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Sustainability Assessment in the Food Supply Chain: Study of a Certified Product in Italy

The assessment of sustainability practices in the supply chain involves not only defining the measures or indicators, but also implementing, using and updating them according to driving elements that motivate companies to opt for sustainability. The aims in this study are to investigate if, how and why firms in different stages of the food supply chain assess their sustainability, and the alignment of the supply chain sustainability (SCS) assessment with the SCS practices and drivers. This paper studies the case of Grana Padano cheese, one of the major Italian PDO (protected designation of origin) products. The case comprises eight companies in the main three supply chain stages; plus, the Consortium that manages the PDO label. The Grana Padano supply chain opts mainly for a loose-coupled approach in their SCS performance management. The study contributes to the SCS literature by providing a typology of assessment approaches, in terms of alignment among drivers, practices and measures, and provides insights for understanding the reasons why companies adopt a certain approach.

Keywords: sustainability assessment, sustainability practices, sustainability drivers, food supply chain, PDO product, certified product

Word count: 11145

Introduction

Literature concerning supply chain sustainability (SCS) performance has been prolific in proposing numerous indicators and reporting systems for different industries (Bloemhof et al. 2015; Epstein and Yuthas 2012; Sureeyatanapas, Yang and Bamford 2015; Walker, Di Sisto and McBain 2008). Sustainability assessment in the supply chain entails evaluation of environmental, social and economic dimensions, which means evaluating many aspects and having multiple objectives simultaneously. However, contributions in literature recognise that it is impractical, especially because of the effort required, the difficult access to data, redundant measures, and the lack of clarity in the purpose of the measurement (Bourne et al. 2002; Genovese et al. 2017; Varsei et al. 2014). Furthermore, SCS assessment implies not only defining measures and metrics, but also considering their implementation, use and update (Bourne et al. 2002) in multiple tiers of the chain (Bai and Sarkis 2014; Gualandris et al. 2015;

Varsei et al. 2014). Hence, a more comprehensive understanding of SCS assessment in the supply chain requires a broader consideration of what drives companies in different supply chain stages to adopt sustainability, and its corresponding evaluation, prior to establishing an SCS assessment management strategy, which corresponds to each stage's objectives and capabilities. Thus, in this study we aim to investigate i) the path toward sustainability assessment in different supply chain tiers, ii) whether the SCS assessment is aligned with the practices implemented and the drivers perceived, and iii) the consistency of SCS assessment along the supply chain.

The context of study is the food industry, which is facing increasingly demanding sustainability issues. For instance, product quality, safety, nutrition content, origin, traveling distances, scarce natural resources, and volatile food prices are commonly cited (FAO 2013; European Commission 2014). Literature has explored the diffusion of sustainability practices in the food supply chain (FSC) for handling such issues (Mena, Humphries and Choi 2013; Wilhelm et al., 2016). Similarly, sustainability performance is also studied in the food industry (Bourlakis et al. 2014; Bloemhof et al. 2015; Epstein and Yuthas 2012). Nonetheless, in addition to defining the metrics, there is a need for further research on the challenges of implementing sustainability assessment, using and updating them in a specific industry, and in particular aligning sustainability assessments properly with sustainability drivers and practices, considering multiple stages of the supply chain.

Specifically, the study focuses on the Grana Padano cheese supply chain. Italy is the country with the highest number of certified products in Europe (Fondazione Qualivita 2015), which demonstrates the clear desire to preserve quality and origin in Italian food products. European regulations regarding food product quality involve three schemes to identify products and foodstuffs farmed and produced to exact specifications (European Commission 2018): PDO (protected designation of origin), PGI (protected geographical indication) and TSG (traditional specialty guaranteed). In this paper, we study the Grana Padano cheese, one of the most consumed and exported Italian PDO products. Eight companies are investigated on three stages of the chain, as well as the role of the overseeing body, the Consortium. The sustainability drivers, practices and assessments are identified along the chain, and an analysis of the SCS assessment management strategy alignment and consistency are included in this study.

The paper contributes to literature about SCS assessment and provides a range of approaches in terms of alignment among drivers, practices and assessments, in a particular FSC. In addition, the study shows the level of SCS assessment alignment in different SC stages and how it is influenced by different factors in this specific product supply chain.

The paper is organised as follows: the context of study is described, then a comprehensive review of the relevant literature is presented. Subsequently, the research questions are formulated along with the research methodology applied in the study. Next, the main findings are described, and finally the discussion of results and conclusions are presented.

The Grana Padano Case

The PDO certification is a European quality scheme that requires foodstuffs to be produced, processed and prepared in a given geographical area and following traditional knowledge (European Commission 2012). Therefore, many practices for land utilization, animal welfare, processing and nutritional characteristics are expected in these kinds of products (European Commission, 2014). In the European Union, there are 584 PDO food product registrations, and 23% of those are Italian products (Fondazione Qualivita 2015). The label applies to various cheeses, meats, breads and pastas from throughout various regions (European Commission 2018). Among those products, cheese is the one with the highest number of PDO registrations in Italy, representing almost half million tons of yearly production and sales of 6.555 million Euro in 2013. Out of those cheeses, "Grana Padano" and "Parmigiano Reggiano" represent up to 41% of the sales (Fondazione Qualivita 2014).

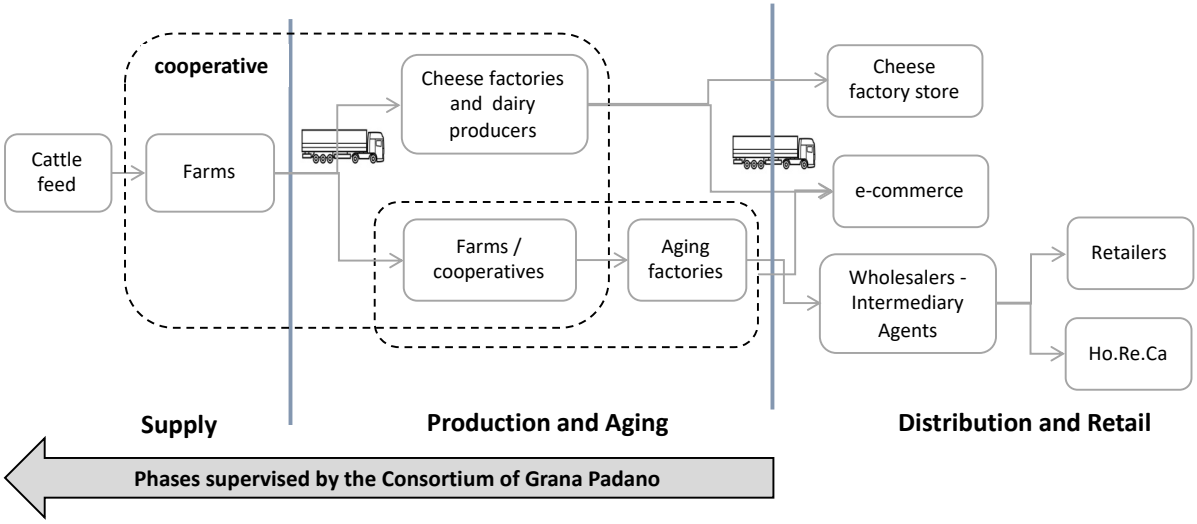
The Grana Padano name is derived from two terms: "Grana" that refers to its granular texture, and "Padano" that denotes the production area, which is the "Pianura Padana", the plains around the Po River, which cover several provinces in northern Italy. Grana Padano is said to be created by the Cistercian monks in the year 1135 near Milan. Food preservation techniques were limited and with the aim of preventing milk deterioration, the monks developed a process that involved slow cooking the milk, adding rennet and salt, and ripening the product for a certain amount of time. By 1477, it was one of the most famous Italian cheeses (Consorzio Tutela Grana Padano 2015; Futura Foods 2016).

The Grana Padano Consortium was created in 1954 with the aim of guaranteeing product quality and origin, and promoting it to increase the market share. The Consortium involves companies throughout the chain in order to preserve the original recipe and quality. Moreover, the Grana Padano PDO label, obtained in 1996, required some activities to be performed in certain way (e.g., animal food features, production processes and production area), to be an example of excellence, not only concerning the quality of the product but also about social and environmental impact. In 2010, an ethical code was established for guiding transparency and fairness in relationships among members and with the Consortium. This initiative embodies the policies and procedures that all members must follow (Consorzio Tutela

Grana Padano 2015). The three main stages composing the Grana Padano supply chain are depicted in Figure 1.

