Chain Governance Systems and Sustainable Capital Use – A Conceptual Approach

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Abstract

Due to pressures such as climate change, globalization, price volatility and scarcity of natural resources, our agri-food chain is urged to make a transition towards more sustainable production. How to organize such a transition, given the various stakeholders involved, and how to monitor progress still remain important challenges. This paper presents a new conceptual framework that follows an integrated chain approach to help address these challenges. First, it tackles the complex ecological and socio-economic challenges along the chain and its members (agriculture and food industries), and second, allows for decision support to chain members and policy.

This framework combines two existing theoretical frameworks. The first framework is global chain value analysis (GCVA) of Gereffi (2005) which has its roots in institutional economics. GCVA categorizes five governance types of value chains (markets – modular – relational – captive – hierarchy) based on three variables: (i) the complexity of information and knowledge transfer required to sustain a particular transaction, (ii) the ability to regulate transactions, and (iii) the capabilities of actual and potential suppliers. The second framework, which was first formulated in ecological economics, extends the set of traditional economic resources to various forms of capital in the production system. These are natural (land, water, …), manufactured (buildings, machinery, ...), human (labour, skills,…), and social capital (networks,…). The economic system is fully embedded in the social system which in turn is embedded within the finite ecological system. Throughput of natural, social, human, and manufactured capital allows for the description of agri-food systems in terms of the maximal sustainable use of their stocks and flows.

These two frameworks can be combined to perform an integrated system analysis of the agri-food chain, including the governance structures and the boundary conditions for the various types of capital. This paper describes this new conceptual framework illustrated by means of a case study of the agri-food chain in Flanders, Belgium.

Keywords: *Global value chain analysis, ecological economics, agri-food chain, sustainability*

1 Introduction

The overall attention for sustainable agriculture has risen during the last decades due to increased concerns about global environmental change and food security (Dicks *et al.*, 2013). These concerns increased as the result of (growing awareness of) pressures such as climate change (Beddington *et al.*, 2012), risks to food security from an increase in the global population and changing dietary habits (Duchin, 2005), the rising prominence of the sustainability agenda amongst consumers and in corporate governance (Lockwood *et al.*, 2010), and the depletion of natural resources (Daily & Ehrlich, 1992).

As in many other countries and regions, the Belgian and more specifically Flemish research, policy, and food industry actors acknowledge these concerns and have increased their attention to the sustainability of food production. As agriculture, food manufacturing and distribution are thoroughly linked, an integrated chain approach is necessary to monitor sustainability. Flanders is a small region (13.522 km²) with a high urbanization rate and a dense population rate with an average of 462 inhabitants per km² in 2010 (ADSEI, 2013). The Flemish agri-food chain is exposed to pressures such as, a high aging population, urbanization and a consolidated agri-food chain with a bottleneck structure. Furthermore, the Flemish agri-food chain consists mostly of SME's (small and medium enterprises) and focuses on import and export (Samborski, 2013).

To further improve the shift towards a sustainable agri-food chain in Flanders, a transition is required that involves a radical change of societal functions towards a new dynamic equilibrium (Geels, 2002). The changes can occur at the level of institutional organization, and rules and attitudes. A transition is more likely if it is endorsed by all supply chain actors with support of the policy level and the consumers, which still remains a challenge. This paper aims to answer the following three research questions to support decisions of chain members and policy:

(i) Which concepts need to be combined to perform a system analysis of the sustainability of the Flemish agri-food chain?
(ii) What does the system analysis reveal empirically about the sustainability aspects of the Flemish agri-food chain?
(iii) How adequate are the existing chain governance types to answer the current sustainability challenges?

Firstly, we combine two existing frameworks into a new framework that addresses all sustainability aspects in an integrated chain approach. Secondly, we apply this framework for the Flemish agri-food chain to learn lessons about the current sustainability and lastly, we analyze the existing governance types, i.e. the explicit or implicit contractual outline (including markets, firms and mixed modes) within which a transaction is located (Gereffi *et al.*, 2005), to respond to specific sustainability challenges identified by the system analysis.

