sustainability

MDPI

Article

Measuring the Economic, Environmental, and Social Sustainability of Short Food Supply Chains

Agata Malak-Rawlikowska [1,*], Edward Majewski [1], Adam Wąs [1], Svein Ole Borgen [2], Peter Csillag [3], Michele Donati [4], Richard Freeman [5], Viet Hoàng [6], Jean-Loup Lecoeur [7], Maria Cecilia Mancini [8], An Nguyen [6], Monia Saïdi [7], Barbara Tocco [5], Áron Török [3,9], Mario Veneziani [8], Gunnar Vittersø [2] and Pierre Wavresky [7]

1 Faculty of Economic Sciences, Warsaw University of Life Sciences, 02-787 Warsaw, Poland
2 SIFO Consumption Research Norway, Oslo Metropolitan University, 0130 Oslo, Norway
3 ECO-SENSUS Research and Communication Non-profit Ltd., 7100 Szekszárd, Hungary
4 Department of Chemistry, Life Sciences and Environmental Sustainability, Università degli Studi di Parma, 43124 Parma, Italy
5 Newcastle University Business School, Newcastle upon Tyne NE1 4SE, UK
6 School of Economics, University of Economics Ho Chi Minh City, Ho Chi Minh City 700000, Vietnam
7 CESAER, AgroSup Dijon, INRA, Univ. Bourgogne Franche-Comté, F-21000 Dijon, France
8 Department of Economics and Management, Università degli Studi di Parma, 43125 Parma, Italy
9 Department of Agricultural Economics and Rural Development, Corvinus University of Budapest, 1093 Budapest, Hungary
* Correspondence: agata_malak_rawlikowska@sggw.pl

Received: 31 May 2019; Accepted: 12 July 2019; Published: 24 July 2019

Abstract: The production and distribution of food are among the hot topics debated in the context of sustainable development. Short food supply chains (SFSCs) are now widely believed to be more sustainable in comparison to mass food delivery systems. To date, very little quantitative evidence exists on the impacts of various types of food supply chains. Using a cross-sectional quantitative approach, this study assesses the sustainability of distribution channels in short and long food supply chains based on 208 food producers across seven countries: France, Hungary, Italy, Norway, Poland, the United Kingdom, and Vietnam. Ten distribution channel types are used in this study. To provide a comprehensive sustainability assessment, a set of economic, social, and environmental indicators are applied. Indicators commonly used in the literature are used, supported by original indicators constructed specifically for the present study. In total, 486 chains are examined and the study confirms that individual producers participate simultaneously in several, short and long chains. Participation in SFSCs is beneficial for producers from an economic perspective. SFSCs allow producers to capture a large proportion of margin otherwise absorbed by different intermediaries. It appears, however, that 'longer' supply channels generate lower environmental impacts per unit of production when measured in terms of food miles and carbon footprint. Finally, ambiguous results are found regarding social dimension, with significant differences across types of chains.

Keywords: short food supply chains (SFSCs); economic, social and environmental sustainability; indicators; impact assessment

1. Introduction

Traditional food deliveries based on direct supplies or sales in physical market places (farmers' markets) were the forerunner of today's short food supply chains (SFSCs). Markets through the centuries acted as links between cities and the countryside and became "strategic outlets" by the 18th century, whilst continuing to maintain an important social function [1]. As Chiffoleau states, "their role naturally

decreased with the industrialization of Europe and the development of long-distance transportation, urbanization and technical advances" [1] (p. 2). These processes resulted in the development of long, logistically sophisticated mass distribution systems that have dominated most industries, including, although probably to a lesser extent, the supply of food.

Recent developments in the food market show a renaissance of traditional, direct ways of delivering food, coupled with an emergence of more innovative types of distribution systems which provide direct linkages between producers and end consumers. As a result, there are numerous types of short food distribution channels under the common name of SFSCs, which coexist with longer, more 'conventional' channels of (mass) food distribution. Geographical proximity is a common criterion used to characterize the 'shortness' of food supply chains. As argued by Lusk [2], this return to traditional food systems is the result of growing consumer criticism of modern food production practices and policy; that there has been a shift from a food-producer to a food-consumer majority, placing a greater emphasis and focus on the involvement of consumers in food supply chains.

Another similar perception is of 'local food systems', in which food is produced and consumed locally within a relatively small area. Whereas the operation of local chains may still be relevant in many geographical territories, their importance may have diminished due to the growing competition from discount food stores in the cities, as well as the steady out-migration of people away from rural areas, creating a further geographical distance from the primary production, or raw processing of products and final consumption.

Nowadays, both SFSCs and 'local food systems' are often considered to be sustainable and are widely promoted in agricultural policy, particularly in the European Union. However, to date, the empirical evidence supporting the sustainability of SFSCs is qualitative and very little quantitative evidence on the impacts of food supply chain types exists. As recognized by Kneafsey et al. [3], in an extensive assessment of SFSCs in the EU, there is a need for more rigorous, quantitative assessments of the socio-economic and environmental impact of SFSCs.

Against this backdrop, this study contributes to existing knowledge on the sustainability of SFSCs through a multi-product assessment of the distribution channels used in short and long food supply chains across multiple product categories and several countries. Focusing on the distribution stage of food chains (from producer gate to consumer), we evaluate the economic, social, and environmental sustainability of SFSCs in a quantitative assessment of key performance indicators. The production phase (farming system) is omitted here, assuming that regardless of the production system used, producers equally diversify the sales channels.

2. Literature Review

In the public and scientific discourse SFSCs are typically introduced as "alternative modes of food supply and consumption", as opposed to "more conventional industrial modes" [4], but also as "alternative food chains" [5], "alternative food networks" [6,7], or "sustainable food chains" [8]. Some newer types of food chains, such as Community Supported Agriculture or Solidarity Purchasing Groups, may also be perceived as a means of re-establishing social relationships between producers and consumers [9,10].

To date, there seem to be two main criteria employed in the literature to classify SFSCs, encompassing the (geographical) distance between the point of production and the point of sale, and the so called 'social proximity' between producer and consumer, associated often only with the 'organizational' aspect of the chain—number of intermediaries involved in the food chain [3–5,11,12].

Some authors, also emphasize the 'social closeness' aspects associated with short chains, including considerations such as social capital, cultural aspects, territorial cohesion, etc. [10,13,14], also the delivery of products to the consumer embedded with information [4].

Indeed, introducing a social aspect to the definition of SFSCs adds a third criterion, separate from physical (geographical) distance and 'organizational' structure expressed by the number of intermediaries between producer and consumer. The 'social aspect' in this context can be presented as

'social distance or social proximity' and "implies communication between producers and consumers [3], giving producers the possibility to control information provided to final consumers and to receive feedback from them, regarding not only the name of the producer, food quality features or farming practices but also the ethical and social values of the process" [3].

An example of the incorporation of social aspects into the definition of SFSCs is the proposition of the European Rural Development Regulation 1305/2013 [15] where a "'short supply chain' means a supply chain has a limited number of economic operators, committed to co-operation, local economic development, and close geographical and social relations between producers, processors and consumers" [15]. This regulation also stresses the importance of social relationships between the people involved in the food chain in defining the quality of collaboration in the operation of SFSCs. A Commission delegated regulation dated 11.03.2014, stipulates that support for the establishment and development of short supply chains shall cover only supply chains involving no more than one intermediary between farmer and consumer (Article 11), [16].

Marsden [4], and later Renting [11], proposed three main types of SFSCs, which create specific forms of relations between consumers and food producers:

- Face-to-face: the consumer buys a product directly from the producer on a face-to-face basis, allowing for authenticity and trust via the personal interaction (e.g., on-farm sales, farm shops, farmers' markets, pick-your-own, etc.).
- Proximate: products are produced and sold close to where they are produced. Consumers are aware of the 'local' nature of goods at retail level (e.g., consumers' cooperatives, community supported agriculture, etc.).
- Spatially extended: information about the place of production and the producer is transferred to consumers.

The value and importance of the latter is increasingly growing and encompasses situations when the product is delivered to consumers who are outside the region of origin and who may have little or no knowledge of that specific region (e.g., via certification labels, restaurants, public food procurement), as pointed out by Renting et al. [11].

Giving recognition to a variety of concepts and interpretations of Short Food Supply Chains' definition, and in order to capture their complexity in our study, we distinguish three proximities to define SFSCs, where:

- 'Physical (geographical) proximity' which refers to the distance of transportation measured with Food Miles of the product from production place to the final consumer;
- 'Organizational proximity' expressed by the number of intermediaries in the chain (zero or maximum one);
- 'Social proximity' which emphasizes some form of 'relationship' between consumer and producer of food based on mutual trust and closeness of the transfer of information.

The sustainability of SFSCs is a hotly debated issue, especially in the context of comparisons with long, conventional chains. According to Sisco et al. [17] (p. 7) a sustainable supply chain is broadly understood as one which "manages environmental, social and economic impacts and works for good governance throughout the life cycle of products and services. The goal of a sustainable supply chain is to create, protect and grow long-term value for all stakeholders involved in the presence of products and services on the market". Assessing the sustainability of supply chains is undoubtedly a challenging task. The Foodlinks report [18] considers a variety of food production and distribution systems and the complexity of relations with different sustainability pillars, including both complementary and competing interactions between these pillars [19,20]. That is why they are often part of market niches created for specific production systems or products characteristics (e.g., organic, 'healthy', traditional or regional food), selected groups of consumers (e.g., urban food cooperatives), or unique marketing and retailing approaches (e.g., box schemes). When taking a geographic coverage criterion, short chains

may be associated with 'local food chains' in which production and sales are restricted to local areas, albeit this may increasingly not be the case, as the distance between food producers and consumers increases and the food traceability systems are developed.