- Supply: this stage involves activities from cattle feed production to breeding and milking. Cattle feed is monitored and controlled as it influences the milk and the Grana Padano's nutritional composition. Breeders are either independent farms or cooperative members. Different types of farms belong to cooperatives, in terms of volumes of milk produced and level of technology; however, all of them are required to guarantee the standards imposed in the Consortium code and the PDO label.
- Production and aging: this stage is more complex because companies are structured in different ways according to the productive processes they manage. Production and aging encompass the activities needed to transform milk into the finished product, and aging, which requires several months (from a minimum of 9 up to 24). This stage involves two types of actors, cheese factories (or dairy producers) and farms (or cooperatives). The cheese factories usually produce higher Grana Padano volumes, and operate in differentiated business areas (i.e. dairy producers that sell other types of cheese and dairy products), commercialising various products, with leading positions. They have higher turnover and are able to invest resources to improve their operations, if needed. Cheese factories can also manage the aging process directly and may also have access to facilities for portioning, grating and packing. Frequently, cheese factories are owned by a large cooperative or have one of the larger farms as a main representative. On the other hand, the farms (or cooperatives) are smaller companies in terms of production volume, even if they work with many milk suppliers, usually members of the same cooperative. Farms can manage the aging phase internally, though this seldom happens, or another company or cooperative can manage it along with the portioning, grating and packaging processes.

Figure 1. Grana Padano supply chain (created from the Grana Padano Consortium information)



- Distribution and retailing: the third supply chain stage involves the transportation, storage and retail activities and it is not supervised by the Consortium. In this stage, the main selling channels are factories' own stores, e-commerce, and wholesalers, agents or other intermediaries who manage the retail and Ho.re.ca (i.e., hotel, restaurant, catering) channels. The last two are by far the most important in terms of volumes, but also those with the lowest unit margin for the producers.

Conceptual Background

Sustainability Assessment in FSCs

According to Bourne et al. (2002) a performance measurement system (PMS) is conceived in four phases: design, implementation, use and update. In terms of supply chain performance measurement, the PMS usually refers to the individual stages' performance (Aramyan et al. 2007; Seuring and Muller 2008; van der Vorst 2006). Though recently, Maestrini et al. (2017) defined a supply chain PMS as a set of metrics that quantify efficiency and effectiveness, and relationships along multiple firms. Several contributions in previous literature addressed different elements related to PMS phases in supply chain studies, that we summarize in Table 1.

---------TABLE 1 HERE----------

In research related to sustainability in the FSC, authors pointed out, on one hand, that the numerous sustainability metrics or indicators proposed run the risk of being too numerous,

redundant, resource- and time-consuming, difficult to assess or misaligned with the company's strategy. On the other hand, authors underlined that sustainability assessment – which includes economic, environmental and social performance indicators simultaneously – is impractical, especially regarding the effort required, the accessibility to data and the lack of clarity in the purpose of the measurement. From a supply chain perspective, these considerations involve higher complexity. Nonetheless, studies on the first and second PMS phases are rather established, covering different angles and industries. However, a wider view of the FSC considering multiple tiers in the chain could provide new insights about the adoption of a degree of sustainability measures and its relevance for improving performance along the chain by managing the three main sustainability dimensions simultaneously.

Regarding the PMS use and update, research on SCS assessment also describes and distinguishes between risk and opportunity-oriented. Risk avoiding refers to 'criteria or rules about what must not be done', while opportunities to 'what could be improved and should be done'. Nonetheless, literature is still short on studying how SCS performance needs to be managed in food supply chains. That is, how to assess or measure, how to use and update, according to the sustainability and supply chain strategies (Schaltegger and Burritt 2014; Gualandris et al. 2015) considering multiple tiers in the chain and a specific context to analyse the consistency and alignment.

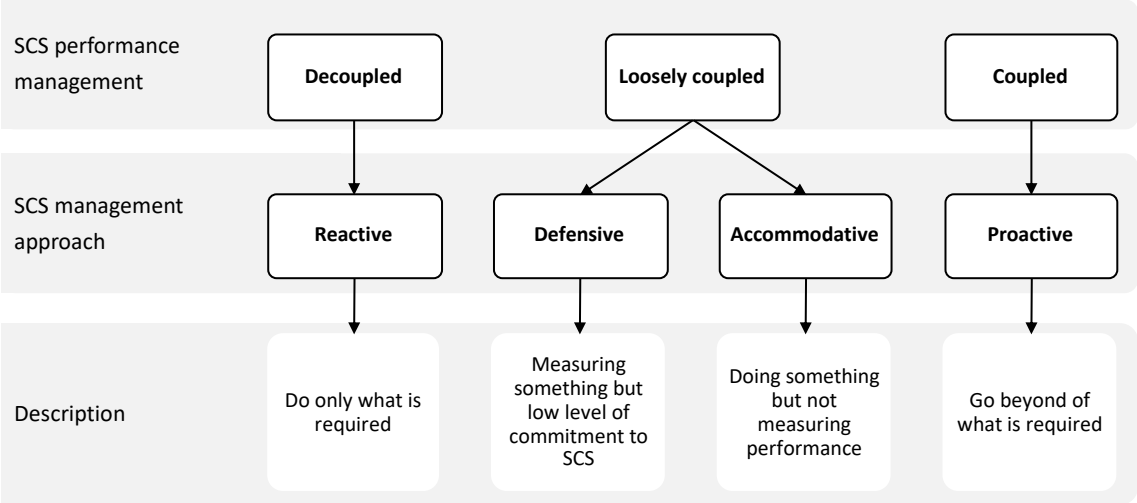
Supply Chain Sustainability (SCS) Performance Management

Previous studies explained that performance measurement and management in the supply chain requires information coming from multiple actors and an agreement among actors in how to obtain the measurements and how to use them along the chain (Grosvold, Hoejmose and Roehrich 2014; Gualandris et al. 2015; Maestrini et al. 2018; Moazzam et al. 2018; Hadiguna and Tjahjono 2017). Furthermore, He et al. (2019) argued that greater awareness of sustainability could be available in inter-firm relationships, as well as in the supply chain, and that it needs to be diffused and integrated.

Specifically, for sustainability performance, literature suggests the benefit of having few but relevant measures and indicators, (Bai and Sarkis 2014; Genovese et al. 2017). For instance, Sureeyatanapas, Yang and, Bamford (2015) highlighted the need to consider quality separately from the economic, social and environmental dimensions for performance measurement in sugar manufacturing and identified the main indicators to minimize inconsistencies. Yet, research is still concerned with addressing the assessment and performance management strategies in multiple supply chain tiers in a particular context, more in-depth, to analyse their

consistency and alignment. To undertake this endeavour, a suitable framework for sustainable performance management is discussed by Grosvold, Hoejmose and Roehrich (2014), in four approaches (see Figure 2): reactive, defensive, accommodative and proactive (as quoted in Carroll 1999; Clarkson 1995; Meyer and Rowan 1977) and van Tulder et al. (2009). Other authors, such as Kähkönen, Lintukangas, and Hallikas (2018), also discussed these strategies while categorizing sustainability practices and arguing which ones tend to be proactive or reactive, and, also which ones could develop dynamic capabilities.

Figure 2. SCS performance alignment (adapted from Grosvold et al. 2014)



These four approaches indicate how SCS performance could be managed in a company and how in turn it has a coupled or decoupled SCS alignment with goals and practices. On one side, the decoupled SCS performance management implies that a company separates its core business from sustainability, does just what is strictly required and just when is required, and focuses only on economic gains (i.e. reactive approach) (Grosvold, Hoejmose and, Roehrich 2014; van Tulder, van Wijk and, Kolk 2009). On the other side of the spectrum, a coupled SCS performance management implies that a company understands and aligns its practices with stakeholder's expectations and institutional aims, even anticipating requirements and responsibilities (i.e., proactive approach). In between, authors identify an intermediate strategy: the loose-coupled SCS performance management. This approach is found in companies that start looking for alignment between practices and measurement, but they have not reached a complete alignment yet. This approach can be either defensive or accommodative, i.e., measuring something but with low level of commitment to improve (i.e., defensive), or doing

something but not measuring it (i.e., accommodative), respectively (Grosvold, Hoejmose and, Roehrich 2014 based on Clarkson 1995; Meyer and Rowan 1977).