2 Methodology

The overall used methodology is transdisciplinary research. Researchers and societal actors work together to co-create knowledge which allows the continuous alignment and validation of results (Figure 1). Moreover, different forms of triangulation validate the results (Golafshani 2003, Guion *et al.* 2011, Koro-Ljunberg 2008). Firstly, data triangulation is performed by using data derived from different stakeholders. Secondly, methodological triangulation is ensured by the use of different methods to collect and analyze data (e.g. scientific and popularizing literature, interviews, expert meetings). Lastly, triangulation of researchers is guaranteed for the data analysis and interpretation by four researchers.

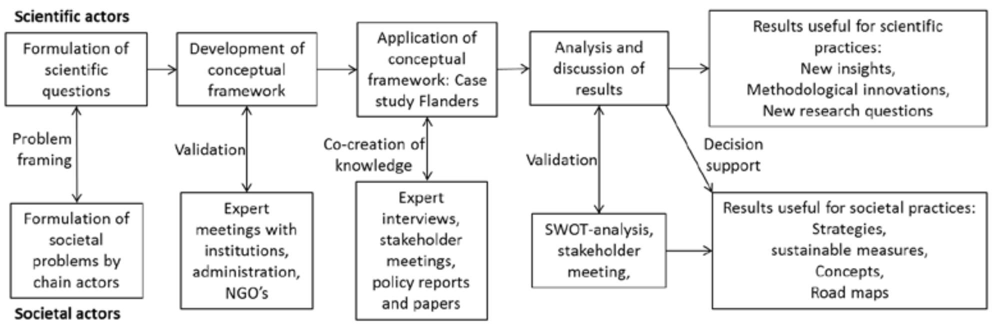

Figure 1. Transdisciplinary methodology used throughout the research process

2.1 Conceptual framework

A conceptual framework is developed based on an extensive literature review. The integrated chain approach describes (i) system boundaries, (ii) the different system components and their interrelationships, (iii) the internal and external forces, (iv) the system changes in a multilevel perspective, and (v) the various chain actors (Rotmans, 2003).

2.2 System analysis of the Flemish agri-food chain

We used the nested/embedded design as illustrated in Figure 2 which is part of mixed methods as defined by Mortelmans (2013) based on Tashakkori & Teddle (2003), Leech & Onwuegbuzie (2009), Creswell (2009) and Creswell & Clark (2007). The nested design uses both qualitative as well as quantitative data but one of the two is secondary and covers a particular part of the research question.

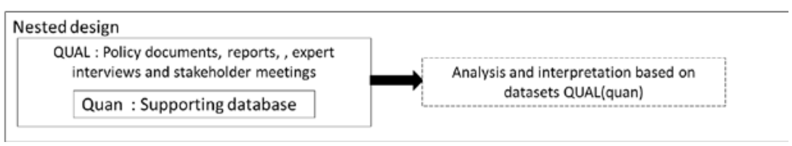

Figure 2. Nested design used to perform system analysis by applying conceptual framework

We built an extensive qualitative database based on the collection of policy documents, reports, and information about existing initiatives and projects (see below for details). Moreover, we organized two stakeholder meetings with actors of the agri-food chain, i.e. input suppliers, agriculture, food manufacturing, distribution, and policy and NGO's actors. Additionally, we had five expert meetings with academic scientists and chain experts and conducted interviews with main chain actors (e.g. agricultural association, food industry federation, retail). Furthermore, we developed a quantitative database based on existing databases such as Statbel, MIRA database and documents of existing projects.

2.3 Sustainability challenges

To identify the current sustainability challenges, all current responses and initiatives originating from the system analysis are listed. These responses and initiatives were formulated through stakeholder meetings, focus groups, and workshops. We used the categorization technique of open coding (De Mey *et al*., 2011). We categorized the responses into categories and the categories into sustainability challenges, as illustrated in Figure 3.

