Evaluation of the LARG (lean, agile, resilient, green) performance in a food supply chain: a case study in Italy

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Abstract: The study proposes an evaluation of the LARG (lean, agile, resilient, and green) performance of a real food system, whose focal company is a main manufacturer of food products, based in the North of Italy. In a previous study by some of the authors of the present paper, a framework for evaluating the LARG performance of food supply chains was delineated, and appropriate key performance indicators (KPIs) were identified, on the basis of a review of the available literature on supply chain performance measurement and food supply chains. In this study, the application of that framework is presented along with the presentation of a case study. Direct interviews with the company's managers and the usage of other available sources allowed first to acquire a detailed knowledge about the context in which the company operates, so as to evaluate the relative importance of the various KPIs, and second, to gather the relevant data for deriving a score against these KPIs for the targeted company. From an analysis of the outcomes obtained and from the detailed description of the case study, some insights can be derived for the whole food supply chain.

Keywords: LARG (lean, agile, resilient, and green), performance measurement system, framework, case study, food supply chain.

I. INTRODUCTION

Supply chains and their players are increasingly facing various internal and external challenges. Besides the typical phenomena that have been characterising the markets of the last decades (e.g., globalization, price volatility, competitiveness, network complexity, or demand customization - Lotfi & Saghiri, 2018), the recent epidemic outbreak caused by the COVID-19 pandemics largely disrupted supply chains worldwide; its unpredictable behaviour could lead to inappropriate decision-making, in turn causing severe economic shocks (Jha et al., 2021). In this context, good supply chain management (SCM) practices are of fundamental importance and become necessary for achieving efficiency and effectiveness in all processes. SCM refers to the coordination of within and in-between linkages of various echelons, namely suppliers, focal firms, distributors and customers, to maintain the efficient and effective flow of materials and information, with the final goal of meeting the stakeholders' requirements (Carvalho et al., 2011).

Performance measurement systems (PMS) are tools that allow managers to monitor the relevant performance indicators of products, services and processes inherent in the targeted supply chain, over a given period of time (Piotrowicz and Cuthbertson, 2015). Performance indicators, in turn, reflect the criteria by which the outcomes of a company, in terms of products, services, and production, can be evaluated. According to Parker (2000), the use of PMSs allows for showing the capabilities of a supply chain to determine whether the customer needs are being met, to detect the occurrence of problems and to find ways to solve them. PMSs within the supply chain are useful to streamline the flow of materials, information and money, to simplify decision-making processes and to eliminate non-value-added activities (Gunasekaran et al., 2004). Performance evaluation also allows companies to compare their results with the so-called best-in-class and thus gives them an idea of how to best target their resources. However, measuring the performance of business activities and processes involves the definition of a system of indicators that allows for the representation, in a single and prospective framework, of the company's ability to pursue its short, medium, and long-term objectives, in a dynamic scenario.

In the past, companies have mainly used economic indexes, such as return on investment (ROI), return on asset (ROA) or return on equity (ROE), to evaluate their

state, while indexes related to operational aspects have never been used. However, using only financial ratios, many of the existing measurement systems remain static in nature and fail to address the constant changes that the supply chain is subject to. In this respect, Gunasekaran et al. (2001) argue that until the early 2000s, there were no balanced approaches capable of simultaneously considering financial and non-financial indicators. Furthermore, research has shown that while the evaluation of financial ratios is important for making strategic decisions and for external reporting, the daily monitoring of production and distribution operations is made possible by the analysis of non-financial ratios (Maskell, 1991). The literature has also highlighted further limitations of existing performance measurement systems, such as: short-termism due to the exclusive consideration of financial ratios, lack of strategic focus (lack of alignment between the system and strategic objectives), encouragement of local versus global excellence, and lack of information about competitors' performance. The identification of suitable indicators for measuring and evaluating the supply chain provides general visibility of how it is performing and helps managers identify those areas on which they need to focus.

The present paper proposes an evaluation of the performance of a real company, operating in the food industry and in particular in the area of tomato-based sauces. The evaluation grounds on the lean, agile, resilient and green (LARG) perspectives. For the purpose of this study, which is the prosecution of a previous publication by some of the authors, the LARG indexes were taken directly from the that previous publication (Bottani et al., 2022); the reader is referred to this study for a detailed description of the framework developed. From a logical point of view, this paper thus represents the prosecution of the previous study, whose main aim, however, was only to develop the LARG model and the relating indexes; no implementation nor testing were instead carried out. Using the previous model makes it possible to test the set of indexes in a real context, and to propose refinements or amendments on the basis of the findings obtained. Along with the testing, some implementation challenges are detected and solved; interesting insights to implement LARG model in practice are therefore derived.

