

51st CIRP Conference on Manufacturing Systems

How Soft Drink Supply Chains drive sustainability: Key Performance Indicators (KPIs) identification

Claudia Pinna^{a*}, Melissa Demartini^b, Flavio Tonelli^b, Sergio Terzi^a

^a *Politecnico di Milano, Department of Management, Economics and Industrial Engineering, Milan, Italy*

^b *DIME - Department of Mechanical Engineering, Energetics, Management and Transportation, Polytechnic School, University of Genoa, ITALY*

* Corresponding author. Tel.: +39 0223999565; fax: +39 0223992206. E-mail address: claudia.pinna@polimi.it

Abstract

Even if sustainability is a relatively new research area, it has already shown an interesting number of measures and metrics mainly de-structured and at very different levels. Furthermore, a specific framework of Key Performance Indicators (KPIs) has not yet been developed for soft drink supply chains (SDSC). This variety is creating confusion among industries when they attempt to select a set of indicators for assessing sustainability in manufacturing in practical terms. A company should be able to analyze each element of its strategy and business model in order to understand which factors influence sustainability. Therefore, to address this challenge, Authors have collected sustainability KPIs SDSCs. KPIs helps soft drinks companies to have a more complete vision concerning their sustainability impact and to point out potential best practices. Finally, in order to provide a practical view of the methodology, a sample is presented and discussed.

© 2018 The Authors. Published by Elsevier B.V.

Peer-review under responsibility of the scientific committee of the 51st CIRP Conference on Manufacturing Systems.

Keywords: Soft drink supply chain, sustainability, Key performance indicator (KPI)

1. Introduction

The soft drinks industry is a very competitive sector, characterized by numerous smaller companies and dominated by few multinationals. Its consumption has increased substantially over the last 50 years. Moreover, its demand has shifted due to changes in consumers' behaviors.

This sector is not just growing in consumption but it is also constantly evolving. For these main reasons, companies are forced to invest in research, innovation and development in order to be competitive and respond to market requests [1]. At the same time, new marketing strategies are required and are often more important than the product itself in satisfying new consumers' needs [2]. Soft drinks generally include non-alcoholic beverages, such as bottled water, sugar sweetened beverages, carbonated beverages, sport drinks, energy drinks, diet drinks, fruit beverages, juice drinks and fruit-flavored drinks.

In this context, over the last years, much attention has been given to development of new products. These focus more on the nutritional and functional aspects whilst paying attention to the sustainability of the whole supply chain.

Usually, F&B firms identify their critical success factors (CSFs) leading the company's strategy. The main CSFs characterizing the F&B companies are: efficiency, quality and sustainability. In this paper, a greater focus will be made on the sustainability aspects.

In this context, the environmental regulations and the sustainable developments are forcing industries to assess, optimize and improve their processes in order to minimize costs and increase the efficiency of environmental sustainability. This effect is even more evident in the food and beverage industries due to the high impact that this sector has on industrial sustainability, considering the primary role of packaging systems, the huge water consumption both for the production and the cleaning processes or the energy utilization related to the treatment plant or to the raw material

production. Thus, the main objective of this work is to help companies operating in the soft drinks sector to understand and measure their sustainability aspects, in order to enhance their operations. In achieving this main aim, sustainable performances in soft drinks supply chain have been defined with particular focus on two main aspects: the water (which is the basis for most drinks) and the packaging. These are the two features that mainly impact on the operations considering the production process -where water is the main component - and the packaging process, both from the material used and from the process itself.

Starting from these considerations, in the first section of this work a literature review has been conducted.

Then in the second section of the paper, the research methodology has been described, going through the case study research, describing the research tool and the company sample. In the following section, the research findings are shown. The key conclusion of this study allows on one hand to depict the current set of sustainable performances according with the literature review and therefore, revise the actual body of the literature, while on the other hand it figures out which of these performances are also used in the real world, helping companies to simplify the decisional process.

1.1 Soft Drink Supply Chain description

As shown in Figure 1, SDSCs present a multi stage structure. The first step in the production of soft drinks is the syrup preparation, generally it is a sugar and water solution in which, sugar or glucose can be used, while diet drinks are prepared using sweeteners or a combination between sugar and sweeteners. Depending on the production concept, the basic components used for the beverages come in powder, liquid or concentrate form. Then suitable dissolving methods, mixing processes, heating and filtration steps are used in mixing the beverages to constitute the basis for the individual syrup variants. Once the syrup has been prepared, it is sent to be bottled. Here, the syrup is mixed with the main ingredient, water, in this phase it is crucial to guarantee that correct quantities of syrup and water are used, and then the mixture is carbonated. Feedback control systems are required to ensure that the product carbonation is kept within specified limits. The packaging process consists of filling cans or bottles with soft drinks. After the filling process, the soft drinks are sent to the distributor, who can repack the drinks in smaller quantities or deal directly to the final customers.