It is noticeable that small and medium-sized enterprises are predominantly involved in SFSCs. However, they may face a "competitive strategy ... especially for those small family farms, which struggle to interface with the conventional markets" [21], (p. 65). They are often less competitive in conventional chains due to the lack of economies of scale and higher production costs per unit of produce. SFSCs represent a solution that may increase the profitability of small and medium-sized farms or processing companies. This is because food delivered through short supply chains is often associated with high quality by some consumers who are willing to pay a premium price [22–24]. Thus, short food supply chains offer financial gains for producers, but this is largely due to higher prices paid by consumers [9].

SFSCs are often devised as collective economic initiatives in response to deteriorating market conditions, thereby "shortening" and strengthening links between local businesses and mobilizing local resources [25]. SFSCs can thus contribute to the revival and growth of local rural economies [16,23,26–29].

According to Kneafsey et al. [3], most of the previous studies suggested that "SFSCs were 'beneficial' for the environment but then did not provide any further qualitative or quantitative evidence to substantiate the claims made". However, because of the smaller scale and volumes distributed, the environmental performance of short chains may not be so positive.

In this sense, the statement "referring to the definition Reg. 1305/13 is able to reach goals of 'sustainable agriculture', through the reduction of transportation costs and consequently of CO_2 emissions" [30], (p. 402) may be considered highly controversial.

On the contrary, Gonçalves and Zeroual [31] and Mancini et al. [32] indicate that the need for frequent deliveries of relatively small quantities of food may have negative impacts on environmental sustainability or, according to Bloemhof and Soysal [33] there are negative impacts although they are "not so important".

Regarding the social sustainability dimension, there is strong evidence of growing social appreciation of short food supply chains. Social sustainability refers to their contribution to fairness among food chain actors, understood as a lack of favouritism towards any party, and the vitality of local communities. It is deeply rooted in trust and personal relations, whereby solidarity and the exchange of shared values are embedded in the encounter between consumers and producers.

Consumers may learn additional information on how the food they buy was produced, the methods used and the specific territorial attributes, and build trust and confidence based on a good (direct) relationship with the producer. It could be easier to establish fairness in direct relationships between producers and consumers by means of more individual interaction than is the case with impersonal large supermarkets. To conscious consumers, it is easier to understand the true cost (and perhaps observe externalities) of food production, making it easier to pay a producer that is known and trusted. The role of middlemen in adding value may also be more easily recognized in an observable short chain and thus, their receipt of a fair return may be more likely [11]. SFSCs may also contribute to the revitalization of local communities. The value and importance of the product and its origin gives rise to a sense of pride, social cohesion and belonging to a certain area and community [26].

In summary, it can be argued that SFSCs can provide producers with a higher share of the value added, while strengthening local development and territorial cohesion, with lower food miles and carbon footprint.

3. Methodological Approach

The sustainability assessment was conducted in seven countries: France, Hungary, Italy, Norway, Poland, the United Kingdom, and Vietnam. The EU countries selected allow for the different socio-economic and environmental characteristics across Europe to be considered. Extending the

analysis to Vietnam, a country characterized by unique food supply characteristics of its own, offers a good additional comparison as a non-European country.

The sample covers 208 food producers, mainly farmers, participating in several short and long food chains. Farms constitute the majority of objects selected for the research sample (186). In the cases of Norway and the United Kingdom, 22 fishmongers have also been added to the sample due to the importance of the fish industry in the agri-food sector in respective countries and regional coverage. It should be emphasized here that although unlike other research objects in the sample, fishmonger activities are not agricultural land based, although they participate in the same set of distribution channels as sampled farms. To make the descriptions of the methodological assumptions and analysis of results as transparent as possible, we will be referring to farms from now on.

The procedure applied in our study is in line with Tellis [34]. In the planning phase, the key methodological assumptions have been made regarding the general strategy of conducting the study (selection of categories of products and producers sampling approach), creation of the list of indicators to be calculated for the economic, environmental and social sustainability assessments and construction of the survey questionnaire.

The producer survey was conducted in the next phase, preceded by questionnaire testing in pilot surveys conducted in France and in Poland (Locavorium initiative and Korycin cheese, respectively).

The main goal of this fieldwork research was to identify different types of chains in which farmers participate when delivering their products and, at the same time, collect data for the calculation of indicators for the quantitative sustainability assessment. The starting point was to select farm businesses that participate in at least one type of SFSC, which will be more clearly defined in the following section.

3.1. Typology of Food Supply Chains

There are several types of supply chains that may be identified depending on the product's destination (type of client or end consumer), number and functionality of intermediaries involved, and the product type (raw materials or processed foods). Farmers may belong to several chains that differ not only in the length measured by the distance and the number of intermediaries, but also type of intermediaries in the chain (e.g., wholesalers, small retail outlets, large hypermarket chains).

Referring to the general structure of the food market [35] and categorizations of distribution channels e.g., [3,36–38] a typology of 'short' and 'long' distribution channels has been developed (Table 1). In accordance with the literature, all chains with no, or only a single, intermediary between the producer and consumer are classified as 'short', and chains with more than one intermediary are classified as 'long'. The number of intermediaries reflects, to some extent, a physical distance despite there being close social ties between the chain actors.

Table 1. Distribution channels in short and long food supply chains selected for the study.

Short Food Supply Chains (SFSCs)	Long Food Supply Chains (LFSCs)
(a) Direct on-farm sales: pick your own	
(b) Direct on-farm sales: sales to individual consumers	(g) On-farm sales to intermediaries
(d) Direct off-farm sales: Internet deliveries	(h) Sales to wholesalers or on wholesale markets
(e) Direct off-farm sales: delivery to consumer	(i) Sales to retail chain (two intermediaries)
(f) Direct off-farm sales: farmers' markets (fairs)	(j) Sales for processing
(c) Sales to small retail outlets (one intermediary)	

Source: own elaboration.

Our assessments focus on the distribution stages of the broadly understood food systems related to physical movement of products from the farm (producer) gate to the end consumer. Regardless of the production system used, producers equally diversify the sales channels used [39]. As such, production (farming) systems were not a subject for the analyses. Several studies focus on assessing sustainability of different farming systems, which are considered a part of supply chains. For example, [40] assess

the sustainability farming system with the use of life-cycle assessment methodology concluding on this basis, on the sustainability of the entire supply chain. Difference in the sustainability of various production systems, and the farms (businesses) within them, is well recognized and, thus, beyond the scope of the present analyses. Focusing on distribution channels we consider that producers use several distribution channels, which differ in sustainability. In practice, irrespective of the production system, farmers use the same channel types (Table 1). Therefore, the main outcome of the study is in-depth quantitative sustainability assessment of distribution channels, an integral part of all food supply chains.

Within selected chains various specific sub-types could be distinguished. However, considering the complexity of supply chain types, some interpretations were necessary to provide a manageable analysis and presentation platforms. Therefore, in the category 'sales to small retail outlets' different forms of deliveries through an off-farm retail point were included, such as hotels or restaurants and, in the case of the French sample, in AMAP (association for maintaining peasant farming, a system close to community supported agriculture) [41] or the cooperative AlterConso, based in Lyon.

Both producer and chain perspectives have been considered regarding the economic and social indicators. In the calculation of the two key environmental indicators—food miles, carbon footprints, and distances travelled by consumers have also be examined. Participation of producers or intermediaries transporting goods to retail outlets depending on the chain, and travels of consumers to purchase foods are illustrated in Table 2.

Table 2. Participation of producers, intermediaries, and consumers in selected food supply chains *.

Chain	Produce Gate	Yellow—Consumer Travel; Green—Product Travel			
Short Chains					
a. Pick your own	Producer	Consumer			Consumer
b. On-farm sales to individual consumers	Producer	Consumer			Consumer
d. Direct sales—Internet deliveries	Producer	Courier company			Consumer
e. Direct sales—delivery to consumer	Producer				Consumer
f. Direct sales on farmers' markets (fairs)	Producer				Consumer
c. sales to retail shops (1 intermediary)	Producer			Retail Shop	Consumer
Long Chains					
g. On-farm sales to intermediaries	Producer	Intermediary	Wholesalers	Retail Shop	Consumer
h. Sales to wholesalers or wholesale market	Producer	Wholesalers		Retail Shop	Consumer
i. Sales to retail chain (2 or 3 intermediaries)	Producer	Producers Group	Logistics Centre	Hyper-marke Store	Consumer
j. Sales for processing	Producer	Processor			

* The yellow color in the table indicates a part of the physical distance in the distribution channel in which food is transported from the purchase (sales) by the consumer. Green color indicates that the product travels from the farm gate to sales point being transported by producers or intermediaries. Source: own elaboration.

Short food supply chains are those marked with letters 'a' to 'f.' There are no intermediaries in the chains: pick your own and (**a**), on-farm sales (**b**), Internet deliveries (**d**) delivery to consumer (**e**) and sales on farmers' markets and food fairs (**f**). There is one intermediary in sales to retail outlets (**c**).

In the group of 'long' chains (**g–j**), which serve in the study as a reference for comparisons with SFSCs, there are four distribution channels with two or more intermediaries. Three intermediaries may be identified in the chains 'on-farm sales to intermediaries (an agent purchasing product-wholesaler or

wholesale market-retail outlet)' and 'sales to retail chain (farmers' co-operative-logistic center-hypermarket),' both of which are commonly used in the fruit market in Poland.

Chains analyzed in the study can be divided into three categories depending on participation of consumers in transporting food:

- Consumer only involved (pick your own and on-farm sales);
- Producers only involved (Internet deliveries and delivery to consumer);
- Producers and intermediaries supplying retail outlets, and the 'last mile' transportation done by consumers or couriers providing home deliveries (all the remaining chains).