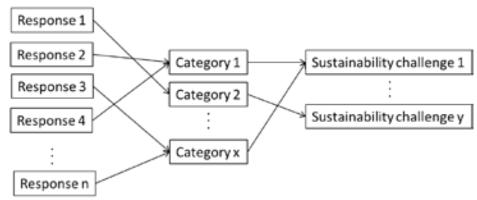

Figure 3. Illustration of categorization method

3 Conceptual framework

We developed a conceptual framework to perform a system analysis that identifies the sustainability challenges of the Flemish agri-food chain. Moreover, the existing governance types are identified to address these challenges. The agri-food chain is defined as the full range of value-adding activities from raw material (e.g. seed, water) over the production and marketing phases such as agriculture, food manufacturing and distribution to the final consumption, and disposal after use. Between these different value-adding activities also relationships exist between activities and interrelationships between buyers and suppliers (Dekker, 2003). This allows to monitor institutional changes and implement sustainability measures covering the agri-food chain.

3.1 The forms of capitals to monitor sustainability

Ecological economics (Daly, 1974; Daily & Erhlich, 1998; Costanza *et al.*, 1997; Lawn, 2007) extend the set of traditional economic resources used to describe the sustainability state of a system to various forms of capital of the production system. We describe the agri-food chain using the linear throughput representation of a socio-economic activity (Lawn, 2001, Lawn, 2007). It considers the agri-food chain as part of the economic system fully embedded within the social system which in turn is embedded within the finite ecological system. Five central elements exist to define the different forms of capitals. Figure 4 represents the agri-food chain and its interrelationships to the five elements of the linear throughput representation.

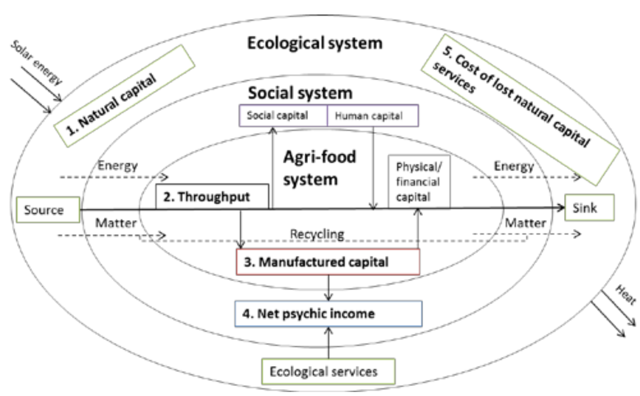

Figure 4. Linear throughput representation of the agri-food system

As explained by Lawn (2001, 2007), the first element is natural capital, the resource of all human realizations which has three functions: (i) it generates low-entropy resources or raw materials such as soil and water (source function), (ii) it assimilates the waste, e.g. greenhouse gasses, packaging waste and food surpluses (sink function), and (iii) it provides the earth's life-support services such as biodiversity necessary for human well-being (the ecosystem services). The second element is the throughput of material and energy. Low-entropy resources are converted into the manufactured output, i.e. food and high-entropy waste products. This conversion to manufactured capital (the third element) may requires multiple components such as machinery and technology (= physical capital), labor, knowledge and skills (= human capital), cooperation and innovation (= social capital), and financial capital. The produced manufactured capital increases - if well-produced - the human welfare. This human welfare is associated with the net psychic income, the fourth element, which is the benefit of a socio-economic activity coming from the consumption of manufactured capital, the participation in economic activities and non-economic activities such as leisure time. The final and fifth element is the cost of lost natural capital services caused by the exploitation, manipulation and conversion of natural capital to produce the manufactured capital.

Capitals are described by using information on the quantities of resource stocks and flows. Therefore, the throughput of natural, social, human, physical, financial and manufactured capital allows to describe agri-food systems in terms of flows and maximal sustainable use of stocks. The result is that we can distinguish essential resources (e.g. biodiversity) vs. interchangeable resources (e.g. proteins) and renewable resources (e.g. solar energy) vs. non-renewable resources (e.g. fossil fuels).