Fig. 1. Soft drink supply chain

2. Literature Review

This paper starts from the results of a previous work based on the identification of the industrial sustainability KPIs [3]. As described by Demartini et al., even if sustainability is a

relatively new research area, shows an interesting number of measures and metrics mainly de-structured and at very different levels. This variety is creating confusion among manufacturers when they attempt to select an operational set of indicators for assessing sustainability in manufacturing. The same issue is arising in the soft drink sector. Furthermore, a specific framework of KPIs has not yet been developed.

Starting from this research gap a qualitative but structured literature review has been developed with the aim to analyze sustainability SDSC performances from the scientific point of view. Literature review is considered a suitable research methodology because it provides a brief but comprehensive description with quantitative and qualitative details that helps readers to know and understand something about a specific topic [4].

Academic papers were selected through a keyword search regarding the aforementioned field. The set of keywords were “soft drink supply chain”, “Key Performance Indicator (KPI)” and “sustainability”. Table 1 shows the results of the literature review.

Table 1. Results of the literature review

Keyword 1	Keyword 2	Number of publications
Soft drink supply chain	Key Performance Indicator	1
Soft drink supply chain	Indicator	2
Soft drink supply chain	Sustainable indicator	0
Sustainable KPI	Beverage sector	1

The aforementioned search technique allowed the identification of 3 academic papers, which were reviewed in order to evaluate their adherence to the study. After reading all the papers, 1 was eliminated and 2 were accepted for further analysis. One paper was excluded because not relevant for the study; indeed, it was focused on food chemistry.

A KPI framework for the food service businesses in Taiwan has been developed by Wang (2013). The model investigates the evaluation dimensions and criteria in KPI for the operation of food service industry aiming to improve the competitiveness and sustainable management in companies. KPI have been organized and classified into: i) business experience and the overall image; ii) software, hardware, and logistic support; iii) staff performance and quality responsibility; iv) implementation of safety and hygiene management and v) marketing capability.

Shahbazkhan et al., study lean-agile supply chains, indicators and effective factors in order to improve and promote soft drink management. KPIs have been organized in four clusters: i) responsibility, ii) competence, iii) flexibility and iv) speediness. The authors claim that customer-oriented factor has the most important effect in order to increase supply chain agility, and particularly “introducing new product” is considered a top priority for SDSCs.

To conclude, the literature review has shown that the identification of sustainable KPI for SDSCs is an uncovered

field, and it needs more studies. With this in mind, starting from the previous work [3] in which a hundred of sustainable measures have been collected and categorized, authors aim to select and arrange those KPI developing a structured framework for SDSCs.

3. Methodology

In this research, case study is used as methodology. As said before, the main objective of this work is to identify how soft drink supply chains measure sustainability through the identification of the different performances. In order to reach this aim, one main research question has been identified (see Table 2).

Table 2. Research question and methodology

Research Question	Methodology
RQ: How do soft drink supply chains measure sustainability?	Literature Review + Case Studies

A questionnaire was developed and used as research tool for gathering data. The questionnaire started from the results proposed by Demartini et al., using the sustainable KPIs identified in order to investigate which of those could be classified as SCSD sustainable KPIs.

Once the questionnaire was developed, the following phase was related to the contacts search. This phase is very delicate because of the difficulty in finding the right person (with the right knowledge on the topic under investigation) and because of their availability. Indeed, even if the right person was found, it often happens that they are not available for the interview. This is the reason why the contact process is always a very demanding phase. In order to obtain the best results, personnel in the R&D or Operation and Supply Chain positions have been contacted and asked for their willingness to participate in our research. The Authors decided to select these specific company positions because of their superior knowledge in the field of investigation. The questionnaire was initially sent to the company manager. Afterward, the interviews were recorded and transcribed in order to allow a better analysis.

As the research focuses SDSC, we selected two companies in this sector who were interested in performance as case studies. Both the firms are working to improve their process and have the intention to achieve sustainability leveraging on water and on packaging.

In order to give an answer to the research question, results coming from the Demartini et al. work and case studies results have been combined. In this way, at first performance indicators concerning sustainability along the supply chain were considered and used to develop the questionnaire. After that, those indicators were proposed through interviews to the companies selected. The last step allowed identifying the sustainability performance indicators for the specific SDSC. The identified indicators were then divided in four main categories and mapped for each stage of the SDSCs.