The remainder of the paper is as follows. Section II contains a description of the methodology followed in this study, and in particular, it proposes a background on LARG model. The application of the LARG model is detailed in section III, together with an evaluation of the current performance of the supply chain under examination. Section IV concludes by summarising the main results of the work, commenting on the limitations and implications, and outlining possible future research activities.

II. MATERIALS & METHODS

This section describes the research methodology followed in this study, encompassing a background on LARG models and the description the company chosen for the implementation and testing of the model itself.

A. LARG models

In an attempt to combine the various features of the supply chains, as associated with the necessity of being increasingly efficient, the concept of LARG was coined (Azevedo, Carvalho, & Cruz-Machado, 2011). The four LARG perspectives are recognised as a suitable response to the changing demand and characteristics of modern markets. The integration of these four perspectives on the same PMS is of paramount importance also from a strategic point of view. If, on one hand, lean strategies would call for designing products to minimize the waste and increase the added value for the customer, agile and resilient strategies, on the other hand, advocate that a supply chain must be responsive to customers and able to regenerate after a disruption. Lean manufacturing and agile manufacturing paradigms have often been studied together in operations management literature. Some studies in the literature declare that lean and agile are somehow overlapping concepts and therefore have tried to distinguish them in a precise way (e.g., Narasimhan et al., 2006). This is why in LARG models the two perspectives are evaluated separately. Greenness, finally, suggests that all the above aspects should be obtained without affecting the environment. For a proper implementation of the LARG concepts, there is typically the need to measure the capability of supply chain players along the four perspectives, which could be obtained by developing an appropriate set of metrics. Also, evaluating the supply chain performance against these metrics is important for undertaking possible actions for improving them.

As mentioned in the introduction section, the available literature includes a variety of indexes useful for the evaluation of the lean, agile, resilient and green perspectives of a supply chain. Although the importance of PMSs is well known, however, finding a suitable set of metrics is not an easy task.

B. Data collection and computational approach

The set of LARG indexes elaborated in a previous study was tested on a big Italian company, called *Company A* for the sake of confidentiality, operating in the production of vegetable (tomato-based) shelf-stable sauces and located in the North of Italy. The case study company is actually well-known to academics of the University of Parma, having carried out various research projects with the University and having been visited several times, for didactic and research purposes. Moreover, some of the authors of this paper have carried out research projects in the field of the production of tomato sauces and had the occasion of

visiting various companies working in that field, thus acquiring a good knowledge of the relating processes and system. That knowledge was corroborated by a dedicated interview carried out with the logistics manager of Company A, who provided a detailed picture of the system (i.e., the supply chain) under examination.

Various sources of data were used for providing a quantitative assessment to the set of indexes listed in the previous section. As recalled just above, an interview was carried out with the company's logistics manager, with the aim to discuss the indexes, their applicability to the context of the company and the context in which the company operates (relating details are summarized in section III). Other relevant sources were internal reports of Company A and the company's balance sheet, that cannot be reported in this paper because of confidentiality reasons.

From a practical point of view, it was found that the company under examination already had in place a useful PMS, in which some indexes of the LARG model were included. For those indexes, obviously, the evaluation was quite immediate and was made directly during the interview. It basically consisted in retrieving the numerical value of the index and translating it into a linguistics judgement, based on an appropriate scale chosen for the purpose of this study. On the contrary, for indexes not already evaluated by the company, a more detailed analysis was made, involving the pertinent business functions of the company, for assessing them against the proposed scale.

The measurement scale used ranged from 1 (very low) to 4 (very high). The scale was reversed for indexes that are "cost" attributes, meaning that "the lower the better" logic applies, as opposed to "the highest the better" logic, which typically applies to "benefits" attributes. The qualitative scale was preferred, compared to the quantitative one, for two reasons. First, for the sake of confidentiality, it is not possible to display the numerical values of the various indexes. Second, performance indexes typically have different units of measurement, which makes them difficult to be compared. Using the same scale for all indexes means normalizing them and obviously involves some losses of information, but at the same time, allows for comparing the performance obtained against the various parameters and derive synthetic measures.

For each of the indexes in the perspective, a judgement was therefore used to express the performance reached by the company; these performance values were averaged to obtain an aggregated output for each perspective. A radar chart (Kolence, 1973) was finally built to display the company's performance against the four perspectives in a synthetic way.

III. Application and discussion

A. Context description

The Italian market of shelf-stable sauces is quite small, overall, with less than 5% of the Italian dishes dressed with ready-made sauces (in UK, this figure is 95%). As opposed to fresh sauces, shelf-stable ones do not need particular thermal conditions. Also, from a logistics point of view, retail delivery points, frequency of delivery, stock management policy and type of shelf differ if taking into account shelf-stable vs. fresh sauces. This is why, typically, manufacturers focus on one specific product category only.