Thus, studying the adoption of one of the four approaches (i.e., reactive, defensive, accommodative and proactive) and the consequent strategy (i.e. coupled, loose-coupled, decoupled) in multiple tiers of the food supply chain could provide new insights about the level of engagement with SCS practices, and how companies handle risks and grasp the benefits of their SCS management.

Sustainability Drivers and Practices in the FSC

Prior to studying SCS assessment, the motivations for sustainability implementation as well as the practices actually used are to be identified. Several studies on sustainable supply chain management have identified a broad range of drivers that persuade companies to develop environmental and-or social practices in their supply chains. Recent studies also discussed how institutional pressures motivate companies in different FSC supply stages to implement certain sustainability practices (León-Bravo, Caniato and, Caridi 2018) or how sustainability assessment initiatives exert pressure to achieve sustainability (Kauppi and Hannibal 2017). For the aims of this study, the drivers include motives such as internal strategic motivations, external pressure from stakeholders – that can be coercive, normative or mimetic (Kauppi and Hannibal 2017; León-Bravo, Caniato and, Caridi 2018) – or the company's desire to gain a competitive advantage via sustainable strategies. We summarize the drivers for sustainability from literature in Table 2. The drivers for sustainability could come from outside the company, as market pressure or regulations (D1, D5); or from inside, as intrinsic to company culture or top management beliefs (D2, D3, D4). We follow previous literature on sustainability to classify the main drivers, combining different perspectives.

---------TABLE 2 HERE----------

In addition to the drivers, the sustainability practices implemented in the FSC are defined as the initiatives, projects or programs, referring to all possible actions that a firm in any stage of the FSC puts in practice with regard to sustainability. The categories as well as the practices in Table 3 are based on propositions from the broad range of previous studies and industry organizations, as presented in León-Bravo et al. (2017) and complemented with information from Chien and Shih 2007; Matopoulos and Bourlakis 2010; Porter and van der Linde 1995; Vachon and Klassen 2008; and Zhu, Sarkis and, Lai 2013.

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Research Objectives and Questions

Previous contributions in literature have raised the need to further investigate sustainability performance management in the supply chain (Schaltegger and Burritt 2014, Varsei et al. 2014). The issue is that each company in the supply chain would apply the indicators or measures that make more sense for them, according to their own sustainability drivers, though we lack in understanding how such drivers in different supply chain stages trigger the implementation of sustainability practices and their corresponding assessment.

In the FSC, performance measurement has focused on assessing quality and financial aspects (Aramyan et al. 2007), though sustainability performance measurement is increasingly present in literature and practice (Bloemhof et al. 2015; Bourlakis et al. 2014; Gualandris et al. 2015; Schmitt et al. 2017; Walker, Di Sisto and, McBain 2008). Numerous indicators of sustainability are proposed but there is no clear understanding of the drivers that lead companies in the food supply chain to use one or more metrics to assess their performance.

In this study, we consider three stages of the Grana Padano supply chain. Although certain practices could be expected along the chain because of the PDO label, companies may apply other activities that focus attention on the environment and the community, or to reinforce the traditional image in the market, that are not known or described so far. In the same way, companies in the Grana Padano supply chain must report certain figures and performance results to the Consortium that oversees the chain, but not every practice a company implements must be reported. Hence, there are aspects of sustainability that need to be identified before setting up a sustainability performance management strategy. Therefore, the first objective in this study is investigating the approach toward sustainability performance assessment that different stages in the Grana Padano SC deploy, that is, the reasons why firms, assess their sustainability performance in different stages, if they do; and the dimensions of sustainability they assess, as reported in the first research question:

RQ 1 Do firms in the Grana Padano supply chain implement sustainability practices and assess sustainability performance, and why?

RQ 1.1 What are the reasons (drivers) to act towards sustainability?

RQ 1.2 What are the sustainability practices implemented?

RQ 1.3 What are the sustainability assessments applied?

Previous contributions in literature noted that SCS assessment is usually not aligned with the practices implemented nor the company strategy (Bourne et al. 2002; Grosvold, Hoejmose and, Roehrich 2014; Schaltegger and Burritt 2014) or it responds to external pressure (Kauppi and Hannibal 2017). Additionally, considering the PMS phases (Bourne et al. 2002), research about SCS assessment is concentrated in metrics design, lacking studies on the actual implementation and use of the PMS (Bourne et al. 2002; Gualandris et al. 2015), which could provide insights to companies on how to actually apply the measures and to handle the information obtained.

Specifically, SCS assessment in the food supply chain risks being disconnected from the company strategy, thus making it much more difficult for firms to apply the measures, use the data obtained and identify opportunities for improvement (Bourne et al. 2002; Neely, Gregory and, Platts 2005; Genovese et al. 2017). In particular, companies in the Grana Padano supply chain report certain elements (see Appendix A) to the Consortium in order to ensure the PDO requirements (Consorzio Tutela Grana Padano, 2015), however, there is no obligation to communicate all the practices they implement in regard to the environment and the community, if they deploy any. Moreover, although companies do report certain measures, it is still necessary to study if such measurements respond to the drivers and practices that shape the company approach toward sustainability. The understanding of the alignment among sustainability assessments, practices and drivers could delineate the SCS performance management strategy for a company to meet stakeholders' expectations and organizational goals (Grosvold, Hoejmose and, Roehrich 2014). Therefore, the second objective in this study is to investigate whether the SCS assessment is aligned with the SCS practices implemented and with the drivers perceived, in the Grana Padano supply chain, as reported in the second research question:

RQ 2 How aligned is the SCS assessment with practices and drivers in the Grana Padano supply chain?

RQ 2.1 Is the SCS assessment aligned with drivers?

RQ 2.2 Is the SCS assessment aligned with practices?

Finally, the third objective is to analyse the consistency along the Grana Padano supply chain in terms of their SCS assessment management approach (decoupled, loosely coupled, coupled). In particular, since the Grana Padano supply chain is a regulated environment where certain practices are expected, it would be interesting to understand whether the SCS assessment is

consistent among the stages in the chain, and if there are similarities or differences and why, prior to defining an SCS performance management strategy that is beneficial for everyone. Hence, the third objective is to study the consistency of SCS assessments along the chain and to understand the reasons behind them, as reported in the third research question:

RQ 3 What are the reasons for adopting a specific SCS assessment management approach in different Grana Padano supply chain stages?

In order to address the research questions listed above, we needed to first identify the elements of investigation, i.e., drivers, practices and assessment for sustainability in the FSC. These elements are drawn from established constructs in literature and by international organizations as well. Specifically, the drivers for sustainability we considered are listed in Table 1, and sustainability practices in the FSC are listed in Table 2. Regarding sustainability assessment in food industry, we identified and summarized several specific contributions for this industry (Aramyan et al. 2007; Bloemhof et al. 2015; Bourlakis et al. 2014; Matopoulos and Bourlakis, 2010; Pullman, Maloni and, Carter 2009; van der Vorst, Peeters and, Bloemhof 2013; Varsei et al., 2014; Yakovleva. Sarkis and, Sloan 2010). Moreover, in this study, the SCS assessment needs to be characterised according to the specific context of investigation, the Grana Padano supply chain, as reported in Appendix A.

Research Methodology

Due to the exploratory nature of this study, the research method selected in this paper is case-based (Yin 2009), covering three stages of the Grana Padano supply chain and the overseeing body, the Consortium. The case study method is useful to investigate contemporary phenomena, not yet clearly understood, and also when an existing theory can be extended by including new elements or situations that deserve deeper observation (Meredith 1998; Yin 2009). The a priori identification of the investigation variables is suggested in the case study method to "measure the constructs more accurately" (Eisenhardt 1989) when researchers intend to inductively develop theories (Eisenhardt 1989; Yin 2009). Studying multiple cases in multiple supply chain tiers is recent in literature and suggested by authors for further developing the field (Meqdadi, Johnsen and, Johnsen 2017; León-Bravo et al. 2017; Mena, Humphries and Choi 2013; Wilhelm et al. 2016). Multiple sources of evidence compose the data analysed (e.g., interviews, company documentation, archival records), ensuring construct validity and reliability in the study.

