Adding Value to Sustainable Agri-Food Chains: Experimentation in the Pork Sector

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1. Introduction

Price volatility is recognized as a great threat for farmers as well as for food companies and, consequently, for consumers (Interagency Report, 2011; OCDE/FAO, 2018). The globalization of food markets, end products, raw and semi-finished products, has increased pressure for farm sector and food industry re-engineering. The price decrease imposed by distributors has also accelerated the need for structural changes in agri-food chains. The most common reflex is to adapt the size of farms and industrial units: Big is better. Automatization often tends to follow close behind as yet another knee-jerk reaction. The increasing availability of new technologies in the farm sector, food industry and multichannel distribution and, in particular, the digital revolution, has had tremendous consequences on business organization in these three sectors.

This article shows how a new collaborative modeling approach could create value in the agri-food chain, and how this value could be shared equitably via innovative contractualization. Economic literature has largely underlined the interest, modalities and risks of using contracts, defined as commitments between parties. Whereas *critical size* is commonly invoked in order to better manage price volatility, a new collaborative approach offers the further possibility of associating both consumers and producers. This article introduces a new Sustainable Demand-Supply Chain (SDSC) approach. The objective is to be more efficient from an economic, environmental and social point of view. Supply chain and demand management are combined in order to build a new collaborative modeling tool. This tool creates added-value via a new organization of the agri-food chains and day-to-day operations. It also helps economic optimization, and guarantees the attainment of the environmental and social objectives defined by the actors. Some of its components (*i.e.* impact measures) provide elements for the new contractualization between actors and fair value-sharing rules.

The aim of the present article is to propose this new approach to improve interactions between stakeholders, using traceability and contractualization. Faced with a crisis generated by volatility, collective action~~,~~ incorporating all stakeholders, including consumers, is needed: but what exactly must be done? The article first describes the SDSC approach which combines three main concepts: Extended Demand, Extended Supply and Demand-Supply Chain (DSC), and then goes on to detail how a collaborative modeling tool needs to be built up. This approach is currently being tested in a pork agri-food chain. The experimentation is detailed in the article, especially as regard the modeling aspect, together with the different options needed to create value and indicate how to ensure it is shared. The results presented in this article show how to reconcile Extended Demand and Extended Supply, and how to provide the bases for new commitments. We give, in particular, the background elements needed for implementing the model, together with a framework for measuring the performance of the supply chain, and its role in supply chain management. In the first part, we recall the international stakes confronted by all stakeholders in food chains, introducing in the second part, in what way SDSC constitutes a major rethink of supply chain relationships. We present the SDSC approach illustrated in the pork sector. Then, we discuss the new modeling approach for adding value to agri-food chains.

2. From international crisis to a collective need

Even though the most recent World Bank report (2016) estimates that the balance of risks

for global growth has tilted further downward, that report seems unduly pessimistic, since vulnerability and the structural crisis tend to condemn developing and developed economies alike. “Although global growth is projected to accelerate gradually, a wide range of risks threaten to derail the recovery, including a sharper-than-expected slowdown in major emerging markets, sudden escalation of financial market volatility, heightened geopolitical tensions, slowing activity in advanced economies, and diminished confidence in the effectiveness of policies to spur growth. These risks are compounded by the fact that for many countries policy buffers have eroded substantially, particularly in commodity-exporting emerging and developing countries » (World Bank, Report, 2016, p. XI). Producers face increasing risks of being eliminated as a result of raw material price volatility (OCDE/FAO, (2018).

At the European level, the agricultural crisis is usually explained by changes in public policies (like the end of dairy quotas), price volatility and increased competition (ESCIP, 2016). Various initiatives have been launched to promote sustainability, including better responses to consumer worries about food production. Extending cooperative-style behavior beyond the supply chain should be explored. “A key principle is that environmental information communicated along the food chain, including to consumers, shall be scientifically reliable and consistent, understandable and not misleading, so as to support informed choice” (Food SCP, 2013). Consequently, the quality of close interactions between stakeholders is essential for the functioning of supply chains: imbalances in bargaining power between actors can lead to the application of so-called unfair trading practices (UTPs), with strong actors imposing themselves on the weak ones (Areté, 2016; Chabault et Hulin, 2016). In addition to legislation, voluntary/self-regulatory approaches, involving operators and other stakeholders, are also used to tackle UTPs in the EU food supply chain. Voluntary initiatives aimed at addressing UTPs have been implemented both at EU and Member State level, and more are being developed” (Areté, 2016, p. 14).

