equivalent / kg bananas, according to the international overseas transport used. Among the main contributors to the carbon footprint are the stages of agricultural production and foreign transport. Mitigation and reduction strategies for the main emission sources were suggested to achieve sustainable banana production.

Egilmez et at (2014) assess the direct and indirect environmental footprint of the 33 US food manufacturing sectors, using the Economic Entry and Exit Life Cycle Assessment (EIO-LCA) model. Among their results, they found that the average score for the US food manufacturing sectors is 0.76. In addition, 19 of the 33 food sectors are found to be inefficient, indicating an average reduction of 45-71% for various categories of environmental impact.

The results of the analysis also indicate that the supply chains of the food manufacturing sectors are highly responsible for the impacts, with more than 80% participation in the categories of such as energy, water, carbon footprint, fishing, and grazing. Especially the slaughter and animal processing sector (except poultry) are the most dominant sector in most impact categories (ranked second in the fishing and forestry industry). Sensitivity analysis indicated that the forest land footprint is found to be the most sensitive environmental indicator on the overall sustainability performance of the food manufacturing sectors.

Vanham eta at (2015) calculate food waste for consumption in the European Union (EU) and the associated natural resources required for its production, in terms of water and nitrogen, as well as the estimation of the uncertainty of these values. In their results, they identified the food waste of total EU consumers averaging 123 (min 55-max 190) kg / capita per year (kg / cap / year), that is, 16% (min 7-max 24%) of all food that reaches consumers.

Almost 80%, that is, 97 (minimum 45-maximum 153) kg / cap / year is an avoidable waste, being food not consumed. The authors calculated the water and nitrogen resources associated with avoidable food waste. The associated blue water footprint (the consumption of surface and groundwater resources) averages 27 liters per capita per day (minimum 13-max 40 l / cap / d), which slightly exceeds the total urban water consumption of the EU. The associated green water footprint (use of rainwater for consumption purposes) is 294 (min. 127-max. 449) l / cap / d, equivalent to the total use of drinking water for green purposes for crop production in Spain.

Nitrogen content in avoidable food waste has an average of 0.68 (minimum 0.29-max 1.08) kg / cap / year. The food production footprint (whatever is used in the food production process) averages 2.74 (minimum 1.02-max 4.65) kg / cap / year, equivalent to the use of mineral fertilizer by the UK and Germany combined. Among all groups of wasted food products, meat accounts for the largest amount of water and resources, followed by wasted grains.

Accorsi et at (2016) present a design framework that supports strategic decision-making on agriculture and food distribution issues, including climate stability. To do this, they describe a methodology used to build a framework, with a multidisciplinary approach based on a linear programming model that optimizes infrastructure, agriculture, and logistics costs. The model also balances carbon emissions within the agri-food ecosystem in a regional potato supply chain where they illustrate the effectiveness of the proposed model.

Among the main findings, the authors show the interdependence between infrastructure, production, distribution, and environmental resources. The results highlight the consequences of unbalanced planning focused solely on cost efficiency. Concluding with the identification of the enabling conditions, drivers, and metrics for the design of profitable agri-food ecosystems with a carbon balance.

Allaoui, Guo, Choudhary, and Bloemhof (2018) conduct a critical review of the literature of operations research methods for the design of sustainable supply chains. To do this, they propose a novel two-stage hybrid solution methodology. In the first stage, the selection of a partner is done using a hybrid multi-criteria decision making based on the Analytical Hierarchy Process (AHP) method and the Ordered Weighted Average (OWA) aggregation method.

The result obtained in the first stage is used in the second to develop a multi-objective mathematical model, to optimize the design of the supply chain network. This approach allows the simultaneous consideration of all three dimensions of sustainability, including the carbon footprint, the water footprint, the number of jobs created, and the total cost of supply chain design. The approach proposed by the authors generates a Pareto frontier to help users make decisions. Numerical experiments are completed using data from an agri-food company to demonstrate the efficiency and effectiveness of the proposed solution methodology.

Analyzes of the numerical results provide important organizational, practical and policy information on (1) the impact of financial and environmental sustainability on the design of the supply chain network (2) the analysis of the trade-off between environmental emissions, the water footprint, the social implications, and the associated cost for manufacturing.