Moreover, triangulation of data is performed among data sources and among multiple researchers (Yin 2009).

Data Collection and Analysis

The case of the Grana Padano supply chain in this paper is composed of a set of eight units of analysis, summarized in Table 4, plus the Consortium as governing body. The companies were selected observing suggestions from Meredith (1998), Yin (2009), and Seawright and Gerring (2008) to include multiple units with polar or extreme characteristics. Thus, according to the Seawright and Gerring (2008) classification, cases in this study are diverse. We include small and large companies, companies performing several productive activities by themselves and others that focus on only one activity, independent companies and others that are cooperative members, companies that are concentrated on one product and others with different product lines, and finally, companies positioned in different stages of the supply chain. Thus, cases are expected to represent the main variation of the population.

---------TABLE 4 HERE----------

In the *Supply* stage, we analysed three farms, members of the same cooperative (Producer 1), with different sizes and product portfolios. All companies in this stage are rather small family-managed farms that produce cattle feed for their own consumption, breed cattle and produce the milk to sell specifically to P1. Farms are particularly responsible for the cheese quality and organoleptic characteristics. S1 is the smallest firm, though the most varied in terms of products sold: butter, ricotta cheese, whey, male calves, hay and rye. Instead, S2 only sells milk and fodder; while S3, the largest farm in this stage, and is specifically dedicated to producing and selling milk for Grana Padano cheese.

In the *Production and aging* stage, we selected three different sized cooperatives that operate as cheese factories in differentiated business areas. All of them transform the milk into cheese, and then age it and stock it before selling it through different channels. The largest company grates, portions and packages the cheese into different configurations too. P1 is the smallest cooperative in our sample, and produces Grana Padano cheese but also butter, caciotta cheese and ricotta. It sells 5% of its Grana Padano directly to consumers in its own sales point, and the rest to a second level cooperative (wholesaler). P2 has a similar structure as P1 but instead its production is devoted to Grana Padano only; the aging process is done as well, though only for 30% of the production, the rest is sold to other aging factories. P3 is the largest

in the sample, dedicated to production, aging, portioning, grating and packaging. P3 also produces Provolone cheese, butter and fresh milk, and sells its products mostly (60%) to Italian retailers, with its own brand or with a private label, and the rest is either exported or sold to the Ho.re.ca channel.

In the *Distribution and retailing* stage, we investigated two companies with different types of operations and sizes as well. R1 is a large supermarket chain operating in all food categories, with both private label and general brands. The company devotes especial attention to traceability, monitoring and control of private label products as they are strongly related to the company's reputation. In particular, Grana Padano cheese is sold as a general brand and therefore the level of supervision is rather standard because the company entrusts the PDO label. The second company studied in this stage is R2, a large distribution and retail organization that puts together a series of small supermarkets and distribution centres. R2 is also a member of the National Distributor's Association that delineates specific rules in terms of competition, compliance, sustainability and transparency. R2 sells both private labels and general brands, being Grana Padano in the second category. The company performs standard controlling procedures for general brand products because suppliers remain accountable for the product's characteristics.

Lastly, the *Grana Padano Consortium* was studied, as the overseeing body that monitors, controls, and safeguards the product's quality and origin features, and also supports supply chain actors. The role of the *Consortium* in this supply chain is determined as the policy settler, market supporter and brand protector. Therefore, this organization includes actors in the entire productive chain, since they need to be registered and certified in order to produce and sell the PDO product.

Information was collected from multiple sources for each company, e.g., semi-structured interviews, official Consortium website, company websites, company sustainability reports, and industry news; in this way, we could ensure construct validity and reliability. The data collection and analysis methodology adopted is consistent as well with previous case-based studies such as Wilhelm et al. (2016), León-Bravo et al. (2017), Meqdadi, Johnsen and Johnsen (2017), León-Bravo, Caniato and Caridi (2018). Data collection followed three main non-consecutive steps.

First, we gathered information from the *Consortium* regarding registration, number and types of operations performed, geographical localization, and contact information, when available. Additionally, with the Consortium archival records online, we were able to map the supply chain steps, to identify the type of companies that participate in the chain and understand

the rules that all of them are compelled to perform. The supply chain mapping and identification was validated with the president of the *Consortium*.

Second, semi-structured interviews allowed us to identify the main variables under study; they were performed in person or by phone, depending on interviewee availability and preference. The interview protocol was drafted in a first version with the president of the *Consortium*, and was then updated and adjusted according to the supply chain stage; and it was revised after each interview as well, when new elements were discovered (interview protocol available upon request). Interviewees in the *Supply* stage were company owners, and in the *Production and aging* stage, they were the cooperative vice-president (P1), company director and quality manager (P2) and logistics manager (P3). In the *Distribution and retailing* stage, they were the purchasing category managers for dairy products. In companies P2, R1 and R2 the interviewee was appointed by the top management during the first phone or email contact. In all the other companies, the respondent was the person managing all external relationships.

Third, a secondary data search to complement information that could have been unclear or incomplete: if the informant was not sure about the data, he/she pointed out the sources that could confirm the information, or provided us with printed documentation that were also useful for triangulation and proving reliability. Secondary data were retrieved mainly online, starting from the Consortium information (e.g., regulations, codes, history, localization), and then, we consulted company websites, when available, otherwise, industry and regional associations, and news reports were compiled both before and after the interviews. Likewise, printed documentation was collected from industry magazines or was provided by the interviewees. All these data were useful to complement the evidence collected in the interviews and in the official Consortium documentation. For instance, companies could be registered with the Consortium as cheese factories and aging facilities, and then, during the interview, we could either confirm or complement the data; e.g., if the company does not age the cheese, or if the company also portions the product. This level of precision was important during data collection because companies involved in different activities with various facilities would perform different sustainability practices, driven by different reasons, and they would assess their efforts differently. Similar data triangulation was performed when identifying all the variables in all companies, hence ensuring data reliability throughout the study (Yin 2009).

In SCS research, the possibility of finding social desirability bias (Carter and Easton 2011) has been recognized. Even though we tried to prevent it by identifying the research variables a priori, and, collecting data before and/or after the interview, it may still have happened. However, we consider that the analysis and results of the study are still relevant,

since companies that declared to be sustainability-oriented but then (if their implementation and assessment were not coherent) demonstrated their real position.

Subsequently, for the analysis, data were coded according to the variables defined in Table 1, Table 2 and Appendix A. With the intention of achieving a supply chain view, the variables of investigation were analysed first within each company, then across the companies within each supply chain stage, and finally across the three stages, for the purpose of identifying patterns and recognizing relationships among the constructs under study (Eisenhardt 1989; Yin 2009). These analyses also allowed us to depict the alignment among the parameters, i.e., drivers, practices and assessment for sustainability in the Grana Padano supply chain, thus gaining validity in the study design.

Regarding the alignment among the variables, two levels of alignment are observed. First, the application of at least one of the sustainability assessment measures as a response to the corresponding sustainability driver determines the alignment between the assessment and drivers. Second, the existence of an assessment mechanism related specifically to the sustainability practices implemented in the company would determine the alignment of practices and assessment. This alignment identification is useful to characterize how connected the company sustainability assessment is with its strategy, and therefore the potential for the company to better use, update and improve its performance (Bourne et al. 2002; Neely, Gregory and Platts 2005; Gualandris et al. 2015). The level of alignment in each company will determine if they have a coupled, loose-coupled or decoupled approach, based on Grosvold, Hoejmose and Roehrich (2014) (Figure 1). Consequently, when comparing different FSC stages, consistency implies that the SCS assessment alignment is coherent among companies in the same FSC stage and then, among the three stages in the chain.