Sales for processing, if applicable, are also included as one of the long chains but only for the reason of balancing the farm sales with production. As there are several paths by which food may reach consumers from processors, as it is in the case of products that may be delivered directly to the end consumers, a specific study would be required to calculate indicators reflecting distribution of processed foods, which is beyond the scope and capacity of this study. For this reason, 'sales for processing' are shown in some of the summaries of results yet are not considered in comparisons of 'short' and 'long' chains.

3.2. Research Design—Selection of Products, Farm Survey

Data were collected from 208 businesses, including 186 farmers from all countries and 22 fishmongers in Norway and the United Kingdom (Table 3).

Table 3. Number of farms and fishmongers in the research sample.

Country	France	Hungary	Italy	Norway	Poland	United Kingdom	Vietnam	Total
Number of businesses	22	39	22	16	57	35	17	208
of which: Farms	22	39	22	14	57	15	17	186
Fishmongers	-	-	-	2	-	20	-	22

Source: own elaboration.

Of the sample, 68.3% businesses represent conventional production systems and 31.7% possessed a certificate of organic production.

It is worth emphasizing that the sample cannot be considered representative for the whole population of farms across respective countries. Successful selection of a fully representative sample would require specific data on population of food producers with at least one case of participation in a short channel and such database does not exist. Nevertheless, a large and diversified sample provides the possibility for a deep insight into coexistence of short and long chains and allows for drawing conclusions valid for a substantial part of the agri-food sector. The selection of producers was made on the basis of their engagement in at least one SFSC, while an attempt to capture the diversity of supply chains was made to assess comparisons in sustainability.

Another selection criterion was product category. Product categories, and businesses to be surveyed, were selected based on the importance of the product category to the respective food industry of the sample countries. For example, as fisheries are important sectors in Norway and the UK, fishmongers were added to the sampling frame in these countries. A detailed breakdown of product categories in the sample across countries is presented in Table 4.

The data were collected between November 2017 and November 2018. For interviewing producers, the survey questionnaire was constructed in the form of a self-calculating Excel file, allowing to calculate all the indicators for an individual business immediately after all requested data were provided. The questionnaire contained the following parts: business description (labor, production structure, means of transportation, turnover); sales (quantities sold to different chains, prices, locations,

and distances to final destinations); specific distribution related data (amounts transported in single deliveries, labor inputs, costs of packaging, other distribution costs); self-assessment of bargaining power and evaluation of chains by producers. The questionnaire was translated into the respective country languages. Additional assumptions were required to estimate the food miles and carbon footprint for long supply chains and transportation by consumers (mean distances and quantities purchased, percentage of passing-by purchases, etc.).

Table 4. Total number of chains used by producers in distribution of products in the sample across countries.

Category of Product	Country							Total
	France	Hungary	Italy	Norway	Poland	United Kingdom	Vietnam	
Fruits	8	34	0	0	95	0	0	137
Vegetables	22	8	34	8	23	-	26	121
Fish & Seafood	-	-	-	4	-	43	-	47
Cheese	31	3	32	2	28	-	-	96
Meat	4	2	-	14	-	27	-	47
Honey	-	32	-	-	-	-	-	32
Other (eggs)	-	-	-	6	-	-	-	6
Total	**65**	**79**	**66**	**34**	**146**	**70**	**26**	**486**

Source: own elaboration.

3.3. Sustainability Indicators

For the quantitative assessments of economic, environmental and social sustainability of supply chains, a set of indicators was proposed (Table 5).

The indicators selected for the analysis reflect the three main pillars of sustainability (economic, environmental, social) and 'attributes' such as economic added value, pollution, labor [42]. Based on a literature (e.g., the FAO's Sustainability Assessment of Food and Agriculture systems (SAFA) indicators [43,44]), a collection of indicators was proposed for the Strength2Food Horizon 2020 project [45]. From these indicators, those that were appropriate for the assessment of the sustainability of distribution channels were selected. Some of the indicators (i.e., chain added value, bargaining power, chain evaluation) were designed specifically for the present study.

Table 5. Indicators of economic, environmental, and social sustainability of SFSC.

Economic Sustainability Indicators	
Price difference Farmgate (EUR)	This shows the difference between the average farmgate price in the chain and the average farmgate prices in the region in accordance with the formula below: $\textbf{\textit{Price difference Farmgate}} = \textit{Average Farmgate Price in the chain recived by farmer} \left(\frac{\text{euro}}{kg}\right) - \textit{Average farmgate to retail price in the region} \left(\frac{\text{euro}}{kg}\right)$
Price Premium (%)	This is the relation: $Price\ premium = \frac{Price\ difference\ Farmgate\ (euro/kg)}{Average\ farmgate\ to\ retail\ price\ in\ the\ region\ (euro/kg)}$
Chain value added (EUR) and Chain value added (%)	$\textbf{\textit{Chain value added}}\ (euro/kg) = Price\ difference\ Farmgate - Distribution\ costs;$ $\textbf{\textit{Chain value added}}\ (\%) = \frac{\textbf{\textit{Chain value added}}\ (\textbf{\textit{euro/kg}})}{\textbf{\textit{Average farmgate to retail price in the region}}\ (\textbf{\textit{euro/kg}})}$ Distribution costs contain: costs of transportation, packaging, market fees and similar payments and distribution related labor input. Costs of own labor were calculated at the per hour rates paid to hired labor.

Table 5. *Cont.*

Environmental Sustainability Indicators	
Food Miles Total (km/kg)	This reflects distance measured in kilometres travelled both by products as transported from the farm by farmer or intermediaries, and the consumers after purchasing goods, which is accounted for every kilogram of the product. Food Miles have been estimated both: for the distribution stage from farmgate to retail outlet ("Food Miles Product") and transportation by consumer ("Food Miles Consumer"). Taking into account different purchasing patterns coefficients that may reduce number of Food Mes have been introduced: - coefficients of "return way" if the means of transportation are fully or partially loaded on the return; - coefficients of "passing by", if consumers do shopping when travelling for different purposes *; - coefficient of the share of the product in total load transported to the selling point or in total amount of goods transported by consumers. $$\textbf{\textit{FOOD MILES Total}} = \begin{matrix}\textit{Food Miles}\\ \textit{Product}\end{matrix}\left(\frac{km}{kg}\right) + \begin{matrix}\textit{Food Miles}\\ \textit{Customer}\end{matrix}\left(\frac{km}{kg}\right)$$
Carbon Footprint	The Carbon Footprint (CFP) expressed as an carbon dioxide equivalent (CO2 eq) represents emissions of Greenhouse Gases (GHG) in the process of transportation. In our study CFP is estimated based on the number of calculated Food Miles. For all means of transportation used *fuel consumption (l/kg)* is multiplied by the *Carbon Footprint (CFP) coefficient* [46]. For all transportations that require the use of cooling system *fuel consumption* was increased by the coefficient proposed by Tassou et al. [47]. $$\textbf{\textit{Carbon Footprint}} = \textit{Fuel consumption}\left(\frac{l}{kg}\right) * \textit{CFP coefficient}\ (CO_2/\text{kg})$$
Social Sustainability Indicators	
Labor to production ratio (h/kg)	This reflects the number of hours worked used in respective chains in the distribution processes including preparing products for transportation, loading, transporting, and selling by producer (farmer). $$\textbf{\textit{Labour to production ratio}} = \frac{\left(\begin{pmatrix}\textit{man hours used for}\\ \textit{preparing for sale}\\ \textit{per one delivery}\end{pmatrix} + \begin{pmatrix}\textit{man hours}\\ \textit{used for transport}\\ \textit{and selling}\end{pmatrix}\right) * \begin{pmatrix}\textit{Number of}\\ \textit{deliveries}\end{pmatrix}}{\textit{volume of sales in the channel (kg)}}$$
Gender equality (%)	Represents the share of hours worked by women in distribution processes (see above). $$\textbf{\textit{Gender equality}} = \frac{\begin{matrix}\textit{hours worked by women in distribution processes}\\ \textit{in respective chains}\end{matrix}}{\textit{total labour input for distribution (h)}} * 100\ \%$$
Bargaining power	Estimated based on self-assessment by business managers surveyed evaluating their position in the chain on the basis of the following criteria: 1. Position in the channel (the extent to which they can influence 'things'); 2. Level of trust in relations with other chain participants; 3. Relations with other farmers (producers) participating in the same chain; 4. Relations with the customers.
Chain evaluation	Measure based on self-evaluation of factors which may have influence of the perception of how attractive the chain is for the producer. The attractiveness of the chain has been rated in relation to the following factors: 1. Prices achieved in the chain; 2. Possibility of selling large quantities of produce; 3. Level of labor requirements according to the process of preparing for sale and transportation; 4. Possibility of making long term contracts; 5. Regular and assured payments; 6. General level of satisfaction ("how much do you "like" this chain?"). The Likert scale 1 (poor) to 5 (excellent) has been used.

* estimated on the basis of findings of qualitative assessment, conducted as part of the Strength2Food Project—for more results of qualitative assessment see Vittersø et al. [48]. Source: own elaboration.