4.4 Risk management in the sustainable supply chain

Amorim, Alem and Almada-Lobo (2013) analyze the balance between the expected profit and the risk associated with the perishable nature of the goods in the food supply chain. In particular, the risk of impairment and the risk of loss of income are important when considering stochastic parameters related to demand, consumer behavior and the effect of impairment.

Repar et at (2017) develop a broad implementation framework to define and measure the environmental performance of a farm that meets the concept of environmental sustainability from an ecological perspective. After providing a critical review of the existing indicators in the literature to measure the environmental performance of farms and identify their strengths and especially their weaknesses, they develop ideas on how to implement the concept of environmental sustainability at the farm level.

The authors developed, at the macro level, a series of ideas based on the central concept of ecosystem carrying capacity (constraints), which are related to biophysical threshold thinking. The implementation of this concept at the farm level translates into a framework to measure environmental performance, allowing to conclude that environmental sustainability requires compliance with the carrying capacity restrictions imposed by the natural ecosystem within which a farm operates.

Willersinn, Mouron, Mack and Siegrist (2017) analyze the possible scenarios for reducing food losses in the Swiss potato market. For this, the relationship of environmental socioeconomic sustainability was analyzed in comparison with the current situation by using the "SustainOS" methodology. To this end, they conducted life cycle assessments, comprehensive cost calculations, and an online consumer survey.

Among their results, the authors identified that the environmental improvements through the reduction of food losses were quite small and did not cross the limits of importance, but the socioeconomic performance of the entire supply chain can be considerably improved. Additionally, they also show that perceived risks, observed drawbacks and general acceptance of loss reduction instruments influence consumer preferences.

Voldrich, Wieser and Zufferey (2017) propose a methodology that combines processing time and cost (PTC) with operational risk (ORk) to address these challenges by considering the economic interest of each participant in the supply chain environment. To do this, they present quantitative results from a global food company, showing that the joint analysis of PTC and ORk, in contrast to each of the single-objective approaches, results in measurable and tangible insights for actual practice.

Das (2019) proposes a sustainable food network design model that integrates resilience criteria, lean green practices to overcome the limitations of current chain activities and improve their performance. This model is defined as a deterministic model to improve the sustainability performance of a network-based supply chain network.

The research contributes through the design and planning of potential network locations, their capabilities, and integrates resilience criteria and lean-based practices to improve sustainability performances.

5. Conclusions

Four central axes of the analysis were identified: use of raw materials, waste management, management of social, environmental, and economic impact and risk management.

Each of the dimensions identified is characterized by presenting different methodologies and approaches for measuring sustainable supply chain performance contributing to a better understanding of this issue:

a) Use of raw materials

The overall performance of the sustainable supply chain in the food sector depends to a large extent on the use of raw materials and inputs. Companies are looking for ways to apply measurements on the use of these resources. Efficiency and lower costs are also reasons to measure the use of raw materials. In the sustainable supply chain, the measurement of the use of raw materials reflects the best performance of companies in the environmental dimension. In addition to showing its commitment to hiring socially and environmentally responsible suppliers.

b) Waste management

Waste management is indicated as a primary element in the measurement of sustainable performance. The quantification, reduction and disposal of waste is associated with lower impacts on the environment. Measurements at the end of the production chain, where the greatest number of processes have already been carried out, increases in importance due to food waste. Minimizing overproduction, that is, aligning the amount of food produced with that required, is essential in a sustainable supply chain.

c) Management of social, environmental, and economic impact

The management of social, environmental and economic impacts increasingly have more measuring instruments in supply chains. Many companies have monetized their social (social investment), economic (salary and tax payments) and environmental (carbon footprint) impacts to improve their strategies and sustainable practices. A positive balance of impacts (more benefits than costs to society) shows that a supply chain is sustainable.

d) Risk management

Risk management contributes to the measurement of supply chain performance. The prevention of social and environmental risks facilitates the adoption of sustainable practices throughout the supply chain. The less risks materialize, the more sustainable companies will be in terms of sustainability.

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