3.2 Governance of agri-food chains

The first framework allows to describe all sustainability aspects of a system and the linkage of the different system components. However, the explicit focus on the value chain is lacking. We therefore decided to additionally rely on a second framework which focuses on the internal institutional organization of the chain and the governance type. Governance is the explicit or implicit coordination of a transaction which determines the allocation of financial, material and human resources and how these resources flow through a certain value chain (Gereffi, 1999). A framework that can be used to classify institutional governance types is global value chain analysis (GVCA) (Gereffi *et al.*, 2005). This framework has been a major contributor to our understanding of the working of different value chains and can assist us to reach important insights in which chain member(s) has to implement certain sustainability measures and which possible positive effects these measures can have. GVCA distinguishes governance types based on three variables: (1) the complexity of information and knowledge transfer required to sustain a particular transaction, (2) the ability to regulate transactions, and (3) the capabilities of actual and potential suppliers (Gereffi *et al.*, 2005). The five governance types are markets, modular, relational, captive and hierarchy. Figure 5 presents an archetype of the different governance types with the thin arrows indicating transactions based on price and the thick arrows indicate transactions based on information and control by explicit coordination. Table 1 summarizes the most important characteristics of the different types of governance (Gereffi *et al.*, 2005). Important to mention is that different governance types can exist within one agri-food chain, e.g. a farmer can have a captive relation with a food manufacture which supplies its products in a modular relationship to the retailer.

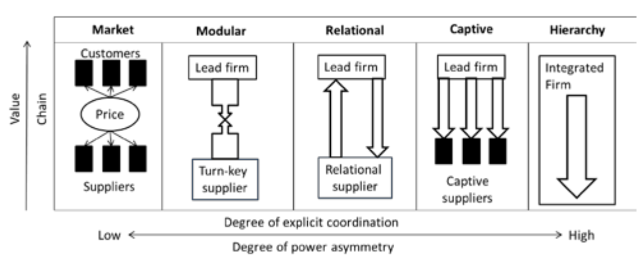

Figure 5. Schematic representation of governance types (based on Gereffi *et al.*, 2005)

Table 1.
Characteristics of governance types (based on Gereffi *et al.*, 2005)

Governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply-base	Degree of explicit coordination
Market	Low	High	High	Low
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	
Hierarchy	High	Low	Low	High

The GVCA proved its applicability in a wide range of studies, including studies about various agricultural products (Guthman, 2009; Raynolds, 2004), and more specific fresh fruits and vegetables (Busch & Bain, 2004; Dolan & Humphrey, 2000; Gibbon, 2001), coffee, cocoa, and tea (Ponte, 2002), as well as fish-based products (Bush & Oosterveer, 2007; Tran *et al.*, 2013). GVCA studies focus on questions of governance, especially exploring how lead firms (e.g., transnational brand-name corporations and large retailers) exercise control throughout the value chain. Therefore, GVCA is important to investigate the institutional structure including the social networks and interrelationships throughout the agri-food chain and is useful for the elaboration of the social and economic dimension of sustainability.

3.3 Structure new conceptual framework

To perform the case study in Flanders, a new conceptual framework which combines the two above described frameworks is constructed. The different form of capitals together with the representation of the agri-food system embedded in the social and ecosystem covers all sustainability dimensions to perform an integrated system analysis. Additionally, the GVCA incorporates the chain perspective and allows to formulate sustainability measures and decision support to chain members and policy. The result identifies key chain members to initiate the transition towards a more sustainable production. The structure of the new conceptual framework is illustrated in Figure 6.