Findings

SCS Drivers, Practices and Assessment in the Grana Padano Supply Chain

The research questions RQ 1.1, RQ 1.2 and RQ 1.3 are addressed in this section. Table 4 shows an example of the first analysis performed for Producer 2 (P2). The second column in the table lists the drivers (RQ 1.1). The second step was to recognize the sustainability practices (RQ 1.2) related to the drivers stated, presented in the third column in Table 5. Lastly, the assessment (RQ 1.3) used in each company for every practice was identified and listed. An ´X´ in the last column indicates that a practice is not assessed in any way. For instance, packaging reduction, an environmental practice, implemented by P2, but the company does not use any assessment measure to know how much or how often the packaging is reduced. Similar observations

regarding drivers were found in the other organizations in the *Production and aging* stage (P1 and P3). Only in P3, the social responsibility driver (i.e., D3), was declared as a motivation.

---------TABLE 5 HERE----------

In the *Supply* stage we could observe that the two dominant drivers were regulatory compliance (i.e., D1), and environmental concern (i.e., D2), found in all three firms. Farms are concentrated on following the Consortium guidelines, which are strongly connected with the environment and quality: for instance, land preservation, attention to cattle feed composition, or ensuring animal welfare. Furthermore, farms are investing in organic production that is not strictly required by the PDO label; and in obtaining voluntary quality certifications. They are also implementing green processing practices and assessing them, e.g., water consumption, use of renewable energy. Only in the *Distribution and Retail* stage was social responsibility (i.e., D3) stated as a motivation for sustainability, along with regulatory compliance, environmental concern, and company image – that is with D1, D2, and D5, respectively. Retailers implement practices along all those drivers.

Moreover, Table 6 summarizes the number of practices applied and the number of practices assessed in each company. It is notable that the eight firms studied in the Grana Padano supply chain do perform sustainability assessment for at least half of the practices implemented in each company. Regarding assessment in the *Supply* stage, farms do monitor most of their environmental practices; also because the Consortium requires them to report e.g., temperature in the cowsheds, double milking per day, hours of grazing, etc. In the *Production and aging* stage, assessment is varied. The focus is primarily on reporting to the Consortium along with the environmental practices. Lastly, in the *Distribution and Retail* stage, the assessment is concentrated on environmental and social concerns.

---------TABLE 6 HERE----------

Table 7 sums up the findings regarding sustainability drivers, practices and assessment, and presents an example of a case statement that supports the answers to RQ1.

---------TABLE 7 HERE----------

Alignment of SCS Assessment with Practices and Drivers in the Grana Padano SC

Two levels of alignment are observed in this research: alignment between assessment and practices (RQ 2.1), and, between assessment and drivers (RQ 2.2). For the former, we can recall findings in Research Question 1, exemplified and summarized in Table 4 and Table 5,

respectively. It was noticed that the eight firms studied in the three supply chain stages do assess their sustainability practices. However, considering the two last rows in Table 6, it was observed that companies do not monitor or control all the practices implemented, thus, suggesting a partial alignment between assessment and practices.

The second level of alignment refers to the application of assessment measures in response to the drivers declared. Although some sustainability practices are assessed, the purpose behind the assessment did not always match the driver originally declared. In order to identify this alignment, first, sustainability assessment data was tabulated according the drivers declared and, second, we searched for a statement in any of the data sources that confirm the application of the measure in relation to the driver. An example is S3 that installed an innovative system for water reuse in the cowshed (i.e., water saving, an environmental practice). The cost reduction gained with this practice is monitored periodically (i.e., assessment), which makes sense for business purposes, but is not directly connected to the environmental driver that was declared (there is no measure for water saved). In our analysis, this farm is not aligning assessment and drivers, even though the practice is monitored, because the type of assessment lets aside potential information that could be used for further environmental development. This exemplifies a loose-coupled approach.

In the downstream stage, R1 presents a coupled approach, i.e., the assessment of sustainability practices is directly associated to the driver stated, only for some practices referring to environmental (i.e., D2) and social concern (i.e., D3), allegedly thanks to its size and structured corporate procedures. However, practices related to regulation (i.e., D1) and company image (i.e., D5) are not monitored, thus the company implements the actions without further understanding of the impact generated, deploying either an accommodative or risk avoidance strategy (Grosvold, Hoejmose and Roehrich 2014; Schaltegger and Burrit 2014.

Similar analyses were performed for each company in the sample, for all the drivers declared and all the assessment measures established, as summarized in Table 8. The fourth column denotes if the company applies at least one assessment mechanism (Partially), or all the practices are assessed (Yes), or if the company does not assess any practice (No). Finally, last column specifies if the existing assessment responds to the corresponding driver (Yes), or if at least one of the assessments corresponds to the driver (Yes, partially), or if the assessment does not correspond to the driver (No). The blank cells in the last column denote that no assessment was present for the practices implemented, and the rows in grey show the alignment, even partial, of driver and assessments.

---------TABLE 8 HERE----------

Summarizing:

- Coupled approach: P2, P3
- Loose- coupled approach: S1, S2, S3, P1, R1, R2
- Decoupled: none

Reasons for Different SCS Assessment Approaches along the Supply Chain

Addressing the third research question, we observed some commonalities and differences in the analysis presented in Table 8. The *Supply* and *Distribution and Retail* stages had some similarities, in spite of having different structures, sizes and business lines. In these companies there is no assessment performed on the practices related to D1 (e.g., no monitoring or follow-up regarding certifications obtained). An example is R1 that acts in accordance with the norms established by mandatory and voluntary certifications, but no further assessment is made of this practice (e.g., to monitor if there is an actual food safety performance improvement or not). This approach is understood as defensive (i.e., loose-coupled) because companies are doing what is needed to reduce reputational risk and respond to stakeholder pressure, but no further monitoring is performed, or further use of the information obtained from the practices implemented.

On the other hand, as described before, no single strategy characterizes the *Production and agi*ng stage as it presents either a coupled or a loose-coupled approach. Recalling Table 4, companies in this stage are indeed different in terms of size, production volumes and operations involved. These could be the contingent factors that influence the SCS assessment approach because companies perceive different motivations, implement different practices and adopt different measures; and just some of the measures are connected to the drivers declared (See Table 6 and Table 8). Overall, the Grana Padano supply chain presents a loose-coupled SCS assessment approach, with the exception of the largest *Producer* that has a coupled strategy (P1). Table 9 summarizes the findings and presents an example data element that supports the answers to RQ2 and RQ3.

---------TABLE 9 HERE----------

Discussion

Companies in the Grana Padano supply chain are subject to verification of compliance from the PDO label (European Commission 2012). In our study, companies apply multiple sustainability practices along the three supply chain stages analysed from which some of those are required by the PDO label while others are implemented voluntarily. Hence, the drivers motivating SCS implementation are certainly regulatory (D1), but also, environmental or social concern (D2, D3) and company image (D5).

Companies in the Grana Padano supply chain assess their sustainability efforts at different degrees. Considering the first level of SCS assessment alignment studied in this paper, the connection between sustainability assessment and sustainability practices was mostly a defensive or accommodative approach (loose-coupled). The second level of alignment, between SCS assessment and drivers, is either coupled or loose- coupled. First, the *Supply* stage is highly aware of sustainability; its assessment is more oriented to reporting to the Consortium and to controlling costs. Thus, it presents a loose-coupled approach, according to Grosvold, Hoejmose and Roehrich (2014) framework. In the *Distribution and Retail* stage, the behaviour is mixed depending on the driver declared, either coupled or loose coupled. Finally, the *Producing and aging* stage differs in its SCS assessment allegedly due to size and structured corporate procedures. Smaller producers could be deploying a risk avoidance strategy (Bloemhof et al. 2015; Grosvold, Hoejmose and Roehrich 2014; Schaltegger and Burritt 2014; Kähkönen, Lintukangas, and Hallikas 2018), meaning that the companies opt for sustainability practices that are required by law, as also noted by Batista et al. (2019) who explained that small companies tend to adopt sustainability for compliance reasons, and that their practices tend to be informal. However, with this approach, smaller companies avoid any potential problems related to the PDO label. Hence, the Consortium and the PDO label –as a voluntary assessment scheme – exert a kind of coercive pressure for adopting certain sustainability practices (Kauppi and Hannibal 2017) and assessing them. Instead, larger companies are more aligned because this stage is responsible for the key productive processes, as well as for selecting and monitoring suppliers, and therefore for ensuring compliance. Besides, larger companies have more structured procedures for performance management and reporting, and show awareness of external pressure and orientation towards an opportunity gaining strategy (Grosvold, Hoejmose and, Roehrich 2014; Kauppi and Hannibal 2017; Kähkönen, Lintukangas, and Hallikas 2018). Therefore, we can posit that the level of SCS assessment alignment depends on the stage/role in the supply chain, company size and expectations, and requirements from the Consortium as an overseeing body. We can formulate the following proposition:

Proposition 1: The level of SCS assessment alignment in different stages of the Grana Padano SC is influenced by different factors:

P 1.1 The level of SCS assessment alignment is positively influenced by company size

P 1.2 The level of SCS assessment alignment is positively influenced by a leading role and stage in the supply chain

P 1.3 The level of SCS assessment alignment is positively influenced by requirements from an overseeing body

The partial alignment between sustainability practices and assessment implies that companies in the Grana Padano supply chain might not be fully aware of their own performance. The implementation of sustainability practices, beyond compliance with regulations (D1) represents a positive attitude towards sustainability (Kähkönen, Lintukangas, and Hallikas 2018), however, assessing only the practices that are required by law or specifically requested by the customer (i.e., defensive or accommodative approach), leaves other practices overlooked. This partial alignment offers room for improvement if companies realized the importance of monitoring their own practices in order to understand the impact of their actions and, being able to communicate, improve them.

Nonetheless, it is important to underline that having a loose-coupled (i.e., defensive or accommodative) or decoupled approach should not necessarily be an issue in the short term because companies could be performing rather well, complying with regulations and surviving in the market, as the cases in our study show. Given that performance assessment requires time and effort, such an approach could be considered as a good balance between costs and benefits. The problem would arise later on if companies are not fully aware of their performance and they do not realize that valuable data, or knowledge as He et al. (2019) define, that are already being collected from the SCS assessment which might help effective sustainability performance along the chain. Therefore, they risk causing their SCS performance to decline in the future. We can therefore posit that a loose-coupled approach can be a first step towards a fully coupled approach, and therefore formulate the following proposition:

Proposition 2: A loose-coupled SCS assessment approach (accommodative or defensive) in the Grana Padano supply chain can be considered as an intermediate first step towards a more coupled approach in the long-term.

Observing consistency in the three stages of the Grana Padano supply chain, findings show either a coupled or loose- coupled approach, highlighting that no single SCS assessment approach is considered feasible nor appropriate along this supply chain. Each stage determines its own sustainability goals, implements a different combination of practices and applies different assessment mechanisms according to its own capabilities and interests. Therefore, we can formulate the following proposition:

Proposition 3: There is no unique SCS assessment approach along the Grana Padano supply chain as each stage faces different challenges, establishes its own sustainability objectives and, requires its own SCS performance measurement system.

The PDO label requires specific criteria regarding quality, animal welfare and resource usage, and actors are expected to behave accordingly as Schmitt et al. (2017) mentioned. In an environment where there are many small actors with limited workforces and information systems, and without the resources for developing more mature capabilities (Batista et al. 2019), the Consortium is responsible for unifying the production processes and product quality for complying with the PDO certification, thus exerting coercive pressure for sustainability adoption (Kauppi and Hannibal 2017) and assessment. Hence, practices implemented tend to be related to the PDO label, and the assessment applied is frequently done for reporting to the overseeing body. Furthermore, the Consortium encourages actors to implement non-mandatory sustainability practices, such as organic production, or renewable energy use, to enhance the product characteristics and reputation, and ultimately increase the market share. Therefore, we can posit that the existence of an overseeing body provides the critical coordination and control role that also allows a fragmented chain, which involves several small companies, to implement some form of sustainability strategy. We can summarize this in the following proposition:

Proposition 4: An overseeing body plays a determining role in the supply chain sustainability deployment, in particular when several small firms are involved, as in the Grana Padano chain, because it regulates and encourages practices and assessment, and it enhances product value by playing a coordinating and safeguarding role.

Consequently, the PDO label already provides a structure for actors in the chain to ensure quality, traceability, and animal welfare; nonetheless, it would be necessary to encourage

companies to acknowledge the value of SCS assessment and to make good use of it for their own benefit and for the whole chain. As R1-Purchasing manager stated:

"*We know we are contributing to sustainability in the supply chain, but we just don't know how much*".

Conclusions

Sustainability performance assessment in the supply chain is essential for achieving high quality, safe, nutritious and responsible food products. Nonetheless, sustainability assessment is hardly implemented even though many indicators and measures are proposed in literature (Bourlakis et al. 2014; Bloemhof et al. 2015; European Commission 2014; FAO 2013; GRI 2013; Sureeyatanapas, Yang and Bamford 2015; Yakovleva, Sarkis and Sloan 2010; van der Vorst, Peeters and Kolk 2013). SCS sustainability assessment implementation, use and update needs more attention from a multiple tier perspective.

Companies need guidelines to implement the measures and, consequently, on how to use the information obtained (Gualandris et al. 2015; Sureeyatanapas, Yang and Bamford 2015). However, the first step would be to explore the reasons why companies in the SC commit to sustainability. They can vary from compliance to the search for a competitive advantage; however, the reasons whether or not those sustainability practices are assessed can be very different. Certainly, companies in any supply chain are not compelled to measure everything they do as they risk being overloaded with indicators that make understanding the firm's current performance status even more complicated (Genovese et al. 2017; Moazzam et al. 2018). The opposite could also be problematic as the lack of performance information could lead companies to make blind strategic decisions (Gualandris et al. 2015). Thus, the challenge of performance measurement is the choice of what to measure and for what reasons, in order to set up the most appropriate strategy to improve sustainability.

Sustainability performance measurement in literature has focused on the development of indicators for a company's internal operations and a supply chain view is still lacking. Thus, this study is intended to extend research by considering several stages in the supply chain and investigating the alignment among SCS drivers, practices and assessment. The case studied is the supply chain of the Grana Padano cheese, a PDO product in Italy, by analysing eight companies in three different stages of the supply chain, plus the Consortium that oversees the PDO label, which monitors compliance and supports companies in the chain. One of the contributions of this paper is related to the context of study selected: food supply chain and a

certified product for which sustainability assessment is key to preserving or defending the product identity, as Schmitt et al. (2017) described. In particular, in a certified product supply chain, it could be expected that all companies share similar approaches regarding SCS assessment, and that they be somewhat aligned as they all need to respond to the same standards and overseeing institutions.

Findings showed that all actors in the chain implement sustainability practices, but that not all those practices were assessed (See Table 5, Table 6). Nonetheless, different kinds and numbers of measures are indeed implemented, but not all of those assessments respond to the intentions behind the drivers declared (See Table 8). Still, among all the practices implemented, some companies do assess some of them according to the motivations they had at the beginning. This mixed behaviour is defined in literature as a loose-coupled strategy when managing SCS performance (see Figure 2), and it is found in 6 out of the 8 companies in our sample. On the other hand, it was observed that larger processors have a more proactive approach to SCS performance assessment, presumably thanks to their internal capabilities, which also offer the company the opportunity of getting the most out of the data measured.

Furthermore, findings showed that there is no unique strategy along the chain that turns out to be better than the others in the Grana Padano supply chain. The chosen approach depends on a range of factors from business nature and internal structure to company size and its role in the supply chain. Moreover, the presence of a regulating body, the Consortium, proves to be a crucial element of alignment, as it engages actors in the chain not only for compliance but also for a higher attention to sustainability issues that could increase product value.

Implications for Literature

The contributions for research in this paper are fourfold. First, studies considering sustainability in the supply chain beyond a dyadic relationship are recent (Mena, Humphried and Choi 2013; Wilhelm et al. 2016; León-Bravo et al. 2017; Meqdadi, Johnsen and Johnsen 2017) and in this line, our study extends literature in SCS assessment as it includes three stages in the chain, providing a wider overview of the SCS assessment behaviour. The second contribution is related to the product under study. Investigating the assessment for sustainability along a specific product supply chain where a regulated and structured approach exists concerning quality, origin and tradition, and, where companies are expected to comply with the PDO requirements is a novelty in this paper.