4. Results

4.1. Characteristics of the Sample

Data was collected from a sample of 208 businesses, consisting of 186 farms and 22 fishmongers (in Norway and the United Kingdom). About 68.3% businesses represent conventional production systems and 31.7% possessed a certificate of organic production. The average farm size in the sample (calculated without the fishmongers) was 38.7 ha (Table 6). The largest farm businesses in the sample have been selected for the farm survey in the United Kingdom (215 hectares of agricultural land), followed by Italian (about 80 ha), French and Norwegian farms (about 30 ha). The surveyed farms in other countries are noticeably smaller because of different historical and economic reasons. In Vietnam, the farms in the sample can be classified as particularly small-scale, semi-subsistence (often peasant) farming. In Hungary, where the agricultural sector is dominated by very large former state and cooperative farms, individual family-operated holdings that have been selected for the survey are rather small. Moreover, part of the Hungarian sample consisted of honey producers, who own small plots of land, thus decreasing the average. In Poland, the farm structure is highly fragmented and polarized (small farms in the southeast, large farms in the northwest). The mean in the Polish sample is very similar to the average family farm size in Poland.

Table 6. General characteristics of the sample.

Country	France	Hungary	Italy	Norway	Poland	United Kingdom	Vietnam
Number of Farms	22	39	22	16	57	35	17
Area of Agricultural Land per Farm (ha)							
Mean	31.40	5.80	80.89	30.62	14.54	214.83	0.32
Standard Deviation	64.3	6.5	123.8	28.0	12.1	299.3	0.4
Coefficient of Variation (%)	205	112	153	106	83	139	128
Farms with Livestock (%)							
Share of farms in the sample	50	45	62	88	63	40	100
Education Level of Business Managers (structure in %)							
Primary and secondary (%)	32	82	32	13	66	63	65
Tertiary * (%)	68	18	68	88	34	37	35
Employment							
AWU per business/farm	5.1	2.0	6.6	5.2	4.9	7.5	0.6
Hired labor (% of AWU)	62.8	26.2	54.9	66.7	43.5	80.5	0.0
Share of women in AWU (%)	48.0	53.0	30.0	41.8	47.0	26.3	44.8
Number of Years as a Business Manager (years)							
Mean	15.1	26.4	27.5	18.1	25.0	25.5	18.5
Standard Deviation	9.4	17.6	13.8	10.8	9.2	11.4	15.2
Coefficient of Variation (%)	62	66	50	59	37	45	82

* based on ISCED/Eurostat classification Source: own elaboration.

The labor resources and employment differ strongly in the sample, depending on farm size, type of production and scale of operations in fishmonger businesses. Total labor resources expressed in annual work units (AWU) per business unit ranged on average from 0.6 AWU in Vietnam to 7.5 AWU in the UK (Table 6). The share of hired labor in total labor resources was substantial (58% on average), except for Vietnamese farms which were operated exclusively on a part time basis by family members. The relatively high proportion of hired labor in the total resources can be explained by the fact that in the sample numerous farm businesses are represented that require large labor inputs (e.g., fruit and vegetable grower, cheese, and processed meat producers) as well as the UK fishmongers almost entirely relying on hired labor (81%).

Farmers (and fishmongers), participated in all the 10 chain types outlined in Table 2, with respective sale values and market shares summarized in Table 7. Nearly 52% of the volume of sales was sold through long food supply chains (LFSC)—mainly to hypermarket chains (21%), and about 32% through short food supply chains—of which the most popular were deliveries to retail shops. The structure of sales across categories of products and chain types is presented in Table 8. The largest volumes of almost all products are sold to LFSC. SFSC sales are less in volume, but with a large diversity of short chains in which producers participate. The point is that SFSCs, largely locally oriented, cannot absorb large quantities of produce. Therefore, especially bigger scale producers tend to diversify the distribution channels utilizing to a greater extent long channels. This is also because the demand for food goes with the consumers, who continuously migrate away from food production areas to large urban agglomerations.

Table 7. Structure of sales by distribution channel.

Supply Chains		Total Volume Sold and Market Share		Producer Participation across Chains	
		(tonnes)	(%)	Number of Chains	Producers (%)
Short Chains	a. Pick your own	16.3	0.1	3	0.6
	b. On-farm sales to individual consumers	855.9	5.9	115	23.7
	c. Sales to retail shops	2920.1	20.0	71	14.6
	d. Direct sales—Internet deliveries	148.2	1.0	28	5.8
	e. Direct sales—delivery to consumer	176.7	1.2	28	5.8
	f. Direct sales on farmers' markets	313.1	2.1	73	15.0
	Total	**4282.15**	**30.3**	**318**	**65.5**
Long Chains	g. On-farm sales to intermediaries	2280.3	15.6	46	9.5
	h. sales to wholesalers/wholesale market	2328.1	15.9	61	12.6
	i. Sales to retail chain	3013.9	20.7	29	6.0
	Total	**7622.2**	**52.2**	**136**	**28.1**
Other Chains	j. sales for processing	2558.5	17.5	32	6.4
	Total Sample	**14,611.13**	**100**	**486**	**100**

Source: own elaboration.

Table 8. Sustainability indicators across food supply chains.

	Economic		Environmental		Social			
	Price Premium (%)	**Chain Added Value**	**Food Miles (km/kg)**	**Carbon Footprint (kg CO_2/kg of product)**	**Labor to Productior**	**Gender Equality**	**Bargaining power**	**Chain Evaluation**
a. Pick your own	96.7%	54.7%	1.7	1.211	41.9%	0.0%	4.3	3.4
b. On-farm sales to consumers	70.5%	40.1%	3.6	0.765	15.7%	32.2%	4.2	3.6
c. Sales to retail shops	61.9%	23.2%	0.2	0.113	1.6%	25.4%	3.9	3.6
d. Internet sales	70.4%	35.8%	0.1	0.057	24.7%	25.1%	3.7	3.4
e. Delivery to consumer	70.4%	24.4%	0.6	0.474	4.3%	17.9%	4.0	3.7
f. Sales on farmers' markets	85.1%	57.7%	1.0	0.261	6.5%	49.9%	4.0	3.8
g. Sales to intermediaries	5.3%	−10.6%	0.1	0.102	0.2%	23.3%	3.3	3.3
h. Sales to wholesale market	23.5%	5.4%	0.4	0.210	0.5%	24.9%	3.5	3.5
i. Sales to retail chain	20.6%	10.3%	0.3	0.151	0.2%	26.7%	3.8	3.9
j. Sales for processing	21.0%	8.6%	0.01	0.003	0.1%	30.2%	3.8	3.9
Total sample	53.3%	26.2%	0.4	0.162	1.9%	30.0%	3.8	3.6
Indicators According to Type of Chains								
Short chains *	72.2%	38.7%	908.9	0.266	5.7%	30.0%	4.0	3.6
Long chains	16.7%	1.0%	273.3	0.146	0.3%	25.0%	3.5	3.5
Processing	21.0%	8.6%	9.7	0.003	0.1%	30.2%	3.8	3.6

* Underlined values mean that they are significantly higher for short food supply chains than values for long chains, significant at $p < 0.005$; Source: own elaboration.

Regarding the number of chains used by farmers, most of them (65%) were SFSCs (Table 7). The most commonly used was the chain 'on-farm sales to individual consumers,' with 115 businesses visited by individual consumers out of 208 in the sample. The likely explanation is that almost 60% farms represented organic or other food quality certifications attracting not only local customers but in some cases tourists (e.g., Kaszubska strawberry, Dried Plums in Poland; Parmigiano Reggiano in Italy), as well as other, passing by customers (Table 7).

In the sample there were 2.33 chains used on average by a single producer. In the extreme cases, producers participated in up to 5 chains, both short and long.

4.2. Assessment of SFSC Sustainability-Indicators

The main results of the sustainability assessment are presented in Table 8 and are discussed in the following sections.

4.2.1. Economic Sustainability

Across all types of short chains, sales through SFSCs resulted in better prices achieved by producers, as the average values of 'price premium' and 'chain value added' indicate. The average Price Premium in SFSC was 72.2% compared with 16.7% in LFSC. Even greater was the difference in the level of chain value added (CVA). In the case of short chains, it was mainly due to price gains.

Visibly better economic performance of short chains is characteristic to all countries. The only exception is Vietnam, where price premium for long, as well as CVA for both types of chains,

were negative. The most likely reason for this is the almost complete dependence of farmers in the sample on intermediaries and relatively high transportation costs, including the estimated distribution related cost of labor.

The price premium is the highest in sales on farmers' markets and pick-your-own, because prices paid by consumers were almost two times higher compared with average farm gate prices in sales to retail chain. These channels remained profitable even after including costs of labor and other distribution costs. However, because of the small share in total sales or small scale of production these benefits had no significant impact on the overall situation of individual producers. Chain value added was the highest in cases of sales to farmers' markets (57.7%) and pick-your-own sales (54.7%). Regarding the latter, there were only three cases of pick-your-own sales in two countries—that is why these single observations do not provide any solid basis for more general conclusions. Similar relations between economic results for short and long chains were identified across product categories represented in the sample.

4.2.2. Environmental Sustainability

There were two environmental sustainability indicators assessed in the study—food miles and carbon footprint. Food miles is an indicator used to measure the distance that food travels from where it was produced to its destination, usually the end-consumer. It is related to carbon footprint as an intermediate phase in CFP estimation.

The highest value of food miles characterizes chains with the highest level of participation of consumers in transportation linked with the smallest quantities transported (pick-your-own, on farm-sales). The third largest is the food miles indicator for sales on farmers' markets, due to relatively small quantities transported and the location of markets in a relatively long distance both, from the producer place and the final destination of the consumer. Moderately low were values of food miles representing long chains sales in hypermarket chains, through wholesalers or intermediaries despite large distances traveled by products to retail outlets. This is because of transporting large quantities in heavy good vehicles, resulting in relatively small distances per unit of transported goods (Table 8). The lowest food miles characterize Internet sales connected with courier deliveries. Even though quantities delivered to long distances were small, parcels delivered constituted a small proportion of the assumed load transported by specialized courier companies that resulted in the low values of the indicator.