4. Findings

A company should be able to analyse each element of its strategy and business model in order to understand what factors influence sustainability [5,6]. Raw material availability, regulations, waste, climate change and human rights would all be measured using the correct KPIs to calculate their impacts. These factors, which affect the three dimensions of sustainability, are connected to each specific sector of industry, the company location and the company strategy [7]. A further challenge in selecting KPIs for sustainable manufacturing, is that it is not an inherently intuitive process, those KPIs, in fact, are not necessarily related to the function of the product being manufactured [8]. Additionally, a complete picture of the environmental impact and sustainability requires numerous metrics [9].

The first step for measuring sustainability is to identify the critical and relevant points of the industry and then define the improvements goals. Generally, those objectives aim at minimizing materials and energy consumption or maximizing the value.

With this in mind, two SDSCs have been assessed in order to understand which of the selected sustainable KPIs can be used for measuring and controlling their operations.

The first case study (Company A) is a syrup producer and bottling company. It is a leader in the bottling process in Italy, it has 4 plants and more than 20 production lines. The company covers one third of the Italian market, it mainly produces and bottles carbonated and non- carbonated drinks, diet drinks and bottled water.

The second case study (Company B) concerns a company bottling of water. It produces different products such as fruit juice, carbonated drinks but in this case attention is paid on the process of bottling water. The Italian company is a leader in the water bottling industry; it has 4 main brands and operates all over the world.

In our research, we focus on these specific companies because:

- They are leaders in the syrup production and water bottling process in Italy;
- They have a great attention to safety and quality of the products;
- They present a great focus on customer.

The assessment with the companies showed that the critical factors are mainly connected to water consumption issues and packaging in material reduction and recycling, or resources conservation.

Packaging is a fundamental means for protecting and preserving the beverage properties. On the one hand the companies need to control its weight to reduce environmental impact, on the other hand have to use the correct quantities needed in order to extend the products' life and therefore reduce the probability that beverages could not be consumed. Another very relevant aspect for the companies is packaging design. Currently the trend of mass personalization is also covering the beverage sector. There is an increased demand for personalized products in terms of individualized packaging such as the possibility to have one's own name on it. Therefore, packaging remains a huge issue, where the companies need to arrive at a balance between customer demands versus product protection versus sustainability.

An additional aim of the companies is to minimize water

consumption; in fact facing the increasing global water crisis, it is fundamental for them to preserve this valuable resource and adopt strategies for its efficient consumption. The water crisis is defined as the greatest threat that our planet will face, from the arid agricultural areas to the possibility of millions of people having no access to water.

For these reason, the companies would address their efforts in order to measure and control water consumption and material usage with the aim of understanding if their processes are optimized or not. Understanding which processes and how these processes should be measured are fundamental aspects to improve and optimize SDSCs. The main goal of measuring performance is the creation of information, which is relevant in the decision-making process and the prioritization of future strategic actions [10].

In the specific field of sustainability, KPIs are once again a powerful means, which allow synthetizing complex and ample concepts into numerical terms, which drive the decision making process. For this purpose, KPIs should be defined following these common characteristics [11]:

1. *Clarity*: it should be immediately understandable;
 2. *Significant*: it should support the decisional process;
 3. *Relevance*: KPIs should cover all relevant aspects;
 4. *Comparability*: if KPIs are comparable, there is the possibility to compare with other industries;
- Monitoring*: it means that a KPI can be conditioned by company actions and it should be overseen at all time.

Therefore, to address this challenge the Authors have submitted the selected sustainability KPIs to the managers of the two aforementioned companies and therefore they have grouped the selected KPIs in four main sections, which have been designed with the companies: General Aspects, Materials and Packaging, Water and Energy, and Emissions.

- *General Aspects*, encompasses safety, security and customer satisfaction. This section takes into account objectives that are not specific on how to improve the manufacturing processes but, indirectly, are likely to affect the industry’s sustainability performance. Specifically, these KPIs allow analyzing the social perspective of sustainability.
- *Materials and Packaging*, covers all those metrics and indicators about the efficient and effective use of material and it is made up of: material efficiency, reduction of raw material, increase usage of renewable material and waste reduction.
- *Water and Energy*, is the most commonly used and analyzed field for the assessment of the environmental performance. It covers two main aspects: energy and water efficiency.
- *Emissions*, includes the intensity of the weight of all outflows to air/land/water during a specific period. Its objectives are: minimize emissions to air, land and water.

In Table 3 the results of the companies’ categorization of sustainability KPIs for SDSCs is reported.