In the shelf-stable sauces context, Company A is leader in the Italian segment. There is only one other Italian company in that segment that can compete with Company A, plus two/three relevant competitors at global level. Besides these competitors, in Italy ready-made sauces are sometimes produced by private labels, which are increasing their offer of private products, often manufactured by copacker. Indeed, the production capacity of companies working in the vegetable sauces market typically exceeds the demand for the final product, and it is, therefore, easy to find a company willing to work as a copacker.

The complexity of the retail channel is usually higher than that of the procurement channel (in other sectors, different from that of food products, an opposite situation might occur). Indeed, food products can be sold through various channels, such as traditional retailing, online shopping, small shops, or the Ho.Re.Ca. channel. Differentiating among different channels is a form of redundancy, which increases the resilience of a system, and makes, at the same time, the distribution network quite complex.

The slightly lower complexity of the upstream supply chain can actually vary depending on the type of product under examination. Canned goods, due to the numerous ingredients needed for their production, will have a much more complex management and organisation of supply than pasta, which needs only two/three raw materials; the total logistics cost of the system will obviously vary in a similar way. Moreover, the supply chain structure will depend on the specific processes carried out internally. For example, in the case of the production of canned tomatoes (e.g., tomato puree or pulp), there is the need for locating the production plant close to the fields in which tomatoes are harvested. Indeed, these products will lose their characteristics during transport. Also, the harvesting phase is very quick, lasting typically 60 days per year. In addition, during the processing phase, the number of raw materials halves approximately. Similar considerations hold true for other agricultural raw materials, such as basil, required in many recipes of vegetable sauces. Food products, indeed, are made from agricultural raw materials, whose availability depends on various factors, including, e.g., the climatic conditions of a geographic area or weather conditions

during the year. Also, a food product typically requires numerous raw materials, including some "critical" one, which, if unavailable, would compromise the production. For counteracting the possible unavailability, multiple sourcing strategies are typically implemented; this means that more suppliers are available for the same raw material (particularly for a critical one), with a different geographic location. Stocks (if possible) are a widely used countermeasure against the sudden unavailability of raw materials or suppliers.

In terms of sustainability, food production requires a relevant amount of energy, fuels and other facilities. Using renewable resources as alternative to fossil resources is a possible way for greening the production process. Waste can also be generated during delivery, unloading, storage or transport of raw materials (vegetable waste); at the processing stage (product or raw material waste); in other processes, due to accidental causes (e.g., a product that is altered in quality).

B. Case study description

The tomato sauces plant of Company A has a very high production capacity, reaching approx. 60,000 tons of sauce per year. Also, it is relatively new and has been designed to be particularly advanced, efficient for production and energy usage. Overall, that facility is able to produce 24 different varieties of sauces, with a minimum quota of scraps and by-products, thanks to two new production lines added to the original ones in 2018. The set-up time has a minimum impact on the efficiency of the process. Compared to similar sauce production plants, the plant under examination generates 32% less carbon dioxide emissions; similarly, water consumption of the plant is up to 47% lower than other plants. The company also has various certifications relating to sustainability aspects.

From the point of view of the stock level, raw materials for sauce production are seasonal and must be used when fresh; it is therefore necessary to anticipate the production plan. However, some aspects of the food supply chain can actually be controlled (or at least predicted), while other ones fall outside the company's control (e.g., bad weather conditions). This is why Company A has various sourcing channels on which to source raw materials if needed. Another way by which Company A copes with scarcity problems in the food chains under examination is the usage of speculative stocks. For example, triple tomato concentrate is manufactured only in those years in which there is an abundance of raw material and could be used in subsequent years if necessary.

As far as the distribution is concerned, Company A delivers its products only through the large-scale retail channel, while the Ho.Re.Ca. channel or other channels are not used. Appropriate marketing strategies are instead implemented when offering the product on the large-scale retail channel, so as to highlight the product's brand and quality, and offering it at a suitable price; the final consumer, in fact, is typically more sensitive to product quality than to price.

C. Performance evaluation

From the interview and by consulting other relevant sources, the performance values of indexes in embodied in the LARG model were evaluated for Company A as follows:

Lean indexes:

1. Operation Throughput Time (OTT) and Shop Floor Throughput Time (STT): 4
2. Incidence of changeovers and interruptions on the total production time: 4
3. Overall Equipment Effectiveness (OEE) = Availability x Efficiency x Quality: 4.

Agile indexes:

4. Number of supply chain collaboration practices implemented and their diffusion across the supply chain: 3;
5. Inventory turnover rate = Amount of sales / Average Inventory level: 3;
6. Total supply chain lead time of products: 3.

Resilience indexes:

7. Number of production lines, breadth, and depth of range: 4;
8. Percentage of usage of the various distribution channels: 1;
9. Number and geographical areas of suppliers of critical raw materials: 4;
10. Level of stocks of critical raw materials: 4.