On average food miles for short chains were more than three times greater compared to long chains. Although relations between the chains are similar, patterns regarding the value of food miles differ across countries.

The key environmental sustainability indicator is carbon footprint (CFP), which expresses the amount of CO_{2eq} emitted to the atmosphere as an equivalent of greenhouse gases (GHP) calculated per 1 kg of the product (Table 9). Similar to relations for food miles per kilogram of products, the value of carbon footprint for short chains is greater (0.266 kg CO_{2eq}/kg) than for long chains (0.146) although the difference between CFP is much less. This is because, while consumers contribute to food miles, they drive small cars that consume relatively less fuel, so their contribution to CFP for short chains is less significant.

Table 9. Carbon footprint (CFP) for supply chains in the sample.

	Volume of sales (tonnes)	Structure of Sales (% of Volume)	Total Carbon Footprint (kg CO_2/Chain)	Total Carbon Footprint (kg CO_2/kg)	CFP Producer (kg CO_2/kg)	CFP Consumer (kg CO_2/kg)	Share of CFP producer (%)	Share of CFP consumer (%)
a. Pick your own	16.3	0.1%	19,742.7	1.211	-	1.211	-	100.0%
b. On-farm sales to consumers	855.9	5.9%	654,832.7	0.765	-	0.765	-	100.0%
c. Sales to retail shops	2920.1	20.0%	330,442.5	0.113	0.083	0.030	73.5%	26.5%
d. Internet sales	148.2	1.0%	8395.0	0.057	0.057	-	100.0%	-
e. Delivery to consumer	176.7	1.2%	83,693.8	0.474	0.474	-	100.0%	-
f. Sales on farmers' markets	313.1	2.1%	81,813.6	0.261	0.114	0.147	43.8%	56.2%
g. Sales to intermediaries	2280.3	15.6%	232,339.2	0.102	0.059	0.043	57.9%	42.1%
h. Sales to wholesale market	2323.1	15.9%	486,764.8	0.210	0.167	0.043	79.5%	20.5%
i. Sales to retail chain	3018.9	20.7%	455,915.4	0.151	0.060	0.091	39.7%	60.3%
j. Sales for processing	2558.5	17.5%	8735.2	0.003	0.003	-	100.0%	-
Carbon footprint According to Type of Chain								
Short chains	4430.4	30.3%	1178,920.3	0.266	0.084	0.182	31.5%	68.5%
Long chains	7622.2	52.2%	1,175,019.5	0.154	0.092	0.062	59.8%	40.2%
Processing	2558.5	17.5%	8735.2	0.003	0.003	-	100.0%	-

Source: own elaboration.

As presented in Figure 1 on farm sales contribute most (27.7%) to the total carbon footprint despite their relatively low share in the total volume of sales (5.9%). In the case of this chain, many consumers transport small quantities of food from single purchases. Long chains generate about 50% of CFP, but their share in the volume of sales is nearly 70%. This could be explained by more effective use of means of transportation (larger quantities transported, larger vehicles, utilization of return-way transport).

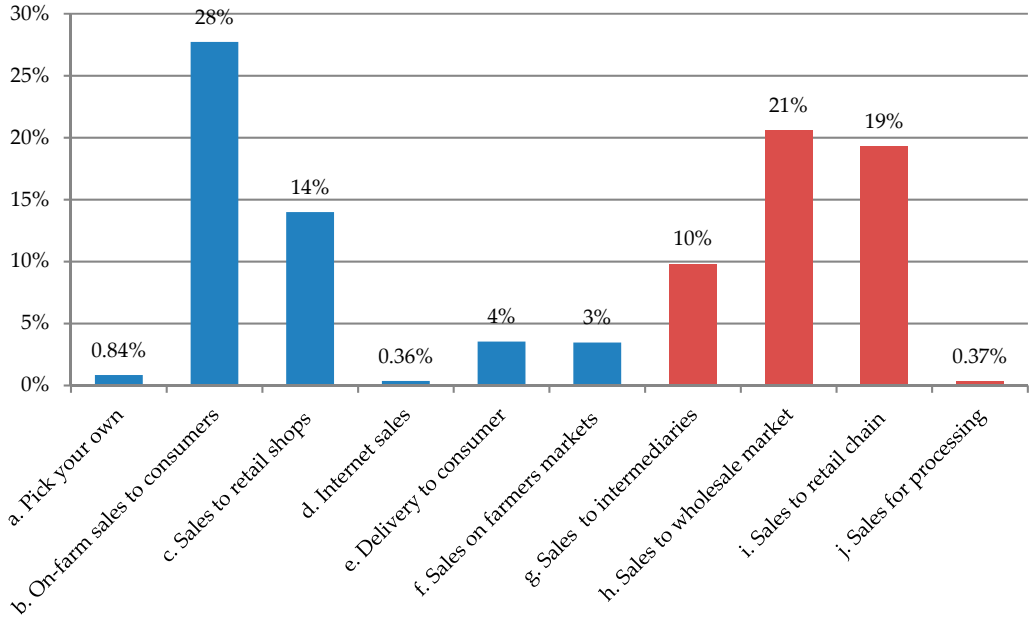

Figure 1. Structure of total carbon footprint across supply chains. Source: own elaboration.

Cross-country comparisons of carbon footprint across chains confirm general relations in CFP observed in the whole sample. There were between-country differences for each indicator that may have resulted from various product-dependent characteristics for quantities purchased, distances travelled by producer and consumers due to locations of producers and retail outlets. For the same reasons, proportions between CFP values for analyzed chains may differ. In the cross-country comparison, as in the whole sample, Internet sales are characterized by the lowest CFP per kilogram of product, while on-farm sales and sales on farmers' markets have the greatest impact on GHG emissions.

In the whole sample, the proportions in the share of producers and consumers in generating carbon footprint are similar (Figure 2). On average consumers generate about 55% of GHG emissions, though, shares of consumers and producers (including intermediaries) differs depending on the type of chain, as illustrated in Figure 2.

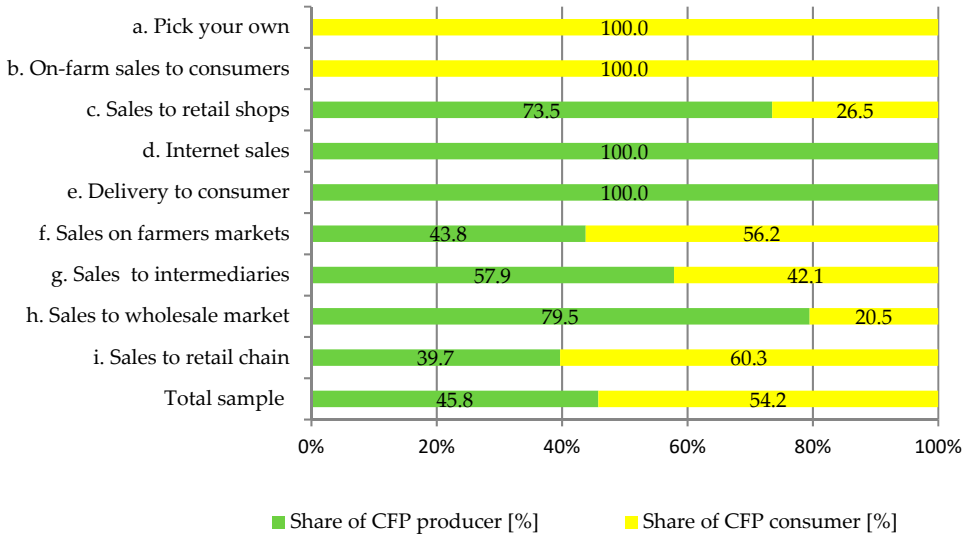

Figure 2. Share of CFP (%) generated by producer and consumer in the total CFP generated across supply chains. Source: own elaboration.

These results show that GHG emissions in distribution processes should be analyzed taking into account the contributions of both–producers and consumers, as well as producers that belong to the same food chain.

The reason for a relatively high consumer contribution to generating CFP (Figures 2 and 3) in the case of almost all chains, (with the exception of Internet deliveries and direct delivery to consumer) is the fact that consumers usually buy small quantities of products most frequently using cars. Even if we take into account that consumers travel relatively short distances emissions from this type of transportation per unit of product are very high. This is particularly evident in the case of on-farm sales and pick-your-own chains, where the consumer is responsible for all the distance travelled by the product, which makes optimizing transport in terms of quantities transported impossible. It should be emphasized that, in our estimates, the distances travelled by individual consumers were strongly reduced through several assumptions made regarding shopping when passing-by (e.g., tourists, consumers travelling home from work, etc.) or joint purchases of products other than the specific type of food. The assumptions were based partially on information collected from surveyed producers but also from consumers interviewed in our parallel qualitative survey [48].