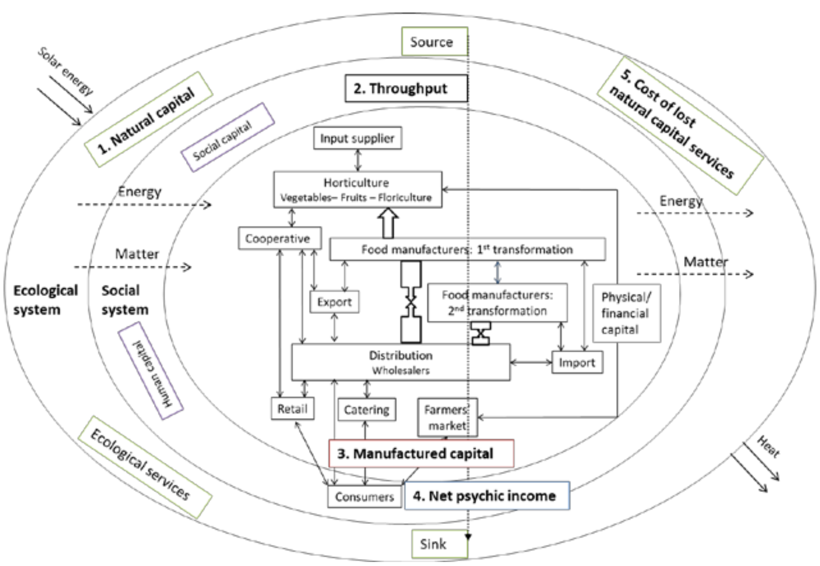

Figure 6. Visual representation of conceptual framework

4 Integrated system analysis Flemish agri-food chain

The Flemish agri-food chain is exposed to major pressures such as globalization, a high aging population, consolidation and urbanization. The first important step in an integrated system analysis is the delimitation of the system boundaries. The system boundaries of the Flemish agri-food chain are defined based on five main chain components, namely (i) input supplier, (ii) agriculture, (iii) food industry, (iv) distribution (wholesale and retail), and (v) foodservices. All the import and export to other regions and/or to other sectors are linked to one of these five system components. Research and development institutes, NGO's, policy and administration are also linked to the agri-food chain. As the main goal of the agri-food supply chain is to deliver the end-product, consumption is not categorized as a separate chain component. However, consumption and the consumer itself is considered as one of the main driving forces that influence the agri-food chain.

4.1 System analysis of Flemish agri-food chain

The system analysis is performed based on the various forms of capital and the five central elements of the linear throughput representation. The quantitative database is presented in Table 2. The quantitative database is extended with information from qualitative research such as stakeholder meetings, expert meetings and expert interviews. The results of the detailed system analysis are summarized and briefly described below.

Table 2.
Summary of quantitative supporting database

Natural capital	**Agriculture**	**Food industry**	**Distribution**	**Food-services**	**Year**	**Source**
Land (ha)	613,860	n.a.	n.a.	n.a.	2011	Platteau *et al.*, 2012
Water usage (1000 m^3)	67,551	97,240	41,510	*	2009	MIRA, 2013
Water source (% of water usage)	81% ground-water	53% surface water	76% tap water	n.a.	2009	MIRA, 2013
Energy usage (PJ)	27.7	41.1	23.5	9.1	2011	MIRA, 2013
Greenhouse gas emissions (kton CO2-eq)	8,961	1,554	701	284	2011	MIRA, 2013
Acidifying emission (Million Zeq)	2,758	57	24	4	2011	MIRA, 2013
Fine dust PM 2,5 (ton)	2,168	102	33	5	2011	MIRA, 2013
NMVOC[1] (ton TOFP[2])	2,135	2,665	1,442	10	2011	MIRA, 2013
Ozone-depleting substance (ton CFK-11-eq)	n.a.	61	43	*	2010	MIRA, 2013
Throughput - Human capital	**Agriculture**	**Food industry**	**Distribution**	**Other categories[3]**	**Year**	**Source**
Number of firms	26,007	3,600	3,405	2,895	2011	Samborski, 2013
Structure of firms	Mainly SME's	Mainly SME's	Few leading companies	*	2011	Samborski, 2013
Employment (amount of employees)	56,629	62,345	7,962	16,700	2010	Samborski, 2013
Labor productivity (euro added value per employee)	*	71,250	107,500	*	2010	Samborski, 2013
Throughput - losses	**Agriculture**	**Food industry**	**Distribution**	**Food services**	**Year**	**Source**
food losses (ton/year)	425.000 – 700.000	1.073.000	116.000	166.000	2012	Sarlee *et al.*, 2012
Throughput – Financial capital	**Agriculture**	**Food industry**	**Distribution**	**Other categories[1]**	**Year**	**Source**
Investment/total revenue	18%	3%	1%	*	2010	Samborski, 2013
Manufactured capital	**Agriculture**	**Food industry**	**Distribution**	**Other categories**	**Year**	**Source**
Total revenue (billion euro)	5.2	32.7	10.9	3.1	2010	Samborski, 2013
Net value added (billion euro)	0.8	3.8	0.8	1	2010	Samborski, 2013

