Challenges and competitiveness indicators for the sustainable development of the supply chain in food industry

Attila Turi\textsuperscript{a,*}, Gilles Goncalves\textsuperscript{b}, Marian Mocan\textsuperscript{a}

\textsuperscript{a}“Politehnica” University of Timisoara, Piata Victoriei No. 2, 300006 Timisoara, Romania
\textsuperscript{b}Univ Lille Nord de France, F-59000 Lille, France
\textsuperscript{c}UArtois, LGI2A, F-62400, Bethune, France

Abstract

Although food industry is one of the most important global industries with significant implications for world economy, very little research has been done to cover this topic and address its specificity, issues or performance assessment. This paper intends to point out the most important challenges and propose aggregate indicators to assess the performance of the food supply chain by considering economic, social and environmental development.

© 2014 The Authors. Published by Elsevier Ltd. Open access under CC BY-NC-ND license. Selection and peer-review under responsibility of SIM 2013 / 12th International Symposium in Management.

Keywords: food industry; supply chain; performance indicators; challenges; sustainable development;

1. Introduction

The European Food Industry is one of the most important sectors in world economy with a highly significant relevance for economic and environmental development as well as social wellbeing. The complexity of the food chain means that it includes a wide range of economic activities which involves an impressive diversity of products according to consumption frequency. However, this variety of products comes from both a relatively limited number of well-known world leading companies and a consistent amount of relatively unknown SMEs (Small and Medium-sized Enterprises (Guerin & Velilla, 2010, Wijnands, Van der Meulen, & Poppe, 2007)

The food industry, as defined by the NACE (Nomenclature statistique des Activités économiques dans la
Communauté Européenne) is divided into sub-sectors: food and drink processing and manufacturing and food supply (List of NACE codes, 2010). The processing and manufacturing of food and drinks includes the following: meat, fish, fruit and vegetables, oils and fats, dairy, cereal related and starch products, beverages and sugar. The food supply includes wholesale and retail distribution of processed food and the catering sector.

The food supply chain links a variety of activities: the procurement of agricultural raw materials, their processing up to final human consumption and their distribution. The food industry involves multiple players such as farmers, input suppliers, manufacturers, packagers, transporters, exporters, wholesalers, retailers and final customers with different and changing interests, cultural attitudes and dimensions, which makes it a very dynamic and challenging industry.

2. Challenges in the Food Industry

The competitiveness of the food industry would thus be the ability to sell products that, on one hand, meet demand requirements (price, quality and quantity) and, at the same time, ensure profits over time that enable the companies to do well economically, develop their business and thrive. However, despite its leading status at world level regarding manufacturing, value added and job creation, the competitiveness of this sector is a matter of concern, especially as consumers preferences are very quickly evolving and becoming more demanding and more and more sophisticated. The food industry has to respond accordingly and adjust or adapt to these circumstances.

The structural adjustment of food sector is therefore linked to consumer preferences, which have an increasing impact on the industry as a result of income developments, shifts in the population structure and new lifestyles. Other important impacts that influence the food sector are globalisation, liberalisation of world trade and agricultural markets and the emergence of new markets from Central and Eastern Europe all the way to India and China. Finally, significant shifts and changes in technology, including information technology have led to new products and methods to organise the supply chain.

2.1. Macroeconomic shifts

Current issues and challenges of the food industry are:

- a very low growth of the population in the EU, which results in a lower growth of demand for processed food in the EU
- a shift in consumer preferences towards more convenient and healthy food and ethical issues (such as animal welfare) which are becoming more and more important;
- the development in technology increases the efficiency in the use of raw materials;
- innovation stimulates product differentiation, the responsiveness of the food chain being important for stimulating this process (Wijnands, Van der Meulen, & Poppe, 2007).

2.2. Food industry regulations

Despite being specifically regulated, food industry has gone through many crises during the last decade: mad cow disease, listeria, bird flu or the recent horsemeat scandal. The final consumer has become more and more sensitive to the origin and conservation of the products they buy. The logistics of this sector must be able to show responsiveness, accuracy and transparency to regain and maintain consumer confidence. The appearance of labels, continuous changes in international regulations as well as technological innovations have influenced and transformed the food supply and established principles like Product Traceability, Cold Chain Control or Hygiene and Quality.