Fostering competitiveness in agriculture and agri-food means adopting good business practices between all supply chain stakeholders, in order to encourage investments and reduce economic constraints for producers. In the case of dairy, meat or cereals, supply chains are submitted to strong constraints and major economic difficulties (FranceAgriMer, 2014). It is less a matter of conjuncture but rather one of structural pressure: Better organization, flexibility and efficiency need to be shared throughout the whole supply chain (Gauzente et Fenneteau, 2006). Other evolutions have to be taken into account, such as consumer expectations for local and sustainable products, with emphasis also being placed on improved traceability. Critical size is not the only solution to boost competitiveness. Such new expectations simply cannot be addressed by structural changes based mostly on productivity increases, thanks to bigger farms and the rebuilding of all production tools. Fierce competition has become very much like warfare, destroying value in supply chains and rural areas in terms of jobs, arable land, productive tools and farms, as well as threatening the very survival of business companies. Securing raw materials, as well as ensuring farmer income, has become a major issue. The way to organize and structure relationships inside supply chains would clearly seem to be strategic, with enhanced collective action being essential.

3. Background

Developing collective action in the supply chain gives rise to different questions. How can leaders accept to share their decision making with other stakeholders? How can producers and atomistic enterprises accept blocked commitments, even if only for a very limited period, thereby risking a loss of income? How can public authorities foster competition by means of contractualization, without introducing rigidity into market price mechanisms? Answering such questions suggests the need to reflect about the sustainability of the supply chains.

3.1. Supply Chain: What's new with SDSC?

SDSC is part of research dedicated to supplier management for risks and performances (Scott, 2015). This approach is not restricted to analyzing conditions for sustainable production: It also takes into account both economic and social issues (Seuring and Muller, 2008 ; Seuring, 2013). Price is not the only signal for consumers: Quality, as well as new criteria, like animal welfare, can also be an important incentive.

The findings in the literature demonstrate how supply contracting might be considered an appropriate mechanism for supply chains' relational structuring. As Meixell and Gargeay (2005) have suggested, research should focus on multi-tier supply chains, with both internal production sites and external suppliers, and also encompass more performance criteria and a broader range of industries. The challenge is that "A greater advance in theory development is possible if researchers adopt a process-based view of Supply Chain Management (SCM), develop conceptual SCM models based on a context-practices-performance framework, and synthesize theories and research of SCM and those of related fields such as organization studies" (Ho et al., 2002). As indicated by Lassale de Salins et al., these two objectives (taking account of all the dimensions of sustainability and jointly managing demand and supply chains) might make the SDSC approach appear overly broad and too complex to be useful in the management world (Lassale de Salins et al., 2014). In this respect, the supply contract offers a dynamic vision, one which accounts for the different kinds of dependency relationships that can exist between partners.

As Chassagnon has explained, the mainstream economic theories considered the firm as an institutional and legal device rather than as an organizational and productive entity. "Contracts, property rights and authority are the main mechanisms that are used to analyze the institutional and legal perspectives of firms" (Chassagnon, 2011, p. 29). The literature distinguishes the firm as the:

- "organization of a bundle of some different contractual arrangements" (theory of the nexus of explicit contracts, Alchian and Demsetz (1972), Jensen and Meckling (1976), Fama (1980) and Cheung (1983));
- "collection of nonhuman assets, and argues that firms arise where market contractual relationships fail" (see the theory of property rights, Grossman and Hart, 1986; Hart and Moore, 1990; Hart 1995);
- "governance structure that is coordinated by a hierarchical authority" (see transaction cost economics, Coase, 1937; Williamson, 1975, 1985, 2002).