Table 3. Sustainable Key Performance Indicators framework for SDSCs.

Group	KPIs	Adopted by	Description
General Aspects	Industrial safety	Company B	Indicates numbers of incidents, fatal and non-fatal accidents, health and safety prevention costs.
	Client satisfaction	Company A and B	Measures the level of satisfaction, well-being, and added value to customers and users.
	Employee turnover	Company B	Measures the level of turnover in a company, in terms of Number of employee departures divided by the average number of staff members employed.
Materials and Packaging	Usage of raw material	Company A and B	Measures raw material consumption per liter of beverages produced, and non-renewable materials intensity.
	Usage of renewable material	Company A and B	Measures renewable raw material consumption per liter of beverages produced
	Solid waste generation	Company A and B	Grams of solid waste generated per liter of beverages produced
	Recycling of solid waste	Company A and B	Percentage of recycled waste in relation to generated waste
	Product Quality	Company A and B	Measures the number of errors, rejected batches, product defects, costs of bad quality and number of deviations
	Packaging Quality	Company A and B	Measures the quality and safety of packaging
	Water and Energy	Efficiency in water consumption	Company A and B
Efficiency in energy consumption		Company A and B	Energy used per liter of produced beverage
Emission to water		Company B	Measures nutrients and organic pollutants and metal emissions
Emissions	Emission to land	Company A	Measures oil and coolant consumption, restricted substances intensity and metal emissions
	Emission to air	Company A	Measures air acidification, dust and particles, transport and greenhouse gases

Group	KPIs	Adopted by	Description
-------	------	------------	-------------

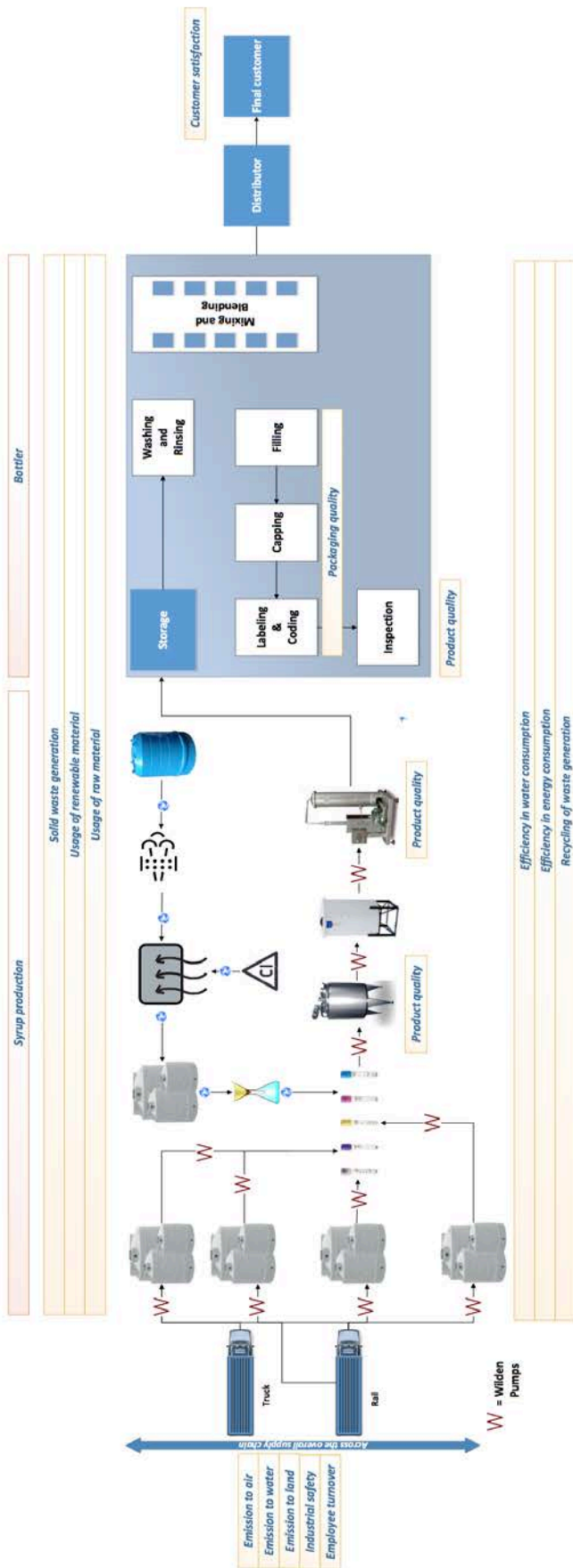


Fig. 2. Practical application of the Sustainable Key Performance Indicators for SDSCs

Finally, Figure 2 shows a practical application of the Sustainable Key Performance Indicators for SDSCs. As previously stated, the KPIs mapping has been discussed with the company managers.