They involve the issue of transparency of the source of goods and merchandises as well as the delivery of raw materials for finished products which in turn is affected by flow management, particularly by the cold chain, either upstream or downstream of the transformation phase. Finally their processing and storage are subject to very strict hygienic and quality conditions. Bar codes, electronic business standards, global data synchronization and radio frequency identification (RFID) are some of the tools used to assure compliance with EU regulations (EU Regulation No 178, 2002) and international standards (Codex Alimentarius, 2012). They supply a series of
guidelines and standards on food safety in order to ensure fair practices in the international food trade, guarantee hygiene and provide healthy food products for consumption.

2.2.1. Cold chain

Hygienic safety of food depends largely on the respect of the cold chain, throughout all stages of storage and transport between producer, carrier, distributer and consumer. Throughout this chain, temperatures must not exceed the temperature regulations for each of the product categories as are the negative cold products (quick and deep frozen food), ultra-fresh products (such as dairy products), fresh products (such as fruits and vegetables), chocolates or dry goods (such as groceries, beverages and liquor).

The cold chain can be broken:
- when products that are not to be kept at the same temperature are stored or transported together
- or when the food is too crowded, thus the cold does not penetrate into products depth
- or when the vehicle is not refrigerated in advance, the products can take in temperature until the truck is cooled
- or when loading or unloading is taking too long, there is a rapid loss of cold

When transporting or storing products that can be stored at different temperatures, the lowest temperature must be selected (Bricout, Carlier, Lanau, Harison, & Hui, 2009).

2.2.2. Traceability

Traceability in the food industry is a key concern to all participants and stakeholders in the food chain and refers to the ability to trace, through all stages of production, processing and distribution, the path of a food product, a food feed, a food-producing animal or a substance to be incorporated or even possibly incorporated into a food product or a food feed.

All links involved, either professionals, producers, processors or distributors must identify and solve critical issues, maintain regulatory compliance, carry out their own self-controls while public service must establish and enforce regulations on hygiene control, consumers must be informed of nature of the products and know how to handle and store the products they buy through clearly identifiable labelling.

To improve the traceability, standards are implemented in the food sector on national and international basis. It aims to better control hazards and to reduce risk levels and is necessary for tracing the source of a problem of food poisoning or fraud.

Traceability in logistics is concerned with setting up a device that is only concerned with following the physical flow of the product with the help of labels as is described in figure 1.

![Figure 1. Traceability in food industry](image-url)

The qualitative traceability is a device that combines both information relating to the physical flow of products and also to additional information on the product itself. This information can be, for example, the nature of its ingredients, the quantity, the origin of raw materials, the link between products, raw materials, finished product, etc. Traceability of food products is mandatory since 2005.

Each intervenient within the food industry supply chain must identify:
- the goods received, processed and shipped (product type, producer’s name and address)
- suppliers and products delivered
- customers and products which are delivered to them

and record information related to goods as well as to be able to identify and recall a manufactured, processed or
distributed product from the market.

Traceability can provide support to public health and help authorities determine the causes of contamination or help the companies reassure customers and increase competitiveness on the market through sales and market share.

Sometimes transforming living products involves a certain measure of variability, take milk for instance. Nevertheless the consumer expects a product to always have the identical quality. Traceability allows companies to assess the quality of the product through the provided information on it and supports finding the cause for the differences in quality. Moreover, it allows internal tracking of all flows of manufacturing, understanding changes or variations that occur in output and the appropriate remedy. The complexity of supply chains as are chain extension, diversified channels and the shortening of lead times makes traceability serve as an internal control of flows.

The responsibility belongs primarily to those who develop the products and offer them to consumers. The interdependence of producers throughout the chain of product development creates a chain of responsibility. To assume it, it is their responsibility to develop self-checks and to implement hygiene best practices and systems that allow them to ensure product traceability.

2.2.3. Quality

Quality is an essential concept in food industry. The compliance certification attests that a non-alimentary and unprocessed food or agricultural product complies with specific characteristics or previously set rules concerning the production, packaging or origin. The specific characteristics of the product based on objective, measurable, controllable and meaningful to the consumer included in a specification, brief or requirement, which can be developed by a collective structure or an individual operator. The certified characteristics may be related to the composition of the product, its organoleptic, physical or chemical or even to certain rules of manufacturing.