[1]NMVOC: Non-methane volatile organic compounds - [2]TOFP: Troposferic ozone forming potential - [3] Other categories: Other categories includes machineries, services, textile and pesticides and herbicides
*: No data available

Net Psychic income		Year	Source
Food and health	46,9% have overweight and 13,8% have obesity	2008	OECD, 2010
% of population with daily consumption	66% fruit - 87% vegetables - 66% brown bread - 27% soft drinks	2008	HBSC, 2010
Nutrition expenses (% of household budget)	13% food & non-alcoholic beverages - 3% alcoholic beverages - 6% cafés, hotels and restaurants	2012	ADSEI, 2013

The sources used for the summarized description of the different capital forms are interviews and expert meeting and reports. The reports used, next to the reports already mentioned in Table 2 are Arthur D Little, 2012; Boute, 2006; Cazaux, 2010; D'Haene *et al.*, 2010; Demolder & Peymen, 2012; Elsen & Kielemoes, 2012; FEVIA, 2011; FEVIA; 2012; Jacobs *et al.*, 2010; Konings & Vanormelingen, 2013; LNE, 2009; Matthijs *et al.*, 2012; Matthijs & Relaes, 2012; and Platteau *et al.*, 2012.

Natural capital: The state of natural capital is described by land, water, energy, air, biodiversity and ecosystem services. Not only the amount but also the type of source is important. Firstly, Flanders has good growing conditions due to fertile silt soils and favorable agronomic conditions. However, the soil quality declines due to overfertilization content. Secondly, the main issue of water is the declining groundwater stock and the declining quality due to factors such as eutrophication and leaching. The use of alternative water sources such as the effluent of purified water increases. Thirdly, energy usage is still high and even increases. Mainly the usage of non-renewable energy sources such as fossil fuels in glasshouse horticulture and cooling in the food industry contributes to high energy use and emissions. However, combined heat and power systems (CHP's) make their ascent. Agriculture is the highest producer of greenhouse gasses, acidifying emissions and fine dust because of the livestock and the use of chemical fertilizers. In contrast, the food industry is the highest producer of NMVOS and ozone-depleting substances mainly originating from respectively combustion processes and refrigerant use. Lastly, biodiversity is under pressure due to factors as overfertilization and fragmentation of habitats.

Human capital: Table 2 describes human capital as the amount and structure of firms, the number of employees and the labor productivity. Furthermore, important issues for agriculture are the increasing age and level of education of farm managers and the low replacement rate. Another bottleneck in the agricultural sector as and the food industry is the shortage of employees. Nevertheless, a high number of low-skilled employees in food industry and distribution reduces the unemployment rate. Food industry and distribution differ in the average employees' age. The average age in the food manufacturing increases gradually while the distribution employs mainly young workers.

Physical capital: The Flemish agri-food chain focuses on two strategies for technological innovations, namely substitution and efficiency. Substitution replaces old technologies by newer ones and efficiency ameliorate the ratio of input factors to output factors. Agriculture focuses mostly on improved efficiency with a high degree of specialization and scaling-up. The food industry emphasizes on the food factories of the future with smart and flexible production processes. Although the investment in product and process innovation is rather low, investments in marketing and organization are increasing. Another trend is the increasing role of information and communication technology in the production process both within and between components.

Financial capital: Table 2 described financial capital by the investment per total revenue. Agriculture has the highest investments per revenue followed by the food industry and retail. Moreover, another factor is the accession of new firms. Inflow of new firms in agriculture and food manufacturing is rather low due to the higher required start-up capital and the initial investment costs. On the other hand, food distribution has a high entry as well as exit rate as a result of the lower initial investment costs but a competitive market which implies a high turn-over rate.