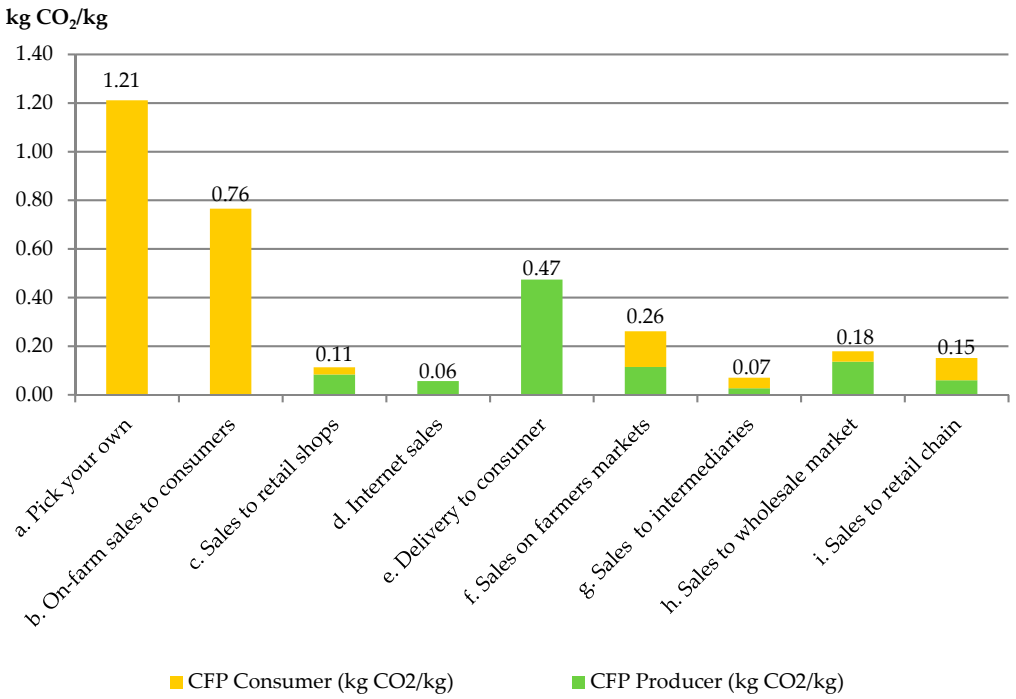

Figure 3. Level of producer and consumer CFP (%) across supply chains in the total sample. Source: own elaboration.

4.2.3. Social Sustainability

(a) Self-Assessment of Bargaining Position in the Chain

The level of bargaining and market power was estimated based on self-assessment by business/farm managers regarding their position in the chain according to the following criteria: position in the market channel (the extent to which they can influence 'things'); level of trust towards other chain participants; relations with other farmers (producers) participating in the same chain; relations with the customers. The results are illustrated in Figure 4 and Table 8.

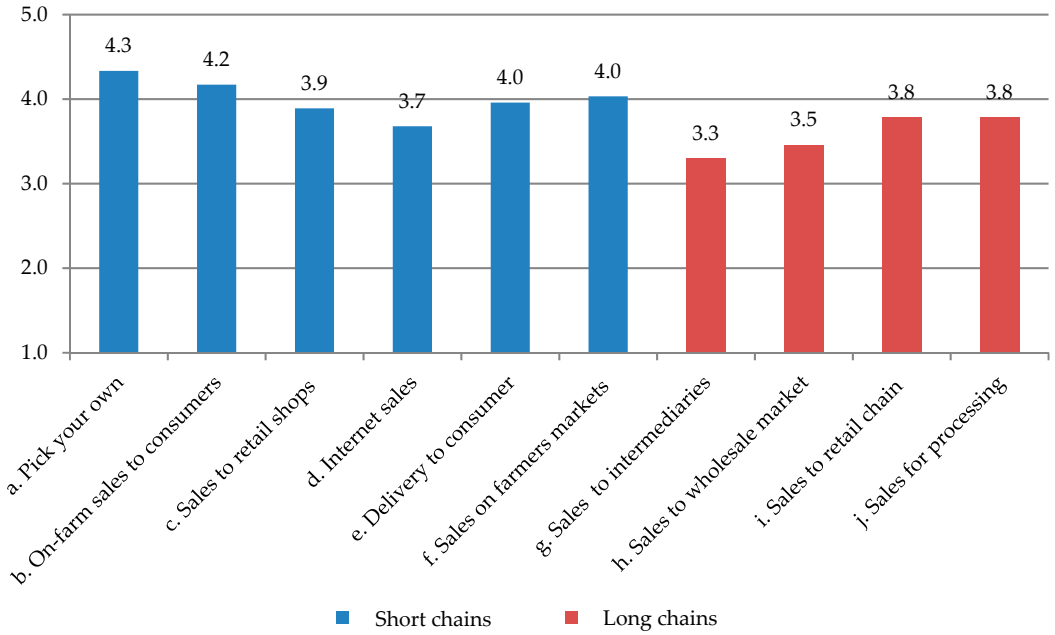

Figure 4. Bargaining position in the food supply chain by self-assessment. Source: own elaboration.

Bargaining position in the chain is visibly perceived as higher in the case of short chains. This can be observed both via the general sample average, as well as across respective countries. As far as the chain type is concerned, it was not surprising to find that, in all SFSC channels where the farmer has a direct contact with the consumer, his/her position in the chain is evaluated higher compared to sales through long chains. However, it was interesting to note that Internet sales scored the worst, despite the fact, that this is the rapidly growing distribution channel.

Of the long chains 'sales to intermediaries' were assessed as the worst. Most likely this is because of the feeling that producers are 'exploited' by intermediaries as stated by some producers in the survey.

The highest score, which may also be considered surprising, characterizes sales to hypermarket chains. This is against a certain stereotype, but again there were several producers who during the survey emphasized the hypermarket chains are nowadays trustful business partners, offering the possibility of purchasing large quantities of produce at reasonable prices.

(b) Self-Evaluation of the Chain

Chain evaluation was based on self-evaluation of factors which may have influenced the perception of how attractive the chain is for the producer. The attractiveness of the chain has been evaluated on the basis of the following criteria: prices achieved in the chain; possibility of selling large quantities of produce; level of labor requirements according to the process of preparing for sale and transportation; possibility of making long term contracts; regular and assured payments; general level of satisfaction ("how much do you 'like' this chain?"). Similarly, as in the case of self-assessment, a Likert scale was used. Results of the evaluation are presented in Figure 5 and Table 8.

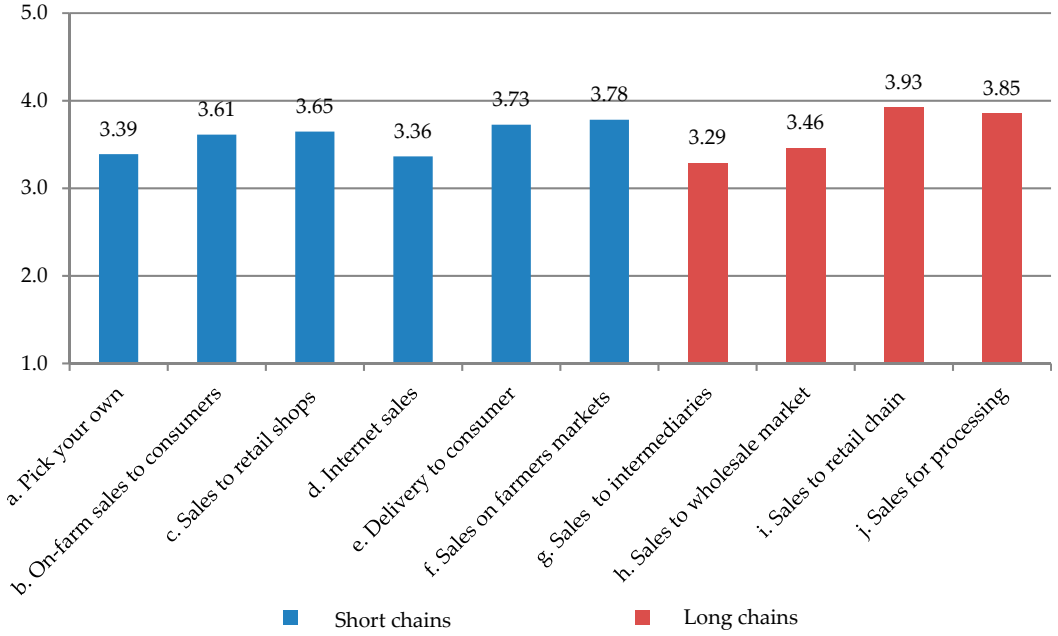

Figure 5. Average chain evaluation indicator. Source: own elaboration.

There is almost no difference in the overall evaluation of short and long chains both in the whole sample (3.6 versus 3.5 on average) and across countries. This could be attributed to the fact that some of the evaluation criteria act 'in opposition' to each other (Table 10).

Table 10. Chain evaluation indicator by different evaluation criteria.

	Good Prices	Large Quantities	Labor Requirements	Possibility of Long-Term Contracts	Regular and Assured Payments	I Like It	Total Chain Evaluation
Short Chains	**4.15**	2.79	3.22	2.86	**4.35**	**4.44**	3.64
Long Chains	2.98	**4.29**	3.21	**3.07**	4.03	3.45	3.50

Source: own elaboration.

For example, the criterion of prices achieved in the chain favors SFSCs, whereas possibilities of long-term contracts and large quantities favors long channels.

In general, SFSCs are better evaluated according to prices obtained in the chain (which is in line with better price premium for SFSCs evaluated under economic sustainability indicators, above) and regular and assured payments (due to the fact that the consumer usually pays during the purchase). Most farmers positively evaluated selling in short chains, expressing this by higher scores for the parameter 'I like it'. On the other hand, such criteria as the possibilities of selling large quantities and of making long term contracts are evaluated better in the case of long channels.

Considering the differences across chains, it could be observed that some of the short chains (pick-your-own and internet sales) were evaluated much lower than the others. Pick-your-own and internet sales chains were poorly evaluated due to small quantities bought by consumers and the occasional character of these purchases, compared with the other short chains. In contrast, sales to retail chains and processing were evaluated highly on average, mainly due to appreciation of the large quantities sold and regular and assured payments received by farmers.