Moreover, this study took a step further in literature and covered the alignment of sustainability drivers, practices and assessment measures put in place in different stages of the

chain, which had been an under-investigated topic so far. Besides observing this alignment, that extends the Grosvold, Hoejmose and Roehrich (2014) approach (originally defined for a single company), this study provides a comparison among supply chain stages that reveals a combination of different strategies for managing the SCS assessment.

Finally, the fourth implication for research is that companies in the Grana Padano supply chain demonstrate that no single SCS performance system is deemed appropriate for all supply chain stages, and we identified some contingent factors explaining these differences. Each stage focuses on different objectives and requires an adapted SCS performance measurement system that contributes to each one's improvement and at the same time strengthens the chain as a whole. As He et al. (2019) suggested, broader knowledge can be created and combined in a supply chain to improve sustainability, and from our study we argue that extensive information exists, depending on each stage in the current SCS management approach, and needs to be further acknowledged and communicated. The role of an overseeing body, such as the Consortium, proves to be a key element to achieving this. These elements should be considered in future research regarding sustainability performance measurement in the supply chain.

Managerial Implications

Findings in this study are of interest to practitioners in three main areas. First, managers could find insights for the identification of SCS performance management strategies as some measures or indicators are somehow standard for every type of company in the Grana Padano supply chain, while others should not be. Given that in the Grana Padano supply chain there are many small firms, each with different roles and its own challenges and capabilities for sustainability practice implementation and assessment, the strategies for SCS performance management are not unique nor standard. Therefore, prior to establishing an SCS performance strategy, it would be crucial to identify each company's critical areas to improve, change or adapt in an industry that is increasingly globalized and complex.

Second, acknowledging the actual approach towards SCS assessment is useful for managers to find the most appropriate ways to increase benefit gains from the sustainability strategies. Companies might realize that even though reducing risk by complying with regulations or ensuring operational flow (Hadiguna and Tjahjono 2017) is beneficial so far, it might not be enough in the future, if they continue to have this type of defensive approach. The same applies when an accommodative approach is in place, since companies might be losing opportunities of getting more benefits from their current SCS assessment, and they will need to develop more mature processes, especially the smaller companies as explained by Batista et al.

(2019). The choice of a loose-coupled approach as an optimal strategy is context dependent and needs to be carefully understood and managed.

Third, managers in the Grana Padano supply chain could rely more frequently and broadly on the overseeing body (the Consortium) that works not only toward compliance but also to encourage and promote more diverse sustainability practices and assessment for a future improvement that is appropriate for everyone.

Limitations and Future Developments

Being exploratory in nature, the findings and contributions of this study are constrained by the research design that involved a qualitative methodology and investigated a specific product in a particular geographical region. Therefore, the opportunities for further research build upon the current study limitations. SCS assessment calls for further investigation and empirical application beyond the metric design, by exploring the implementation and use of the measures and outcomes obtained in different product supply chains, and in different locations. In addition, our alignment and consistency analysis for SCS assessment and drivers is one move towards a more appropriate conceptualization of a sustainability performance improvement plan. Future investigations could test our propositions focusing on a larger sample or different food product typologies, and observe the challenges limiting implementation, use and update of sustainability measures. Moreover, studies could concentrate on developing propositions for a more appropriate implementation and use of an SCS performance system along a complete supply chain in food and other industries.

Disclosure statement

No potential conflict of interest was reported by the authors

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Table 1. Summary of literature contributions on supply chain sustainability assessment

PMS phases (Bourne et al. 2002)	**Previous research observations**	**References related**
Design	• Measures, metrics indicators identification (Appendix A) • Too many, redundant, resource and time consuming • Often for single firm or dyadic (supplier-costumer) relationship	Aramyan et al. (2007); Maestrini et al. (2017); Genovese et al. (2017); Moazzam et al. (2018); Bourlakis et al. (2014); Schmitt et al. (2017); Sureeyatanapas, Yang and Bamford (2015) (Appendix A)
Implementation	• Assessment should consider environmental, economic and social dimensions and, entire SCs • Having too many assessment aspects is complex and impractical • Assessment implementation require effort, clarity and purpose	Bai and Sarkis (2014); Gualandris et al. (2015); Seuring and Muller (2008); Varsei et al. (2014); Bourne et al. (2002); Genovese et al. (2017); Maestrini et al. (2017); Sureeyatanapas, Yang and Bamford (2015)

Use and Update	• Risk and opportunity strategies for SCS assessment use
	  • Risk: criteria or rules about 'what must not be done'
	  • Opportunities: 'what could be improved and should be done'
	• Different logics for assessment and management
	• Different measures can be combined for each strategy
		Schaltegger and Burritt (2014); Hadiguna and Tjahjono (2017); Bloemhof et al. (2015); Kähkönen, Lintukangas, and Hallikas (2018); Gualandris et al. (2015)

Table 2. Summary of drivers for sustainability in the supply chain

Drivers for Sustainability		**References**
D1	Regulations, stakeholder and shareholder pressure	Beamon (1999); Bloemhof et al. (2015); Chien and Shih, (2007); EU (2014); Gualandris et al. (2015); Hall (2000); King and Lenox (2001); León-Bravo et al. (2018); Porter and van der Linde, (1995); Walker et al. (2008); Zhu et al. (2013)
D2	Company environmental concern	FAO (2013); EU (2014); Genovese et al. (2017); Sarkis (2008); Varsei et al. (2014); Walker et al. (2008); Zhu et al. (2013)
D3	Company social concern	Carroll (1999); EU (2014); FAO (2013); Walker et al. (2008); Schmitt et al. (2017); Zhu et al. (2013)
D4	Economic benefit (e.g. cost reduction)	Beamon (1999); Bloemhof et al. (2015); Chien and Shih, (2007); EU (2014); FAO (2013); Porter and van der Linde (1995); Walker et al. (2008); Zhu et al. (2013)
D5	Green image, global competitiveness	Czinkota et al. (2014); Bloemhof et al. (2015); Genovese et al. (2017); Hoejmose et al. (2014); León-Bravo et al. (2018); Roehrich et al. (2014); Walker et al. (2008)

Table 3. Sustainability practices in the food supply chain (adapted from León-Bravo et al. 2017)

Sustainability dimension		**Example of Practices**
Environment	Natural Resources conservation (NRC)	Animal Welfare: Elimination of cruelty; safe handling, housing, slaughter and transport, animal feed quality and safety Soil conservation: Conservation forest, species; prevent soil erosion and pollution, prevent loss of arable land and biodiversity, responsible farming methods (reducing fertilizer and pesticides), elimination of contaminant and pollutant agents Organic production Water conservation: reducing water consumption, efficient water use, waste water re-use and recovery
	Green processing, packaging and transportation (GPPT)	Design, materials and packaging: effective design for reuse and recycling, use of design for disassembly and reuse, material reuse and recycle, reducing packaging, using reusable/ recyclable packaging Waste: reduce waste and hazardous materials, composting organic waste, producing renewable energy or animal feed with waste, lower disposal costs, damage compensation, recycling Processing and transportation: reducing energy use, conservation of energy, reducing CO2 emissions and GHGs, reduce pollution, reduction of fuel consumption, cold chain monitoring
Social	Health and Safety (H&S)	Improved product quality, food safety, food security, traceability and transparency. Promotion of healthy life styles and local food sources. Safer warehousing and transportation
	Work and Human Rights (W&HR)	Better working conditions that result in higher levels of motivation and productivity and less absenteeism. Training, education, advancement. Regular employment, elimination of illegal and child labor, respect of worker rights, gender equality, freedom of association, safe working conditions
	Community	Donation, collaboration with NGOs, philanthropy, support to the economic development in local communities, educational practices, health care, job training, volunteering, childcare
Economic	Sustainable sourcing (SS)	Increasing supplier diversity, ensuring confidentiality, eliminating deception and impropriety, transparency, proper purchasing processes (reciprocity, fairness, no power abuse or special treatment), supplier's labor programs, local sourcing that result in shorter lead-times. Environmental and social considerations when selecting, monitoring and controlling suppliers.
	Support to SC partners	Profit sharing with actors in the upstream SC, premium price payment, support and monitoring for obtaining sustainability certification. Facilitate partners' access to markets, knowledge and technology transfer, fostering financing opportunities, information and expertise sharing.
	Green image and global competitiveness	Investments in promoting the green/sustainable company image. Initiatives to increase the export sales with a sustainable image. Monitoring and control of customer satisfaction regarding sustainability initiatives launched by the company.