As shown, the attention is focused on the first two phases of the SDSCs, because these two factors are the ones involved in the water and packaging practices. Some KPIs such as Emission to air, land, water, Industrial safety and Employee turnover are applied to the whole supply chain, while water measurements are mainly used to control the syrup production and bottling phase, and finally packaging and material metrics are adopted for the material consumption monitoring.

Furthermore, quality controls are arranged in several strategic points, such as the end of the syrup production, the carbonization processes and the end of the labelling and coding procedures.

Additional controls are also scheduled in the distribution phase. Energy consumption is monitored along with the syrup production and bottling processes, as is waste measurement and recycling rates.

Figure 2 shows the complete mapping between a generic SDSC and the Sustainable Key Performance Indicators framework for SDSCs.

4. Conclusions and further research

In this paper, a framework of sustainable KPIs for SDSCs has been developed. Supply chain management and operations management literatures are recognizing the importance to consider such issue in SDSCs, and more specifically to improve the measuring of sustainable performance.

We started exploring KPIs published in the literature by the results of a previous work, and then two soft drink companies have evaluated these results, selecting the relevant KPIs for measuring and controlling their operations.

This research sheds some light on how soft drink companies can measure sustainability and therefore deploy sustainable strategies along manufacturing networks.

Finally, we would also like to analyze some of the main drawbacks of this work.

First, the proposed case studies are limited to only two companies, they could be not sufficient to cover all the SDSC behaviors, maybe more case studies could allow us to give more precise directions.

Second, measuring sustainability performance is a complicated issue. This study provides a first assessment of relevant KPIs for SDSCs; it can stimulate further research on this issue adopting more articulated measures. This will require more efforts due to the various regulations of countries and industries.

Finally, we have not included economic metrics; one additional avenue of future research could be to introduce them in the framework.

References

- [1] G. Arcese, S. Flammini, M.C. Lucchetti, O. Martucci, Evidence and experience of open sustainability innovation practices in the food sector, *Sustain.* 7 (2015). doi:10.3390/su7078067.
- [2] G. Falcone, A.I. De Luca, T. Stillitano, A. Strano, G. Romeo, G. Gulisano, Assessment of environmental and economic impacts of vine-growing combining life cycle assessment, life cycle costing and multicriterial analysis, *Sustain.* 8 (2016). doi:10.3390/su8080793.
- [3] M. Demartini, I. Orlandi, F. Tonelli, D. Anguita, Investigating sustainability as a performance dimension of a novel Manufacturing Value Modeling Methodology (MVMM): from sustainability business drivers to relevant metrics and performance indicators, XXI Summer Sch. “Francesco Turco.” (2016).
- [4] D. Tranfield, D. Denyer, P. Smart, Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review, *Br. J. Manag.* 14 (2003) 207–222. doi:10.1111/1467-8551.00375.
- [5] P. Taticchi, F. Tonelli, R. Pasqualino, Performance measurement of sustainable supply chains: A literature review and a research agenda, *Int. J. Product. Perform. Manag.* 62 (2013) 782–804. doi:10.1108/IJPPM-03-2013-0037.
- [6] E. Nicolăescu, C. Alpopi, C. Zaharia, Measuring Corporate Sustainability Performance, *Sustainability.* 7 (2015) 851–865. doi:10.3390/su7010851.
- [7] C. Shepherd, H. Günter, Measuring supply chain performance: current research and future directions, *Int. J. Product. Perform. Manag.* 55 (2006) 242–258. doi:10.1108/17410400610653219.
- [8] P. Taticchi, K. Balachandran, F. Tonelli, Performance measurement and management systems: state of the art, guidelines for design and challenges, *Meas. Bus. Excell.* 16 (2012) 41–54. doi:10.1108/13683041211230311.
- [9] F. Tonelli, Industrial sustainability : challenges , perspectives , actions Flavio Tonelli * Paolo Taticchi, *Int. J. Bus. Inov. Res.* 7 (2013) 143–163.
- [10] M. Laurus, J. Lamothe, H. Pingaud, A business process oriented method to design supply chain performance measurement systems, *Int. J. Bus. Perform. Manag.* 12 (2011). doi:10.1504/IJBPM.2011.042013.
- [11] E. Roubtsova, V. Michell, Modelling and validation of KPIs, BMSD 2013 - Proc. 3rd Int. Symp. Bus. Model. Softw. Des. (2013).