The certified product has on its label the name of the certifying body and certified characteristics and possibly the logo "Quality Criteria Certified." The food industry is subject to numerous standards and regulations, not only imposed by the legislature, but also by its distributors (Clarke, 2010).

Quality, lead time, cost and compliance with standards of traceability are all within the variety rules imposed by supermarkets to their suppliers, which is even truer when it comes to producers of distributor’s brands (MDD).

Indeed, companies within the food industry must improve their overall logistic performance, be aware of any developments from the very beginning, to anticipate them as soon as possible and to adapt quickly. This in turn implies that the supply chain must be efficient and highly capable. This allows them to better distribute their products, to meet the needs of their customers and ultimately to remain competitive in a highly competitive market.

2.3. Food supply chain

Only a small number of food products have a recognised brand value, like Coca-Cola, but the rest can be described as commodities. This means that products of producers are not significantly differentiated thus being easily substitutable. Therefore food processors do not have power and authority to take decisions in the downstream businesses. Processors can only influence their decision by offering a better price, services or quality. Wholesalers, retailers and food service companies are an important link between the food industry and consumers as end users as is described in figure 2.
The road from producer to consumer is filled with challenges for all partners of the food supply chain the most important being those of complying with EU regulations to assure product quality and generate consumer trust, whereas logistics links all of them and assures product availability. Businesses compete on the basis of financial performance, productivity performance, quality performance and cycle time performance. All are interconnected and represent a framework for measuring competitiveness of an individual company or of a series of linked companies. Thus the generic performance attributes related to logistics processes concern quality, timeliness, logistics cost, productivity and capacity.

Quality is related to product quality but can also be applied to the quality performance of logistics processes along the supply chain as a way to improve these processes while also insuring the customer’s satisfaction level.

Timeliness is related to the capacity to react and respond to customer’s requirements in a certain timespan and is an important indicator of a reliable supply chain.

Logistics Cost is related to all logistics activities throughout all stages of preparation, distribution, transportation and warehousing and is essential for a proper financial performance.

Productivity concerns the efficiency in using available resources and is a measurement of internal performance.

2.4. Performance measurement

In a global economy where there is a highly competitive and dynamic environment, Supply Chain Management is essential to help increase organisational effectiveness while at the same time logistics activities in the industry are becoming more and more important. Hence, the efforts made to manage and improve effectiveness and efficiency of the supply chain are critical in order to remain competitive on a marketplace which is becoming more and more global, and where competition is getting tougher and tougher (Garcia, Marchetta, Camargo, Morel, & Forradellas, 2012). Therefore a series of indicators is needed to properly assess the performance of the food supply chain and to assure and support a sustainable social, economic and environment development.

A performance indicator is a designation for a certain type of performance measurement. Indicators are used by companies or organisations to help assess their internal performance or the performance of a particular activity in which they are engaged. Performance or success is sometimes defined in terms of making progress toward strategic goals, but often it is simply the repeated achievement of some level of previously established operational goals or internal performance policies (for example, zero defects, 100% customer satisfaction, etc.). For the measurement to be effective the levels that have to be achieved must be set according to certain company standards and represent challenging, yet realistic goals. Consequently choosing the right indicators depends on having a proper understanding of what is important to the company and its objectives.

All indicators must be relevant for the business as a whole and must assure an indication of global performance of the entire company and not just for the one or the other department (an indicator that is relevant for finance will be quite different from the one which is relevant to sales, for example). Therefore a good understanding of what is relevant makes the difference in whether performance indicators manage to properly assess the present state of the
business, and its key activities. These assessments, in turn, can lead to the identification of potential improvements and may support initiatives to improve performance.

Performance indicators can be summarized into the several categories, the most important being: quantitative indicators (which can be presented as a number), qualitative indicators (which cannot be presented as a number), input indicators (which measure the amount of resources consumed during the generation of the outcome), process indicators (which represent the efficiency or the productivity of the process) and financial indicators (financial performance).

Indicators are ways to periodically assess the performances of companies, organisations, their departments and employees. Therefore these indicators are generally defined in a way so that they are understandable, meaningful, and of course measurable. In order to be evaluated, indicators are linked to target values, so that the value of the measure can be assessed as meeting expectations or not.

Many organisations have improved the performance of their logistics processes by implementing industry best practices with the help of indicators. However, little attention has been given so far to the performance evaluation, and hence, to the measures and metrics in the food industry.