However, the firm needs to integrate a vision that is based more on the modern disintegrated firm's perspective than on the traditional view, due to the higher degree of

organizational complexity (Opara, 2002 ; Melnyk et al., 2014). So, the new SDSC approach to interactions between stakeholders' needs to conceptualize the firm in terms of inter-firm relationships that combine horizontal cooperation (like strategic alliances, joint ventures and technological licensing), together with vertical cooperation (like outsourcing and externalization), as well as shared governance, intangible assets and specific human capital and Social Responsibility (Kot, 2018; Uribe et al., 2018).

3.2. SDSC Approach

The objective of the SDSC approach is to help actors work more efficiently in creating additional value (economic, environmental and social) in order to meet the expectations of consumers and stakeholders. The approach also provides the means to share those created values fairly. So, the SDSC model is the essential tool for an SDSC approach. Its main objectives are to (1) describe how actors work together, and show especially what levers they use to create value; (2) calculate the indicators defined in the specified extended demand (economic, environmental and social) and (3) help the joint management of the demand and supply chain: a simulation tool to evaluate different scenarios (mid-term or day-to-day operations).

This section describes the key innovative concepts of the SDSC approach. The SDSC approach is founded on two basic considerations: the role of sustainable development in sectorial strategy, and joint management of the demand and supply chain (both at inter-organizational and actor levels). Mastery of three main concepts is needed to ensure implementation of this approach: "Specified Extended Demand", "Specified Extended Supply" and the "Demand-Supply Chain" (DSC). These concepts are first examined in this section, and the objectives and characteristics of SDSC modeling are then detailed.

3.2.1. The "Specified Extended Demand": the primary point to be agreed upon between actors

The idea is to go beyond the expectations of consumers, and to take into account those of stakeholders. This means incorporating product specifications and associated services (economic, environmental and social).

Consumer demand, whether explicit or implicit, is very often difficult to define. "Associated demands" are any stakeholder demands bound up with consumer demand: supply chain actors (for main products and services or co-products, or reverse logistics), but also the State, local authorities, NGOs, associations, labor unions, sector representatives…

Consumer demand**,** combined with associated demand, constitutes extended demand. This extended demand then has to be specified: the choice of demand components to be taken into consideration, and the incorporation of innovations (thereby reflecting both the capacity of the actors, as well as the innovations they want to implement). Such specification also means translating all those elements into both functional requirements, together with a set of sustainable development criteria (economic, social, environmental).

3.2.2. The "Specified Extended Supply": the secondary point to be agreed upon between actors

The first step is to analyze the available supplies, and to take into account accessible innovations. The goal is to discuss how product and associated services are to be brought to the consumer.

The available supplies means, of course, the organization of the main supply chains and their management including the demand chain, but also the co-product supply chains (including those relating to power production and waste reduction).
Supply innovations focus on organization and management of the Supply Chains and their links with demand management, but also on transversal innovations such as blockchain, big data analysis and new communication channels and devices.
It should be noticed that product innovation is analyzed via extended demand analysis. For example, the need for traceability is incorporated in Extended Demand, and blockchain could be part of the solution in Extended Supply.
Supply Chain organization and management analysis, as well as accessible innovations, constitutes extended supply. This extended supply has to be specified by the actors: supply chain design; demand and supply management, and the use of innovations including transversal ones (blockchain, big data treatment…).

3.2.3. The Demand-Supply Chain: a collaborative set of actors

We call "Demand-Supply Chain" (DSC) all the collaborative actors who specify the extended demand and the extended supply. The DSC includes several, but not all, members of the main supply chain, as well as other actors handling co-products, wastes, energy… As DSC member identification is a strategic question, it has to be established in a consensual way.
The main question a DSC has to resolve after specification of extended demand and extended supply is how the actors need to work together. This question can be sub-divided into three different ones:

- What value can be created, and by means of which levers? (Especially as regard how to organize joint management of the demand and supply chain)
- How can the added-value be fairly shared among consumers and DSC actors?
- How can risk, profit and loss among DSC members be shared via an actor contractualization process?

To address these points, a model must be elaborated in a consensual way. The key point for the model construction is the data provided by the actors. The blockchain can help in this data sharing (with the actors retaining control of their data, and encrypting their data via an access key).

The main characteristics of this model have to be simple enough to be understood and, accordingly, accepted by all the actors involved, and to be sufficiently detailed and efficient to be used in an operational way: defining volumes, transfer and sale prices…
The answer to who runs the model provides useful orientations for the organization and governance of the DSC.