Social capital: Social capital includes the horizontal and vertical cooperation's. Horizontal cooperation in the agricultural sector focuses on research, development and commercialization of products. The food industry and distribution only have a horizontal cooperation on research and development due to the *Competetive Trading Act*. Figure 7 illustrates the existing governance types found in the Flemish agri-food chain with a typical example.

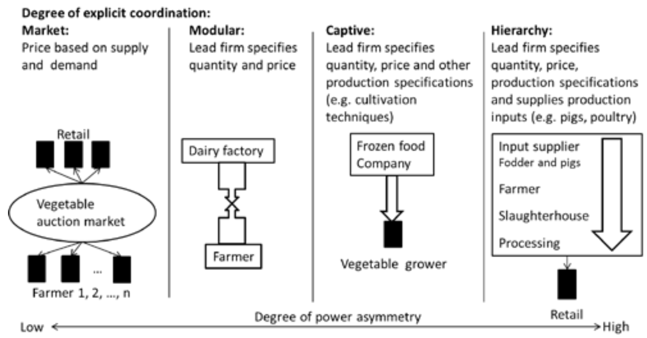

Figure 7: The identified governance types illustrated with an example

Manufactured capital: Total revenue and net value added are represented in Table 2. The Flemish agri-food chain is export and import oriented. 50% of the total revenue of food manufacturing is assigned to export. Export of the agri-food chain focuses for 70% on adjacent regions. An important sustainability issue is that export increases internal land use while import increases external land use.

Net Psychic income: The amount of people with overweight or obesity increased steadily over the last years. Obesity is categorized as epidemic by the world health organization (WHO, 2011). Moreover, some experts state that the physical and emotional distance between the consumer and producer rises which makes food more 'valueless'. To internalize the additional costs of sustainability practices implemented by producers into the prize, consumers should be informed correctly to reduce this emotional distance.

4.2 Sustainability challenges originating from the system analysis

Various responses were formulated as a reaction to the above described states and sustainability description of the Flemish agri-food chain. These responses were listed and categorized into nine principle challenges, as shown in Table 3.

Table 3.
Nine principle challenges of the Flemish agri-food chain

Nine principle challenges of the Flemish agri-food chain
1. To develop new products, new production methods, production sites, markets and new chain configurations
2. To optimize the existing production and chain configurations and alignment of production and marketing to local carrying capacity
3. To focus on closing mineral cycles, to reduce losses, to reduce undesirable by-products and to valorize by-products
4. To optimize transparency within the production process and within the chain
5. To increase consumers participation
6. To reduce the use of scarce resources and to increase the use of renewable resources
7. To stimulate the co-creation of knowledge and innovation
8. To stimulate the inflow of employment
9. To reduce risk and to increase absorption capability and adaptability of the production chain

4.3 Governance types to address sustainability challenges

Currently, different governance types exist in the agri-food chain. Not every governance type is equally suited to address the above mentioned sustainability challenges. To assess this, the main characteristics of each governance type, explained in Table 1, can be used. Additional information on lead firms and their relations with the other chain members can be subsequently explored to analyze impacts on the functioning of the chain. This is however beyond the scope of this paper.

For illustrative purposes, we analyze how the existing governance types (Figure 7) can cope with the challenge to stimulate co-creation of knowledge and innovation (challenge 7, Table 3). In case of innovation, both the innovation process and type are important. The innovation process can range from fully closed to fully open innovation. In case of closed innovation, the lead firm has full internal control of the product development path (Almirall & Casadesus-Masanell, 2010). Open innovation on its turn uses purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation (Chesbrough, 2006,1). The innovation type can range from incremental to radical. Incremental innovation introduces minor changes to the existing product or processes and exploits the potential of the established design while radical innovations introduce a different set of engineering and scientific principles that often opens up whole new markets and potential applications (Han *et al.*, 2012).