The combined use of these indicators (economic, environment and social) will help to further understand the overall logistics performance of the companies within a supply chain as well as the global performance of the entire chain by taking into account key aspects for all links as are quality, logistics costs, time and productivity.

The following 10 indicators are proposed for a proper assessment of the food supply chain links considering the importance of social, environmental and economic development. The first 3 indicators have an impact on social level by making employees more aware of the relevance of training, understanding environmental issues and contributing to improving work conditions and product quality (Aberre, Carbone, Donval, Moatti, & Meibel, 2008, Bricout, Carlier, Lanau, Harison, & Hui, 2009, Guerin & Velilla, 2010). The following 3 refer specifically to the environment through input and output reduction as well as the efficient use of resources in order to hamper impacts on environment (Aberre, Carbone, Donval, Moatti, & Meibel, 2008, Sustainable Supply Chain Logistics Guide, 2009). The next 3 indicators reflect company capacity to satisfy customer demand, the rapidity in making products available and the associated costs (Bricout, Carlier, Lanau, Harison, & Hui, 2009, Garcia, Marchetta, Camargo, Morel, & Forradellas, 2012). Finally the last indicator basically sums up all the 3 key areas (social, economic and environment) being a result of the performance of the company to make a healthier, more environmentally friendly and competitive food product.

1. Number of Employees Trained / To be trained
   = reflects the company's interest in developing and training its employees in specific techniques as well as in environmental issues and is an important asset for a motivated and well-trained staff which in turn supports a sustainable company development.

\[
TER = \frac{NET}{TNE} \times 100 \% \quad (1)
\]

TER – Trained Employees Rate
NET – Number of Employees Trained
TNE – Total Number of Employees

2. Management Levels with Specific Environment Responsibilities
   = reflects the strategic importance associated with the environmental issues and the extent to which the company is or is not concerned about its impacts in the future; an environmental component in the responsibilities of a manager will constantly be of concern to the company and could create sustainable environmental policies

\[
LMPER = \frac{NMPER}{NMP} \times 100 \% \quad (2)
\]
LMPER – Level of Management Positions with specific Environmental Responsibilities
NMPER – Number of Management Positions with specific Environmental Responsibilities
TMP – Total Number of Management Positions

3. Number of Improvement Suggestions submitted by Employees
   = reflects the importance associated by the company towards its current and environmental projects or results and its responsibility towards the community in a certain period of time; it is also an indicator of employee concern towards improving company performance and establishing environmental policies

\[ AIS = \frac{ISE}{current \ year} \left[ \frac{number}{year} \right] \quad (3) \]

AIS – Annual Improvement Suggestions
ISE – Improvement Suggestions submitted by Employees

4. Reverse Logistics (reduce, reuse, recycle)
   = reflects the company’s efforts to reduce waste, its policy on recycling and its concern towards the reuse of materials in other processes after their recycling; these efforts are to be assessed as both economies in the budget and additional revenue occasioned by this policy.

\[ ARLR = \frac{RLG - RLC}{current \ year} \left[ \frac{€}{year} \right] \quad (4) \]

ARLR – Annual Reverse Logistics Revenue
RLG – Reverse Logistics Gains
RLC – Reverse Logistics Costs

5. Reduce Energy Consumption
   = reflects the continuous efforts of the company to reduce energy consumption in a certain period of time; performance should be measured and results should be assessed each year by comparing current levels of consumption to those from the past year and maintain a continuous decrease throughout the years

\[ LEC = \frac{ECCY}{ECLY} * 100 \% \quad (5) \]

LEC – Level of Energy Consumption
ECCY – Energy Consumption of Current Year
ECLY – Energy Consumption of Last Year

6. CO₂ Emissions/Pallet
   = measures the average emissions per unit (in this case, pallet) generated by the company and its operations

\[ AE = \frac{E}{TPD} \left[ \frac{CO₂}{pallet} \right] \quad (6) \]
AE – Average Emissions per unit (in this case, pallet)
E – Emissions of CO₂ per year
TPD – Total number of Pallets Delivered per year

7. Transport Costs/Pallet
= reflects the average cost of shipping/pallet based on destination and shipping service

\[ ATC = \frac{SC}{NP} \left( \frac{\text{€}}{\text{pallet}} \right) \]  