4. Applied Case: the French pork SDSC Model

This part describes the model used in a case study of the SDSC approach applied to a French pork sector initiative called Pork "nouvelle agriculture® U®"(PNA-U), a private brand, launched by Terrena (a French cooperative) and by the Système U distributor. They had initially discussed product characteristics (included environmental and social aspects), and had agreed on annual volume and price engagements. Subsequently, the two actors-wanted to go further, and decided to experiment the SDSC approach for PNA-U.

4.1. Preparatory steps needed before reaching the SDSC modeling phase

Terrena and Système U first specified the extended demand for pork "nouvelle agriculture® U®". In addition to the product specification, the objectives to be reached with the SDSC approach were defined, and their associated indicators used to monitor the results. The chosen indicators conditioned the model (especially the data model, because the model had to be able to calculate these indicators).

Subsequent data analysis was then applied to the whole chain in order to find levers for creating value. These levers provided a basis for modeling interactions within the DSC.

Out of the millions of data elements analyzed (daily levels for one year - 2015), the most useful were, for:

- Each breeder: pig births and accidental deaths, pig shipments to the slaughterhouse (number of pigs, morphologic and quality characteristics) production costs…
- Slaughterhouses and plant transformation: inputs/outputs, detailed production, stock levels by category…
- The Système U platform and stores: product sales in units and tons…

N.B. in order to find possible new levers for value creation, more extensive big data analysis was made. This included the total production of Terrena pigs, the clients, and also all the Système U pork suppliers.

4.2. The objectives of the SDSC Pork Model

SDSC model is described in Fig. 1, which gives a DSC example: the French pork sector.

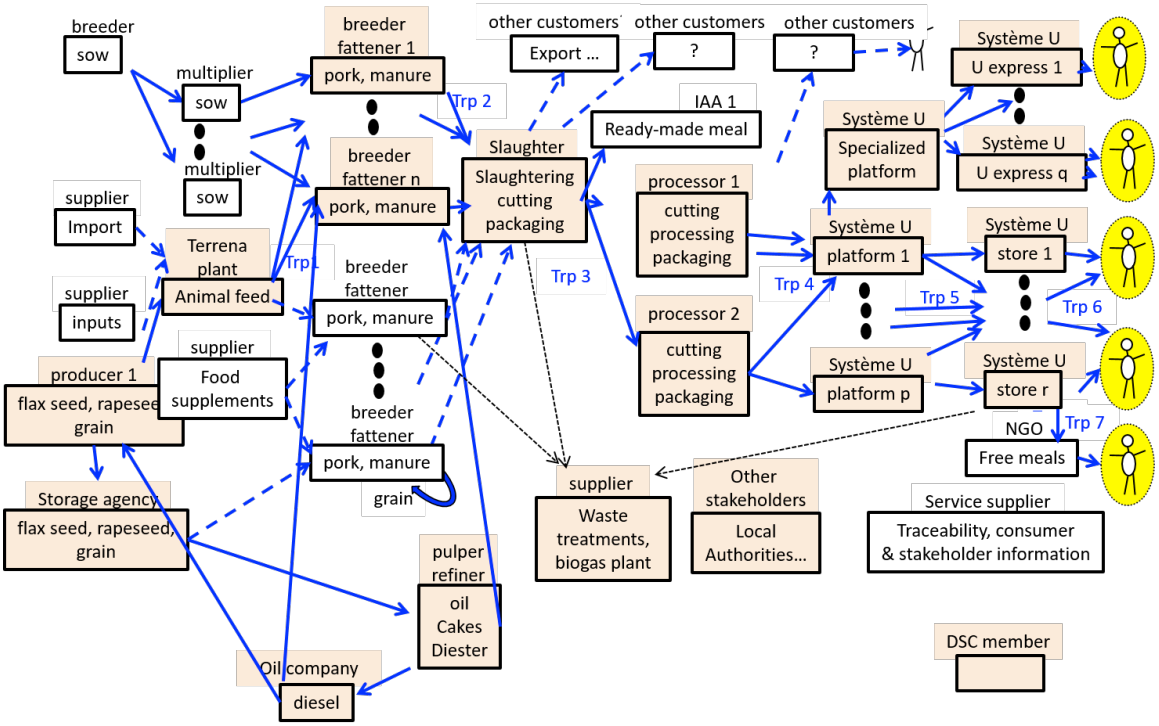

Figure 1 – Example of a Demand-Supply Chain: applied to a French pork application