(c) Labor-to-Production Ratio

Labor to production ratio reflects the number of hours worked in respective chains in sales and distribution processes, that include preparing products for transportation, loading, transporting, and selling by producers. Labor resources needed for sales process differ across chains (Table 8). In almost all SFSCs the ratio is much higher, compared to long chains, regardless of the country and the product type. This may be attributed to different factors. Certainly, the amount of produce per delivery would have the greatest impact. In SFSCs, products are usually individually packed for final consumers what requires much more time for preparation of delivery. The second factor affecting the difference between short and long chains is direct responsibility of the producer for sales to the final consumer, which in case of the longer chains is taken over by intermediaries (retail). In the case of short chains, the producer spends time for transportation and selling on farmers' markets or wholesale markets. Even in cases of chains which do not involve transportation by the producer (pick-your-own, on-farm sales), servicing the consumer may be also producers time consuming.

(d) Gender Equality

As presented in Table 8, greater engagement of women in sales through SFSCs may be observed. The gender equality ratio that represents the share of hours worked by women in sales and distribution processes is greater in short chains, for most of the studied countries, except for Hungary (mainly due to a large share of very small honey farms, mainly reliant on men as part of their labor force) and Vietnam (all part-time farms in the sample, with equal contributions of labor from men and women). The labor input by women was the greatest on farms selling through farm shops, sales on farmers' markets and sales of products that require portioning and packaging (e.g., cheeses, meats).

5. Conclusions

SFSCs cover a whole range of different schemes and initiatives in the value chain which can be seen as an alternative type of governance and organizational structure to the conventional distribution of food. There are numerous initiatives arising with the goal of occupying market niches, capturing a higher market share and better return, as well as establishing specific relations with groups of customers.

Geographic proximity and organizational arrangements are the commonly used criteria for the classification of supply chains. On the basis of these criteria, 10 types of supply chains have been selected in the study, to assess their economic, environmental, and social sustainability.

The first observation in our research is that individual producers participate simultaneously in several short and long chains, creating a mix of supply chains. This leads to the conclusion that different supply chains may coexists on the market, providing options that may benefit producers, but also create the possibility of choosing from a complex market offer that satisfies different consumers' expectations and (societal) needs.

Covering the whole complexity of the food supply chain would be a challenging and interesting task, but for the quantitative assessments, the scope of the research had to be restricted to the distribution process starting at the producer's end of the supply chain. Dealing with the variety of supply chains and different initiatives that arose, we decided to restrict our analysis to six short and four long types of chains, which represent the most typical and commonly used market channels by producers in the countries participating in this research.

Our study confirmed several statements found in the literature—first of all, that participation in SFSCs is beneficial for producers from an economic perspective. Short chains provide a relatively high price premium as they allow a large proportion of margin to be captured, which would otherwise be captured by different intermediaries. This conclusion applies to all short distribution channels, product categories, as well as countries.

On average, participation in SFSCs resulted also in much higher chain value added, although after deducting distribution costs, some chains (e.g., sales on farmers' markets) were less attractive

from the economic perspective. This raises the question whether producers selling through short chains are adequately compensated for the time invested in more laborious distribution. The answer is rather positive, especially in the light of a favorable for short chains self-evaluation of different chains producers participated in.

Self-evaluation of chains and self-assessment of the bargaining power of producers in the chains was a part of the social sustainability assessment. The position of producers in long chains was assessed as worse compared with the short chains.

Regarding self-evaluation the score for short chains was only marginally superior to long chains which suggests that SFSCs do not perform much better from the producers' perspective. There are two possible explanations for this phenomenon:

- producers select different chains to mitigate risks; thus, they accept some of the potential weaknesses of the optional chains;
- among the five components of the self-evaluation indicator, two of them were strongly in favor of long chains—greater possibility of long-term contracts and larger quantities sold through long chains, while variables such as "good prices" and overall evaluation "I like it" worked in favor of short chains.

Considering market developments, it seems reasonable to state, that strong competition forces organization managing long supply chains to improve trade conditions for producers.

Regarding other social sustainability indicators, the results seem to confirm, that short supply chains generate additional employment, despite the fact that our analyses were restricted to distribution only. SFSCs seem to promote gender balance due to greater employment of women in the logistics activities in contrast to long chains, where the role of women in distribution is rather limited. Taking into account both economic and social attributes of the short chains, this implies that they might be particularly important for small and medium scale producers who may often have difficulty accessing long, conventional food chains [49] especially as they can offer better prices or other trading arrangement, but demand large quantities of produce to be delivered.

Turning to the environmental dimension, our study results indicate, that SFSCs generate greater environmental externalities when we focus on carbon footprint, which seem to be the most adequate to address distribution oriented environmental concerns.

Short food chains where customers come to a production place (farm) independently of each other (pick your own, on-farm sales) and so incur costs of transport and opportunity cost of their time. Home deliveries, if the farmer delivers produce to customers, provide potentially some saving in overall travel distance as round trips can be organized, and this could result in a considerable reduction in overall time and distance travelled by customers to come to collect it. In this case, the producer would incur investment and running costs in transportation, though these costs would normally be transferred in price to the consumer. This makes short supply chains beneficial for producers from the economic perspective. On the other hand, the consumer would need to accept higher purchase prices if willing to pay for the convenience and specific attributes of products.

The aggregate transportation effort characteristic for short chains, especially if considering that customers would usually acquire only a few items in their overall diet, is not efficient from the environmental sustainability perspective. Our findings confirm, that as stated by [18], different dimensions of sustainability may not necessarily be complementary, so a trade-off between different priorities and conflicting interests may exist.

In view of the changes that have occurred in the retail sector in some European countries (e.g., UK, Norway) that have resulted in the domination of hypermarket and discount chains in the food market, and changes currently occurring in other countries (e.g., Poland), it can be expected that the importance of traditionally important short distribution channels such as on farm sales or traditional local farmers' markets will have less significance in the overall structure of sales channels, with the exception of modern initiatives such as 'Sunday' or 'breakfast' markets in various innovative forms. Observations

from different countries also indicate that, given the intense digital transformation in the agri-food sector and IT marketing, online retail sales will continue to grow, and with the improving welfare of large groups of societies, various initiatives referring to social proximity concepts will develop.

The findings of our study create a better understanding of sustainability issues resulting from different types of food distribution channels. Clearly the scale of our data demands further verification of our findings but we can make some tentative suggestions in terms of policy implications. In order to strengthen the realization of sustainable development goals first and foremost it is necessary to take a closer look at the existing policy instruments to identify how support for short supply chains may be targeted to further reduce their currently disproportionate environmental impact.

Author Contributions: Conceptualization, A.M.-R., E.M., B.T. and G.V.; Data curation, A.M.-R., E.M., S.O.B., P.C., M.D., R.F., J.L.L., M.C.M., A.N., M.S., B.T., Á.T., M.V., V.H., G.V. and P.W.; Formal analysis, A.M.-R., and E.M.; Investigation, A.M.-R. and E.M.; Methodology, A.M.-R., E.M., B.T., Á.T. and G.V.; Software, A.M.-R., E.M., and A.W.; Validation, A.M.-R., E.M., and A.W.; Writing–original draft, A.M.-R., E.M., and R.F.; Writing–review & editing, A.M.-R., E.M., S.O.B., R.F., J.L.L., A.N., M.S., B.T., Á.T., M.V., V.H. and G.V.

Funding: This research has received funding from the European Union's Horizon 2020 research and innovation program STRENGTH2FOOD under grant agreement no. 678024, and title: "Strengthening European Food Chain Sustainability by Quality and Procurement Policy".

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chiffoleau, Y.; Millet-Amrani, S.; Canard, A. From Short Food Supply Chains to Sustainable Agriculture in Urban Food System: Food Democracy as a Vector of Transition. *Agriculture* **2016**, *6*, 57. [CrossRef]
2. Lusk, J.L. Evaluating the Policy Proposals of the Food Movement. *Appl. Econ. Perspect. Policy* **2017**, *39*, 387–406. [CrossRef]
3. Joint Research Centre (JRC). *Short Food Supply Chains and Local Food. Systems in the EU. A State of Play of their Socio-Economic Characteristics*; Kneafsey, M., Venn, L., Schmutz, U., Balázs, B., Trenchard, L., Eyden-Wood, T., Bos, E., Sutton, G., Blackett, M., Santini, F., et al., Eds.; Publications Office of the European Union: Luxembourg, 2005; p. 154.
4. Marsden, T.K.; Banks, J.; Bristow, G. Food supply chain approaches: Exploring their role in rural development. *Sociol. Rural* **2000**, *40*, 424–426. [CrossRef]
5. Ilbery, B.; Maye, D. Alternative (Shorter) Food Supply Chains and Specialist Livestock Products in the Scottish–English Borders. *Environ. Plan. A* **2005**, *37*, 823–844. [CrossRef]
6. Goodman, D.; Goodman, M. *Alternative Food Networks*; Kitchin, R., Thrift, N., Eds.; International Encyclopedia of Human Geography; Elsevier: Amsterdam, The Netherlands, 2009.
7. Le Velly, R.; Dufeu, I. Alternative food networks as "market agencements": Exploring their multiple hybridities. *J. Rural Stud.* **2015**, *43*, 173–182. [CrossRef]
8. Roep, D.; Wiskerke, J.S.C. *Nourishing Networks: Fourteen Lessons about Creating Sustainable Food Supply Chains*; Reed Business Information: Doetinchem, The Netherlands, 2006.
9. Galli, F.; Bartolini, F.; Brunori, G.; Colombo, L.; Gava, O.; Grando, S.; Marescotti, A. Sustainability assessment of food supply chains: An application to local and global bread in Italy. *Agric. Food Econ.* **2015**, *3*, 21. [CrossRef]
10. Wittman, H.; Beckie, M.; Hergesheimer, C. Linking Local Food Systems and the Social Economy? Future Roles for Farmers' Markets in Alberta and British Columbia. *Rural Sociol.* **2012**, *77*, 36–61. [CrossRef]
11. Renting, H.; Marsden, T.K.; Banks, J. Understanding Alternative Food Networks: Exploring the Role of Short Food Supply Chains in Rural Development. *Environ. Plan. A* **2003**, *35*, 393–411. [CrossRef]
12. Aubry, C.; Kebir, L. Shortening food supply chains: A means for maintaining agriculture close to urban areas? The case of the French metropolitan area of Paris. *Food Policy* **2013**, *41*, 85–93. [CrossRef]
13. Mundler, P.; Laughrea, S. The Contributions of Short Food Supply Chains to Territorial Development: A Study of Three Quebec Territories. *J. Rural Stud.* **2016**, *45*, 218–229. [CrossRef]