\( ATC \) – Average Transport Costs
\( SC \) – Shipping costs
\( NP \) – Number of pallets

8. Perfect Order Percentage
= measures the performance of the company to achieve perfect order delivery and gives a good view on the competitiveness and efficiency of its specific Supply Chain; in order to achieve high levels of quality in delivery the entire supply chain must be competitive and uphold good performance throughout all links

\[ POP = \frac{OPD}{TOD} \times 100 \% \]  

\( POP \) – Perfect Order Percentage
\( OPD \) – Orders Perfectly Delivered
\( TOD \) – Total Orders Delivered

9. Total Validity Period in Transport
= measures the product's validity period used up during transportation and reflects the rapidity and performance of the flow of goods towards the customer; it is a very important indicator of supply chain performance for perishable goods as customers are quite sensitive to expiry dates when buying such products

\[ VPT = \frac{TNT}{TVT} \times 100 \% \]  

\( VPT \) – Validity Period in Transport
\( TNT \) – Total Transport Time
\( TVT \) – Total Validity Time before Transport

10. Number of Green Products
= reflect the concern towards consumers by offering more healthy products either by improving existing products (same taste with less sugar, salt or fat, packing made of superior materials, etc.) or by creating a totally new product

\[ LGP = \frac{NGP}{TNP} \times 100 \% \]  

\( LGP \) – Level of Green products
\( NGP \) – Number of Green products
\( TNP \) – Total Number of Products
The Perfect Order Percentage (8) and Total Validity Period in Transport (9) are among the most important performance indicators for the food industry. A high perfect order percentage means the supply chain is flexible and manages to handle all products by complying with both legal requirements and specific industry standards. It shows a high capability to adapt to different types of requirements and this while being at the same time efficient in on-time delivery. The Total Validity Period in Transport (9) is another complementary indicator which shows the company’s capacity to provide products, especially those with tight expiry dates (days or weeks), on time but also by limiting the time that these products “loose” in transport rather than on the shelves. A consumer is very sensitive to an upcoming expiry date, therefore any margins gained by delivering the product quicker to the shelf reduces the risk of it getting perished without being consumed during its validity period. Although the other indicators may not be necessarily food industry-specific and could be met to measure the performance in other industries as well, they still play an important role to assess the food industry supply chain.

3. Conclusion

The food industry plays a key role in assuring a healthy development of the consumers, a sustainable economic growth and more attention to environmental issues. Its specificity provides certain issues and challenges that are slightly different of those of other industries, thus performance assessment needs to consider them and provide a proper framework. The proposed indicators can be applied to both individual links of the food supply chain as well as to the entire chain and will help companies develop a more competitive position and help strengthen the food supply chain. The paper provides a systematic approach of the industry and is a point of departure for further research both for the authors as well as for other researchers who address the specificity of the food supply chain and its competitiveness.

4. References

Aberre A., Carbone V., Donval Y., Moatti V., & Meibel S. (2008). Observatoire de la Supply Chain 2008, Supply Chain verte: enjeux et maturité des entreprises, Supply Chain Magazine.

Bricout A., Carlier A., Lanau A., Harison R., & Hui S. (2009). Les spécificités de la logistique alimentaire, Université de Picardie Jules Verne, Institut National Supérieur des Sciences et Techniques de Saint-Quentin, France.

Garcia F., Marchetta M., Camargo M., Morel L., & Forradellas R. (2012). A framework for measuring logistics performance in the wine industry, International Journal of Production Economics, 135, 284-298.

Guerin V., & Velilla P. (2010). Rapport du groupe de travail Agroalimentaire, États Généraux Industrie, Association Nationale des Industries Alimentaires (ANIA), France.

Wijnands J.H.M., Van der Meulen B.M.J., & Poppe K.J. (2007). Competitiveness of the European Food Industry, An economic and legal assessment, European Commission.

List of NACE codes (2010). http://ec.europa.eu/competition/mergers/cases/index/nace_all.html. EU Regulation Number 178: Articles 3, 15 and 18 (2002). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF.

Codex Alimentarius (2012). http://www.codealimentarius.org.

Clarke R. (2010). Private Food Safety Standards: Their Role in Food Safety Regulation and their Impact, 33rd Session of the Codex Alimentarius Commission.

Sustainable Supply Chain Logistics Guide (2009). Greater Vancouver Regional District.