Green indexes:

11. Number of certifications obtained in the field of environmental and energy sustainability: 4;
12. Amount of energy consumed from fossil resources and renewable sources 4;
13. Amount of waste, scrap and by-products: 4.

The corresponding radar chart is proposed in Figure 1.

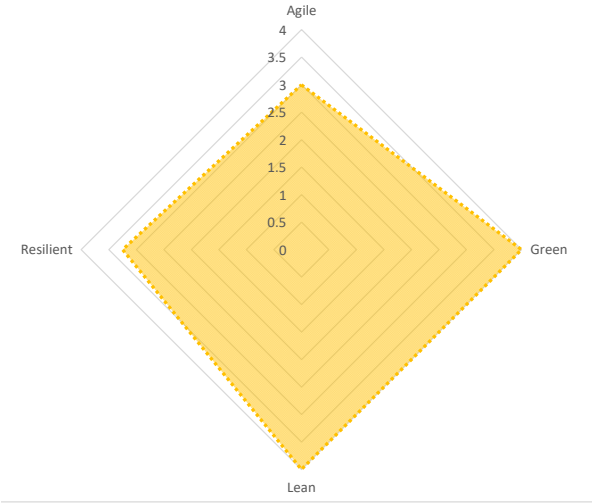

Fig. 1. Radar chart of the Company's performance

From the outcomes above and the synthetic representation in Figure 1, it emerges that Company A shows very good or excellent performance against almost all indexes evaluated. The only exception is about the percentage of usage of the different distribution channels, as the company's distribution strategy only relies on the large-scale retail channel, neglecting other possible channels. This slightly reduces the company's performance in terms of resilience. From a practical point of view, the company could consider widening its sales channels in the future. Despite this limitation, however, the aggregated performance values are always high, scoring at least 3 in all perspectives evaluated.

IV. Conclusions

Measurement has become a fundamental activity in any type of business and PMSs are fundamental to gain market power and making the supply chain efficient.

In line with these considerations, this paper has proposed an evaluation of the LARG (lean, agile, resilient, and green) performance of a real food system, whose focal company is a big manufacturer based in the North of Italy. The set of useful indexes to be applied in the context under examination was taken from a previous study by some of the authors, who have exactly delineated a LARG framework for food supply chains and identified a set of appropriate performance metrics. In this study, which complements the previous one, these indexes were evaluated with respect to the chosen case study. From the implementation of the model and from an analysis of the numerical outcomes obtained, it emerged that the targeted company excels in many of the indexes included in the model, and has, overall, a very good performance against the lean and green perspectives. The index referring to the number of distribution channels on which the products (tomato sauces) are sold is the KPI that received the lowest score. The company, indeed, sells its products mainly in the traditional retailing channel, which could jeopardise the resilience of the system. Actually, resilience is the perspective that would deserve particular attention for ensuring the competitiveness and efficiency of supply chains, as both the COVID-19 pandemics (in 2020-2021) and the war (at present) have clearly shown that external unpredictable disruptions could always be observed in real supply chains (Rinaldi et al., 2022). Hence, the company is advised to take this result into consideration, with the possible aim to improve its resilience by enlarging its distribution network in the future. Apart from this index, however, no further issues emerged for the company under examination.

Again from a practical point of view, the main challenge in applying LARG models in real cases is the proper identification of the set of indexes to be used. Although there are numerous performance metrics in literature, indexes typically need to be customised taking into account the specific market field, for being effectively used in a context and capturing its real situation. Hence, this paper also has the (even scientific) merit of validating a set of suitable indexes for the food production context; these indexes can therefore be used in practice by companies operating in this field. The results returned by the application of the model can be directly used by companies to evaluate their current performance against the LARG perspectives, as well as to highlight the aspects that need improvements (as also shown for the case of Company A).

From the purely scientific point of view, LARG models are not new in literature, as they were introduced at least one decade ago. However, it is easy to observe that they have started being reproposed in the recent times, probably because the recent disturbances recalled just above have highlighted that resilience, in particular, is crucial for supply chain success. Hence, this paper is expected to revamp research relating to the LARG models and to propose their wider usage in practice. The authors themselves are currently carrying out various research activities which involve, to different extent, the development of LARG models. Improvements to these models can also be suggested; for example, new perspectives could be added to the basic four already covered by the LARG models, to capture further characteristics of supply chains. Also, more indexes could be included in the models. Indeed, besides the already recalled importance that resilience has gained in recent times, green/sustainable supply chain management is another theme which has largely been debated in the last years; various indexes are currently available in literature and could be added to the green perspective. Lastly, identifying the most used indexes could somehow guide towards the selection of the appropriate ones. Empirical studies, in the form of survey analyses, could be used to this end; again, this forms part of the ongoing research activity of the authors.

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