The general aim is to create value and to redistribute it fairly between all stakeholders (consumers, Terrena, Système U, local authorities, French state, NGOs), with particular attention to breeder sustainability. This value embraces economic, social and environmental aspects:

- Increased margin of all DSC actors (farmers, breeders, slaughterhouses, transformation and animal feed plants, carriers, Système U platforms and stores).
- Less wasting (material wasting, downgrading, …)
- "Local" considerations (especially local employment)
- Animal welfare (breeding conditions, transport, slaughterhouse stress…).

4.3. The aggregation and linkage of several BU models of the Pork SDSC model

Both Terrena and Système U are cooperative organizations. This means that decisions are taken at farm and store level (even if coordination is handled at cooperative level). The SDSC approach aims to help re-organize a food sector, but in accordance, for example**,** with typical French farm sizes.

The SDSC pork model (see Fig.2) is the result of an aggregation of similar business unit models (for example, farms or stores), and a linkage of these resulting aggregate models and other specific models (for example, slaughtering and transformation plants).

It should be noted that the term "similar BU model" does not mean exactly the same model. For example, all farms are modeled in the same way, but they could be very different from one another (some could be only fatteners). Even farms with the same activity may have different characteristics and different performances (mortality rate, level of pig weight conformity). So, the BU model is adapted for each unit via specific parameters (economic, environmental and social).

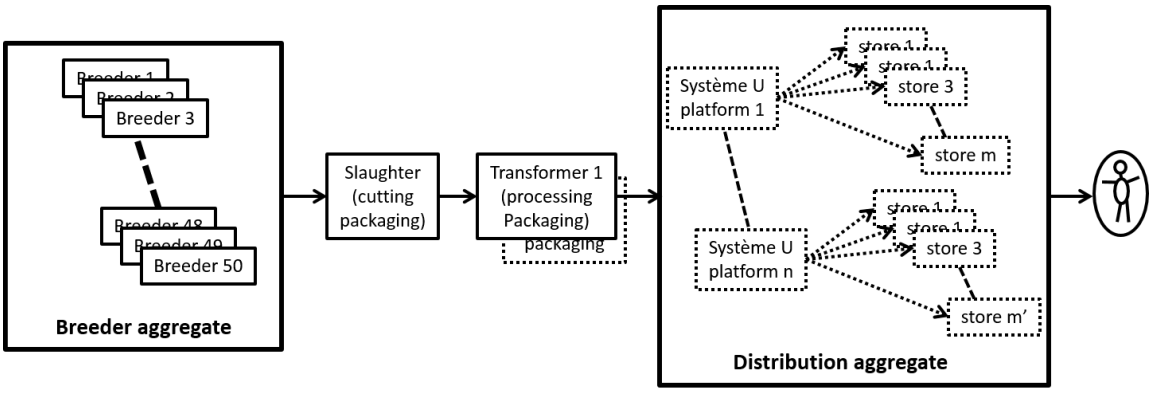

Figure 2 – Global structure of the Pork SDSC model

4.4. The Model creative-value levers and Governance

The first creative-value lever to be considered according to the strategic choice of Terrena and Système U, aims at decreasing wasting. Some wasting depends exclusively on the performance of certain actors (mortality rate in farms, cutting performance in slaughterhouses, unsold rates in stores). Other types of wasting depend on the joint management of the supply chain and demand, for example, to decrease downgrading throughout the chain. This could be done collectively by ensuring a better equilibrium

between supply and demand, at pig level, but also by material balance at piece or product level.
Examples of levers identified in the model to decrease wasting concern different actors:

- Breeders
    - Production volume (number of farms authorized to produce NA pigs, number of pigs per farm)
    - Possibility of downgrading pigs on a specific farm for some weeks (to cut the cost of production: downgrading at this level is cheaper than at the slaughterhouse)
    - Advancing or delaying the delivery of pigs to the slaughterhouse
- Slaughterhouse/ plant transformation: Additional contracts with other clients to sell NA pork or pieces of NA pork that are not ordered by Système U
- Distribution
    - For some stores, indoor cutting and punnet production
    - Changes in ordered volume, sides, pieces, punnets; by product listing in store, pricing, promotions

All these levers could be used in parallel. Governance must define who operates the different levers, and indicate how compromises are to be reached.