Table 4. Set of companies studied in the Grana Padano supply chain

Case	Description	Turnover (million €)	Structure	Operations in charge
S1 Supplier	Breeder, cooperative member	< 1* (2013)	Family business (200 cows)	Cattle feed production, cattle breeding, milk production
S2 Supplier	Breeder, cooperative member	1,1* (2013)	Family business (280 cows)	Cattle feed production, cattle breeding, milk production
S3 Supplier	Breeder, cooperative member	1,6* (2013)	Family business (400 cows)	Cattle feed production, cattle breeding, milk production
P1 Producer	Cooperative, cheese factory	10 (2013)	23 members 21 employees	Cheese production, aging, wholesaling.
P2 Producer	Cooperative, cheese factory	17 (2013)	29 members 20 employees	Cheese production, aging.
P3 Producer	Cooperative, cheese factory	349 (2014)	220 members 550 employees	Cheese production, aging, portioning, grating, packaging
R1 Retailer	Supermarket	1.100 (2014)	5500 employees	Food retail
R2 Retailer	Distributor and Supermarket	2.500 (2014)	10000 employees	Transportation, storage and retail

Table 5. Example of analysis performed for each case study – Producer 2

	Drivers	**Sustainability practices implemented**	**Sustainability assessment**
Producer 2	D1: Regulations, stakeholder and shareholder pressure	Voluntary certifications	Numbers of voluntary certifications
		Compulsory certifications	X
		Annual reports	X
	D2: Company environmental concern	Reduction in energy consumption	Energy consumption
		Reduction in water consumption	Water consumption
		Use of renewable energy	Produced energy
		Packaging reduction	X
		Waste management	X
		Temperature control	Plant temperature
			Milk temperature
		Traceability	X
		Production process compliance	Milk hygienic and nutritional composition
			Final product shape control
			Control of cheese crust % in the grated packages
	D5: Green image, global competitiveness	Customer satisfaction regarding sustainability initiatives launched by the company.	Measuring the results from customer satisfaction surveys
			Sales variations for clients/ level of loyalty
		Initiatives to increase the export sales with a sustainable image	Monitoring the export market
		Investments in promoting the green/sustainable company image	X
		14 practices implemented	***8 practices assessed***
			12 assessment measures

Table 6. Summary of practices and assessment measures applied in the companies under study

Drivers	**Number of sustainability practices implemented per driver**							
	S1	**S2**	**S3**	**P1**	**P2**	**P3**	**R1**	**R2**
D1: Regulations, stakeholder and shareholder pressure	3	3	3	3	3	3	3	3
D2: Company environmental concern	10	10	10	8	8	12	11	7
D3: Company social concern						1	3	2
D5: Green image, global competitiveness				1	3	3	1	2
Total practices implemented	**13**	**13**	**13**	**12**	**14**	**19**	**18**	**14**
Number of practices assessed	*10*	*8*	*8*	*6*	*8*	*10*	*11*	*6*

Table 7. Summary of findings: RQ 1

Findings	Example of case statement/data
Companies in the Grana Padano supply chain assess sustainability only when specifically required, and to respond to regulations and-or stakeholder pressure	*"For the new organic line, we needed to get the specific certification and we are expected to report annually the progress we are doing in the chain […], even though the Consortium doesn't require a report from us too often, we perform all our activities according to the PDO policy" (P2- Quality manager).*
All companies in this supply chain, consider that sustainability, quality and environmental concern are intrinsically related	Cow productivity, animal welfare and revenues are the three objectives of the farm along with efficiency, which lead to high milk value and sustainable development in this company (Magazine article referring to S1) "*Every milk load is controlled and monitored in terms of quality, temperature, delivery on time, […], and in some cases the control goes as far as the cattle feed used…*" (P3- Logistics manager).
All stages in the Grana Padano supply chain perform SCS assessment for environmental goals, at least partially, because not all the practices implemented are monitored.	The department in charge periodically reports how much energy or water the company is using per store. This information is required for the financial statements. However, the amount of food donated is not particularly followed up as the collecting organization is in charge. (case report R2) "*[…] since 2013, we have a cooling system that does not use gas, the temperature in the plant is closely monitored and we contribute to the planet by contaminating less*". (P2- Director).
Only *Retailers* in the Grana Padano supply chain assess, at least partially, practices related to social issues (reputation risk)	*"The number of social events performed for charity is widely known in the company because our employees are part of the community benefiting from these events. It is also crucial for our company's responsible image" (R1- Purchasing coordinator)*
Only *Processor*s in the Grana Padano supply chain assess sustainability practices related to green image/competitiveness	*"We believe that taking care of the environment will pay off in the future, not only because it is the right thing to do for the planet, but also because the market will recognize us for doing it"* (P2- Director).

Table 8. Analysis of SCS assessment alignment in the companies under study

FSC stage	Company	Drivers declared	Practices assessed?	Assessment aligned to driver?
Supply	**S1**	D1: Regulations, stakeholder and shareholder pressure	No	-
		D2: Company environmental concern	Partially	Yes, partially
	S2	D1: Regulations, stakeholder and shareholder pressure	No	-
		D2: Company environmental concern	Partially	Yes, partially
	S3	D1: Regulations, stakeholder and shareholder pressure	No	-
		D2: Company environmental concern	Partially	Yes, partially
Production and Aging	**P1**	D1: Regulations, stakeholder and shareholder pressure	No	-
		D2: Company environmental concern	Partially	No
		D5: Green image, global competitiveness	Yes	No
	P2	D1: Regulations, stakeholder and shareholder pressure	Partially	Yes
		D2: Company environmental concern	Partially	No
		D5: Green image, global competitiveness	Partially	Yes
	P3	D1: Regulations, stakeholder and shareholder pressure	Partially	Yes
		D2: Company environmental concern	Partially	Yes, partially
		D3: Company social concern	No	-
		D5: Green image, global competitiveness	Partially	Yes
Distribution and Retail	**R1**	D1: Regulations, stakeholder and shareholder pressure	No	-
		D2: Company environmental concern	Partially	Yes, partially
		D3: Company social concern	Partially	Yes, partially
		D5: Green image, global competitiveness	No	-
	R2	D1: Regulations, stakeholder and shareholder pressure	No	-
		D2: Company environmental concern	Partially	No
		D3: Company social concern	Partially	No
		D5: Green image, global competitiveness	No	-

Table 9. Summary of findings: RQ 2 and RQ 3

Findings	Example of case statement/data
The SCS assessment in the Grana Padano supply chain is partially aligned with drivers related to social and environmental concern, in the *Supply* and *Distribution and Retail* stages, and in smaller *Producers*	D2- environmental concern: S3 installed an innovative system for water reuse in the cowshed. The cost reduction gained with this practice is monitored periodically, which makes sense for business purposes but is not directly connected to the environmental driver that was declared. D2- environmental concern: The factory installed a photovoltaic station for internal energy production and it also helps to recycle the heat used for boiling the milk. The cost reduction gained with this initiative is recorded periodically (case report P1) D3 - social concern: The amount of food donated is not particularly followed up as the collecting organization is in charge. (case report R2) D2- social concern *"The number of social events performed for charity is widely known in the company because our employees are part of the community benefiting from these events. It is also crucial for our company's responsible image" (R1- Purchasing coordinator)*
In the Grana Padano supply chain, large companies in the *Production and aging* stage present a SCS coupled approach	D5- company image: "*[…] the quality department ensures our Grana Padano chain is totally traceable, with a microchip system we can trace each cheese wheel back to the milk load from which it was made, and also to the cattle feed used at our suppliers. […] if there is a complaint, the product responsibility is ours, so we maintain strict traceability control*" (P3- Logistic manager) D5- company image: *"We believe that taking care of the environment will pay off in the future, not only because it is the right thing to do for the planet but also because the market will recognize us for doing it"* (P2- Director).
There is no single SCS assessment approach along the Grana Padano supply chain.	Findings in Table 5 and Table 7 report the differences regarding the alignment between assessment and practices, and also between assessment and drivers. The chain mostly presents a loose-coupled approach for different reasons. However, larger processors opt for a more coupled approach.