Which innovation type can be pursued depends on the complexity of transaction, the ability to codify the transaction and the capabilities in the supply chain. While incremental innovations do not add much to the existing complexity and can be easily codified with minor changes to the existing capabilities, more radical innovations demand new sets of principles, new production and marketing configurations. This adds to the complexity of the transaction. It furthermore demands new codification mechanisms and strong capabilities in the supply base. Depending on whether the latter are available or not within the lead firm and supply base, a more open or closed innovation process should be followed. The results of a first analysis are summarized in Table 4.

Table 4.
Governance types linked to challenge

Governance type	Complexity	Ability to codify	Capabilities in supply-base	Type of innovation	Process of innovation
Market	Low	High	High	Incremental	Open
Modular	High	High	High	Incremental & radical	↑
Relational	High	Low	High	Incremental & radical	↓
Captive	High	High	Low	Incremental*	
Hierarchy	High	Low	Low	Incremental*	Closed

* Radical will demand a full reorganization of the lead firm and the supply- base

The governance type Market can generally be associated with open innovation, given that all market players equally possess high capabilities combined with low complexity of the transactions. Given that price acts as the main market signal, the possibility to codify transactions is important. All players therefore have an incentive to co-create knowledge and information on new incremental innovations. The Modular governance type is best suited for semi-open innovation. As transactions can be easily codified, open innovation is not necessarily restricted to those supply chain partners already cooperating. Due to the complexity of the transaction, potential partners are however restricted to those possessing the required capabilities. In case of the Relational governance type, the low capability to codify the transactions demands more dedicated suppliers and buyers, further closing the innovation development cycle. In case of Captive and Hierarchical governance types, the lead firm develops the innovation in closed form, given the low capabilities in the supply-base.

5 Discussion

The developed framework captures the complex interdependency between the ecological, social and economic system in a structured way. This allows to analyze the sustainability state of these systems. The conceptual framework can be made more applicable to the agri-food chain, by combining it with principles from GVCA. This also allows to analyze the suitability of current governance types to address identified sustainability challenges. As the above results indicate, the conceptual framework allows to perform a system analysis of the Flemish agri-food chain with respect to sustainability.

Given the complexity of the issue at stake, sustainability from an integral chain perspective, the question remains whether all interactions and interdependencies can be properly accounted for with the developed framework. The process of combined qualitative and quantitative research proved helpful to generate and validate obtained results. Further case study analysis should however be performed to demonstrate the general applicability of the framework.

Another remaining challenge is to increase the common understanding of the concept sustainability. Carpenter *et al.* (2001) define resilience as the magnitude of disturbance that can be tolerated before a socio-ecological system moves to a different region of state space controlled by a different set of processes. In contrast, sustainability is an overarching goal that includes assumptions or preferences about which system states are desirable. During the multi-stakeholder process, it became clear that different stakeholder groups have different understandings of the concept sustainability, depending on their values and preferences. Different sustainability paths exist, ranging from radical transitions versus gradual transformations (Geels & Schot, 2007), and different sustainability goals, such as efficiency or sufficiency. It is important to integrate these in the framework and system analysis to improve its general applicability. These challenges need to be addressed in subsequent research.

Our framework allows to analyze the suitability of different governance types to cope with specific sustainability challenges. We demonstrated this by means of an example. Nevertheless, to obtain a complete overview of the potential capabilities of GVCA, all the challenges of Table 3 should be analyzed and compared in a structured way. Moreover, alternative and new governance types should be studied which might better respond to specific sustainability challenges.

6 Conclusion

In this paper we describe a combined conceptual framework to perform a system analysis of the Flemish agri-food chain. Our framework is on the one hand based on principles from ecological economy where sustainable food production is defined as the full range of value-adding activities from raw material over production and marketing to consumption disposal in terms of their effects on natural capital, throughput, manufactured capital, psychic income and cost. On the other hand, principles from GVCA are used. GVCA characterizes governance types such as markets in terms of their complexity of transactions, ability to codify transactions, capabilities in the supply-base, and their degree of coordination. This combined approach allows us to cover the most important aspects of sustainability. We then use this approach to discuss different sustainability challenges. We also demonstrate for a specific challenge, the challenge of knowledge-transfer, whether different chain governance types are suited to cope with it. This first analysis appears promising, though further research will be required to increase the validity of this framework.

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