14. Sellitto, M.A.; Machado Vial, L.A.; Viegas, C.V. Critical success factors in Short Food Supply Chains: Case studies with milk and dairy producers from Italy and Brazil. *J. Clean. Prod.* **2018**, *170*, 1361–1368. [CrossRef]
15. European Communities. *Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on Support for Rural Development by the European Agricultural Fund for Rural Development (EAFRD) and Repealing Council Regulation (EC) No 1698/2005*; European Communities: Luxembourg, 2013.
16. EIP_AGRI Focus Group. *Innovative Short Food Supply Chain Management*; Final Report; EIP_AGRI Focus Group: Brussels, Belgium, 2015.
17. Sisco, C.; Blythe Chorn, B.; Pruzan-Jorgensen, P.M. *Supply Chain Sustainability*; A Practical Guide for Continuous Improvement; UN Global Compact Office and Business for Social Responsibility: New York, NY, USA, 2010; p. 5.
18. Galli, F.; Brunori, G. (Eds.) *Short Food Supply Chains as Drivers of Sustainable Development. Evidence Document*; Foodlinks (GA No. 265287); Laboratorio di studi rurali Sismondi: Pisa, Italy, 2013.
19. Majewski, E. Trwały rozwój i trwałe rolnictwo: Teoria a praktyka gospodarstw rolniczych. In *Sustainable Development and Sustainable Agriculture—Theory and Farm Practice*; Wydawnictwo SGGW: Warszawa, Poland, 2008.
20. Leat, P.; Revoredo-Giha, C.; Lamprinopoulou, C. Scotland's food and drink policy discussion: Sustainability issues in the food supply chain. *Sustainability* **2011**, *3*, 605–631. [CrossRef]
21. Berti, G.; Mulligan, C. Competitiveness of Small Farms and Innovative Food Supply Chains: The Role of Food Hubs in Creating, Sustainable Regional and Local Food Systems. *Sustainability* **2016**, *8*, 616. [CrossRef]
22. Aubert, M. The Determinants of Selling through a Short Food Supply Chains: An Application to the French case. 9. In *Journées de Recherches en Sciences Sociales (JRSS)*; Actes des journées JRSS: Nancy, France, 2015; p. 25.
23. Conner, D.; Colasanti, K.; Ross, R.; Smalley, S. Locally grown foods and farmers' markets: Consumer attitudes and behaviours. *Sustainability* **2010**, *2*, 742–756. [CrossRef]
24. Mancini, M.C.; Arfini, F. Short supply chains and Protected Designations of Origin: The case of Parmigiano Reggiano (Italy). *J. Depopul. Rural Dev. Stud.* **2018**, 43–64. [CrossRef]
25. Schermer, M.; Hirschbichler, K.; Gleirscher, N. *Encouraging Collective Farmers Marketing Initiatives (COFAMI). Status-quo Analysis*; National Report Austria; COFAMI: Brussels, Belgium, 2008; p. 12.
26. Peters, R. (Ed.) *Local Food and Short Supply Chains*; EU Rural Review; European Network for Rural Development: Brussels, Belgium, 2012; p. 18.
27. Rosset, P.M. The multiple functions and benefits of small farm agriculture in the context of global trade negotiations. *Development* **2000**, *43*, 77–82. [CrossRef]
28. Umberger, W.J.; McFadden, D.D.T.; Smith, A.R. Does altruism play a role in determining US consumer preferences and willingness to pay for natural and regionally produced beef? *Agribusiness* **2009**, *25*, 268–285. [CrossRef]
29. Chang, J.B.; Lusk, J.L. Fairness and food choice. *Food Policy* **2009**, *34*, 483–491. [CrossRef]
30. Canfora, I. Is the short food supply chain an efficient solution for sustainability in food market? *Agric. Agric. Sci. Procedia* **2016**, *8*, 402–407. [CrossRef]
31. Gonçalves, A.; Zeroual, T. Logistic Issues and Impacts of Short Food Supply Chains: Case Studies in Nord —Pas de Calais, France. In *Toward Sustainable Relations between Agriculture and the City*; Soulard, C.-T., Perrin, C., Valette, E., Eds.; Springer: Berlin/Heidelberg, Germany, 2017.
32. Mancini, M.C.; Menozzi, D.; Donati, M.; Biasini, B.; Veneziani, M.; Arfini, F. Producers' and Consumers' Perception of the Sustainability of Short Food Supply Chains: The Case of Parmigiano Reggiano PDO. *Sustainability* **2019**, *11*, 721. [CrossRef]
33. Bloemhof, J.M.; Soysal, M. Sustainable Food Supply Chain Design. In *Sustainable Supply Chains*; Bouchery, Y., Corbett, C.J., Fransoo, J.C., Tan, T., Eds.; Springer: Amsterdam, The Netherlands, 2017.
34. Tellis, W.M. Application of a Case Study Methodology. *Qual. Rep.* **1997**, *3*, 119.
35. Bukeviciute, L.; Dierx, A.; Ilzkovitz, F. *The Functioning of the Food Supply Chain and its Effect on Food Prices in the European Union*; Directorate-General for Economic and Financial Affairs, European Commission: Brussels, Belgium, 2009.
36. Cadilhon, J.; Fearne, A.; Hughes, D.; Moustier, P. Wholesale Markets and Food Distribution in Europe: New Strategies for Old Functions. 2003. Available online: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.587.4053&rep=rep1&type=pdf (accessed on 15 May 2019).

37. Michelson, H.; Boucher, S.; Cheng, X.; Huang, J.; Jia, X. Connecting supermarkets and farms: The role of intermediaries in Walmart China's fresh produce supply chains. *Renew. Agric. Food Syst.* **2017**, *33*, 47–59. [CrossRef]
38. Ferreira, K.; Goh, J.; Valavi, E. Intermediation in the Supply of Agricultural Products in Developing Economies (30 September 2017). Harvard Business School Research Paper Series. Available online: http://dx.doi.org/10.2139/ssrn.3047520 (accessed on 15 May 2019).
39. Shpak, N.; Kyrylych, T.; Greblikaitė, J. Diversification Models of Sales Activity for Steady Development of an Enterprise. *Sustainability* **2016**, *8*, 393. [CrossRef]
40. Gava, O.; Galli, F.; Bartolini, F.; Brunori, G. Linking Sustainability with Geographical Proximity in Food Supply Chains. An Indicator Selection Framework. *Agriculture* **2018**, *8*, 130. [CrossRef]
41. Amemiya, H. *Du Teikei Aux A.M.A.P. Le Renouveau de La Vente Directe de Produits Fermiers Locaux. Économie et Société*; Presses universitaires de Rennes: Rennes, France, 2011.
42. Todorovic, V.; Maslaric, M.; Bojic, S.; Jokic, M.; Mircetic, D.; Nikolicic, S. Solutions for More Sustainable Distribution in the Short Food Supply Chains. *Sustainability* **2018**, *10*, 3481. [CrossRef]
43. FAO. SAFA—Sustainability Assessment of Food and Agricultural Systems—Guidelines, Version 3.0. 2014. Available online: http://www.fao.org/3/a-i3957e.pdf (accessed on 15 May 2019).
44. FAO. *SAFA Indicators*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2013.
45. Bellassen, V.; Giraud, G.; Hilal, M.; Arfini, F.; Barczak, A.; Bodini, A.; Brennan, M.; Drut, M.; Duboys de Labarre, M.; Gorton, M.; et al. *Methods and Indicators for Measuring the Social, Environmental and Economic Impacts of Food Quality Schemes, Strength 2 Food Project, Deliverable 3.2*; INRA: Dijon, France, 2018.
46. Department for Environment, Food & Rural Affairs. Guidance on How to Measure and Report your Greenhouse Gas Emissions. 2009. Available online: https://www.gov.uk/government/publications/guidance-on-how-to-measure-and-report-your-greenhouse-gas-emissions (accessed on 1 March 2018).
47. Tassou, S.A.; De-Lille, G.; Ge, Y.T. Food transport refrigeration—Approaches to reduce energy consumption and environmental impacts of road transport. *Appl. Therm. Eng.* **2009**, *29*, 1467–1477. [CrossRef]
48. Vittersø, G.H.; Torjusen, K.M.; Laitala, F.; Arfini, B.; Biasini, E.; Coppola, P.; Csillag, M.; Donati, M.; Duboys de Labarre, R.; Gentili, M. Qualitative Assessment of Motivations, Practices and Organisational Development of Short Food Supply Chains. Report of Strenth2Food Project. 2018. Available online: https://www.strength2food.eu/wp-content/uploads/2018/10/D7.1-Qualitative-assessment-of-motivations-practices-and-organisational-development-of-SFSC-compressed-protected.pdf (accessed on 15 May 2019).
49. Gorton, M.; Salvioni, C.; Hubbard, C. Semi-subsistence Farms and Alternative Food Supply Chains. *EuroChoices* **2014**, *13*, 15–19. [CrossRef]