The model contributes to defining the economic impact of SDSC. In addition to the calculation of downgrading and wasting in kilograms, the model also indicates each actor's specific revenue. Other indicators (manure treatment, employment level, etc.) are calculated from the model and can be used, like the wasting and economic indicators, for decision making.

N.B. Blockchain experimentation is being used in order to allow enhanced traceability, but also to audit product specification in real time, and to test smart contracts for automatic breeder remuneration.

4.5. SDSC Pork experimentation debrief

The first key step for this experimentation is the difficulty involved in negotiating a strategic project between actors. A "third party" (here the SDSC chair) can be very useful.

Web listening and big data analysis can help to analyze Extended Demand, as well as help to find new levers for creating added-value.

The Blockchain can facilitate data sharing between DSC members (for the modeling phase or the subsequent operational phase). Equally DSC contractualization using smart contracts proves to be a particularly pertinent topic.

The main results of this experimentation are: The redesigning part of the supply chain (indoor cutting and punnet production for some stores); order process changes; better animal collection circuit for slaughterhouses; meat quality, better supply-demand adequacy, leading to a decrease in downgrading, thereby generating bigger profits.

5. Discussion on new modeling approach for adding value to agri-food chains

Building a collaborative modeling tool via the SDSC approach requires specifying the extended demand and conceptualizing the firm with both horizontal and vertical cooperation under shared governance. The SDSC approach raises two questions: How could the collaborative modeling approach create value in the agri-food Sustainable Supply Chain? How could this value be shared fairly, using an innovative model?

In this new modeling approach, output is not only a product (raw material, pork in our applied case), but a good, with different characteristics, including quality, fair, social and environmental friendly practices. It is mostly the result of collective action that focuses on creating and sharing added-value in a sustainable way. Consequently, supply chain output does not only concern pork production, but also the organization of the supply chain in order to confront risk, failure, competitive pressure and consumer expectations**.** This involves understanding the complex relationship between all stakeholders, including consumers, for shared added-value (Porter and Kramer, 2011).

5.1. A governance model to create more shared added-value

Accepting to delegate to a pivot organization integration of the different parts of the supply chain, i.e. the arrangement of transactions and decisions, is reflected according to the equilibrium of cost-benefit (Williamson, 1975). In this sense, the need is to include direct production costs in the related transactions of cost information and negotiation control. Producers thus operate a choice based on the reduction of transaction costs in relation to any additional costs arising from organizing the links (Verhaelgen and Van Huylenbroeck, 2001). This, however, is not sufficient for a full understanding of the complexity of modern economic organizations (Chassagnon, 2011).

SDSC combines vertically organized transactions, which represent the successive stages of creating value along the supply chain, with horizontal cooperation in order to provide information for actors on policy in food chains. The literature on supply chain management emphasizes the role of managerial discretion in coordinating the flow of products, information, and decision making in the supply chain. Interorganizational collaboration is focused on the development of social links, in which the activities are regularly adjusted to each other, and not just planned *ab initio*. All of this supports managerial initiatives aimed at pursuing flexibility in positioning the company in value networks, thereby benefitting from new information and knowledge (Lazzarini et al., 2001).

Governance becomes a hybrid affair, no longer based on a single authority as in the firm (Williamson, 1985; Holmström and Roberts, 1998). In hybrid forms, the SDSC appears as a device in which governance is shared among voluntary members. It is not a matter of a central collective mechanism designed to balance transaction and coordination costs, but rather a means of sharing governance. The governance of the demand and supply chain between Terrena and Système U could be diffused to the other stakeholders. This change of mode of governance is related to the diversity of organization of the food system model (Raynaud and Sauvé, 2005). This hybrid mode of governance is either based on incomplete contracts**,** or each party could retain ownership of its residual rights

of control over its own part in the creation of a collective signal (Hart, 1995).

The model helps to create supplementary additional value (environmental, social and economic). The new governance of the DSC allows a consensual scenario to be defined, one which provides additional value when compared to the standard organization. Regarding additional economic value, the model can also propose how it could be redistributed. For example, a part of the additional "DSC" margin could be given to breeders. This redistribution could also be used as a reward or to incite virtuous behavior (for example, breeders who develop better manure management). These specific redistribution mechanisms could be captured in the model after discussion within the DSC, and updated periodically. Referring to the challenge indicated by Lewandowski (2016) in carrying out an empirical investigation of the value proposition design, SDSC offers a concrete justification of new commitment between stakeholders at local level, including consumer needs (Osterwalder *et al.*, 2014). SDSC provides a concrete example of a sustainable business model in a dynamic perspective (Abdelkafi and Täuscher, 2015).

5.2. The challenge of instability for SDSC

Opening the door to instability and price volatility due to international competition took the actors even deeper into the crisis in the agricultural and agrifood sector (Ancey et al., 2013). The end of milk quotas illustrated the end of sustainable market public policies, leading to a complex and unstable environment. Unpredictability is, then, a new issue for all food supply actors. So, the solutions will need to be truly specific, in order to create mobilizing multi-scales and multi-dimensions. In this perspective, thinking in terms of SDSC justifies the cooperative spirit, thereby reinforcing the need for collaborative partnerships. SDSC, as a device designed to generate stability in a competitive market, manages dependence vis-à-vis other organizations (Porter, 1998). Ensuring stable partnerships will be a strategic issue in order to confront the increase in economic risk and instability (prices, but also norms and legislation).

Based on mutual commitments, actors build confidence by means of ethical and stable relationships, like the social exchange of Blau (Blau, 1964). In this case, equity is a key factor for success (Ring and Van de Ven, 1994; Gauzente et Fenneteau, 2006). Dwyer et al. (1987) underline that justice is an important step at the exploration phase, before developing inter-enterprise relationships, even if certain disequilibria still exist. What is at stake is to create and share added-value between stakeholders. Spender develops the idea that "empirical research shows that private sector businesses pursue new value within multi-dimensioned "opportunity spaces" of around a dozen different "modes of business knowing" (Spender, 2016, p. 63). Uncertainties become the incentive for cooperative behavior due to their limited knowledge, and the necessity to react immediately to new situations (Spender, 2014). While property rivalry is a precondition of economic analysis, the processes of creating property also lie at the core of economics. These are often shaped by ideas from science and technology**,** as well as by the social, political, religious, and psychological aspects of human action and effort. But when property is considered as "material", unambiguous, and certain, business leadership reaches beyond the application of science's truths to property" (Spender, 2016, p. 65). To be smart requires creativity and flexibility: a combination which provides a strong motivation for competitors to cooperate, as Axelrod (1984) indicated in his famous book,

The Evolution of Cooperation.

6. Conclusion

In this paper, we propose SDSC as an innovative approach for the Sustainable Supply Chain because it (1) reconciles extended demand and extended supply and (2) creates and shares added-value between independent units. This is the key point, to avoid conflicts and the destruction of added-value by yardstick competition. The SDSC model is described here in a French pork sector application. We use the model to illustrate how created-value is shared fairly between DSC members.

The competitiveness of SDSC is based on the idea that this collective organization contributes to creating better and sustainable added-value for all members, as well as customers. Our results underline that SDSC modeling needs to improve coordination between stakeholders, as well as incorporating both information technology and indicators to share value and new contracts. In this article, the model focused on is related to the idea that independent units and firms work together in order to create and share added-value, thereby avoiding conflicts or creating common/collective goals. Commitments are guaranteed by shared information and contracts.

Future research should examine the legal risks (competition restrictions) which can occur with this kind of contractualization (volume engagement, price engagement - calculation and revision aspects, circular flows…). Contracts need to guarantee good practices for a fair equilibrium, and to provide accurate information on prices (Masten and Saussier, 2002). Contractualization, in this perspective, constitutes a major mechanism for supply chain stability (Lessassy, 2009).

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