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**Schmitt, Emilia and Keech, Daniel and Maye, Damian and Barjolle, Dominique and Kirwan, James (2016) Comparing the Sustainability of Local and Global Food Chains: A Case Study of Cheese Products in Switzerland and the UK. Sustainability, 8 (5). pp. 419-439. ISSN 2071-1050**

Official URL: <http://dx.doi.org/10.3390/su8050419>

DOI: <http://dx.doi.org/10.3390/su8050419>

EPrint URI: <http://eprints.glos.ac.uk/id/eprint/3454>

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## Article

# Comparing the Sustainability of Local and Global Food Chains: A Case Study of Cheese Products in Switzerland and the UK

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Academic Editor: Gianluca Brunori

Received: 17 February 2016; Accepted: 25 April 2016; Published: 29 April 2016

**Abstract:** Local food has recently gained popularity under the assumption that it is more sustainable than food from distant locations. However, evidence is still lacking to fully support this assumption. The goal of this study is to compare local and global food chains in five dimensions of sustainability (environmental, economic, social, ethical and health), covering all stages of the chain. In particular, four cheese supply chains are compared in detail: a local (L'Etivaz) and global (Le Gruyère) case in Switzerland and a local (Single Gloucester) and global (Cheddar) case in the UK. A multi-dimensional perspective is adopted to compare their sustainability performance. Eight attributes of performance (affordability, creation and distribution of added value, information and communication, consumer behaviour, resource use, biodiversity, nutrition and animal welfare) are used to frame the comparative analysis. The results suggest that local cheese performs better in the field of added value creation and distribution, animal welfare and biodiversity. Global chains, by contrast, perform better in terms of affordability and efficiency and some environmental indicators. This analysis needed to be expressed in qualitative terms rather than quantified indicators and it has been especially useful to identify the critical issues and trade-offs that hinder sustainability at different scales. Cheese supply chains in Switzerland and the UK also often present hybrid arrangements in term of local and global scales. Comparison is therefore most meaningful when presented on a local (farmhouse)/global (creamery) continuum.

**Keywords:** sustainability; multidimensional performance; food chains; local; global; attributes; indicators

## 1. Introduction

The interest in and willingness of consumers to pay for local food has continually increased in the past decade [1], as has research interest in local food [2]. The most often cited reasons for this preference for local food are related to “product quality (*i.e.*, freshness and taste), consumers’ personal health, food safety, care for the environment, and support of the local economy” ([2], p. 157). In essence, the interest in local food is linked to the perception that local products are more sustainable than foods produced far away from the consumer. However, this common belief contains two shortcomings: first, the definition of what is “local food” remains vague and dependant on context [3–5]; and second, the superior sustainability of local food systems remains to be established [6].

The definition of the sustainability of agri-food systems is also debated. Most definitions regarding sustainability cover the economic, social and environmental dimensions, in accordance with the original definition of sustainable development in the Brundtland report [7]. It is also the case that,

when defining sustainable food chains [8], sustainability is multi-dimensional. However, as agri-food chains are very dynamic and differ according to sector and place, a definitive understanding of their sustainability might be impossible to find and might change over time and space [9]. In a systematic review, Velten *et al.* ([10], p. 7857) conclude that there is a great variety of concepts relating to sustainable agriculture and this causes confusion, but there is “no way to streamline the concepts.” However, the integration of different academic disciplines “allows a more comprehensive picture of the situation and approach to resolving the existing issues”.

In the existing literature, assessment approaches often favour one dimension to the detriment of another [11]. For example, studies using methods such as Life Cycle Assessment (LCA) focus on the environmental dimension mainly [12,13]. However, Ostrom [14] stresses the importance of combining scientific disciplines and interdisciplinarity to describe and explain complex social-ecological systems. In this paper, a multi-dimensional perspective has been applied following the authors’ participation in the European Commission funded FP7 research project GLAMUR—Global and Local Food Chain Assessment: A Multi-Dimensional Performance-based Approach ([www.glamur.eu](http://www.glamur.eu)). Within Glamur, the three original Brundtland pillars were taken into account, and health and ethics were added in order to structure the assessment of food chain performance for a range of food products within five sustainability dimensions. Local food is perceived as beneficial for the health of consumers [15] and thus the health dimension also needs to be tested in this assessment. Similarly, assumptions about the superior ethical credentials of local food remain contested [16–18]. An additional consideration in developing sustainability assessments of food chains is that “although the sustainability objectives are often derived from overarching sustainability principles which are highly integrated, criteria or indicators that are developed from these typically revert to a compartmentalised structure in which the environmental, social and economic categories are treated separately” ([19], p. 56).

Sustainability performance is usually assessed by evaluating practices against a set of indicators. One challenge lies in determining and measuring indicators capable of translating the complexity of food chains, with the ability to indicate which characteristics and dynamics of the chain are sustainable or not [9,20]. Universal lists of indicators applicable for any food chain are starting to emerge [21], but indicators must be selected and adapted case by case [22]. There are some guiding principles in the literature that can help in the development and selection of indicators. However, the challenge of choosing enough indicators to capture the complexity of food chains, while simultaneously avoiding using too large a number of them remains [23].

Furthermore, Nardo *et al.* ([24], p. 15) emphasize that “indicators should be selected on the basis of their analytical soundness, measurability, country coverage, relevance to the phenomenon being measured and relationship to each other. The use of proxy variables should be considered when data are scarce”. Bockstaller *et al.* ([25], p. 771) make it even more straightforward, with two evaluation criteria for the selection of an indicator: feasibility and relevance. The feasibility (*i.e.*, “easiness of implementation due to accessibility of data and cost of implementation”) is especially important to maximise the quality of the final assessment. Relevance concerns the soundness of the criteria for the specific context and research goals and can be more difficult to evaluate. This can be done with the consultation of experts, although initially the selection of criteria should be done with an extended knowledge of the system (or in this case, food chains) under study [11]. Bossel [26], but also Binder *et al.* [23], suggest using a participatory process with all stakeholders involved to select indicators [27]. Hammond and Dubé [28] also emphasise the need for collaboration with many actors in order to conceptualize valid models and solve sustainability related problems.

In addition to the challenge of involving stakeholders, methodological challenges exist in the evaluation of sustainability. Berrah and Clivillé [29] justify converting measurements into scores to aggregate them into an overall performance assessment. This process allows the comparison of indicators using different units, but it requires the use of reference values [11]. These reference values are benchmarks defined as “values or qualitative descriptions of activities, used as the basis by which the performance of an enterprise is evaluated within an indicator domain to facilitate a rating of

sustainability performance” ([21], p. 216). Benchmarks can either be absolute values, like a norm or scientific target, or can be relative values such as a regional or sectorial average [11]. The determination of benchmarks allows the calculation of a performance score on a percentage scale.

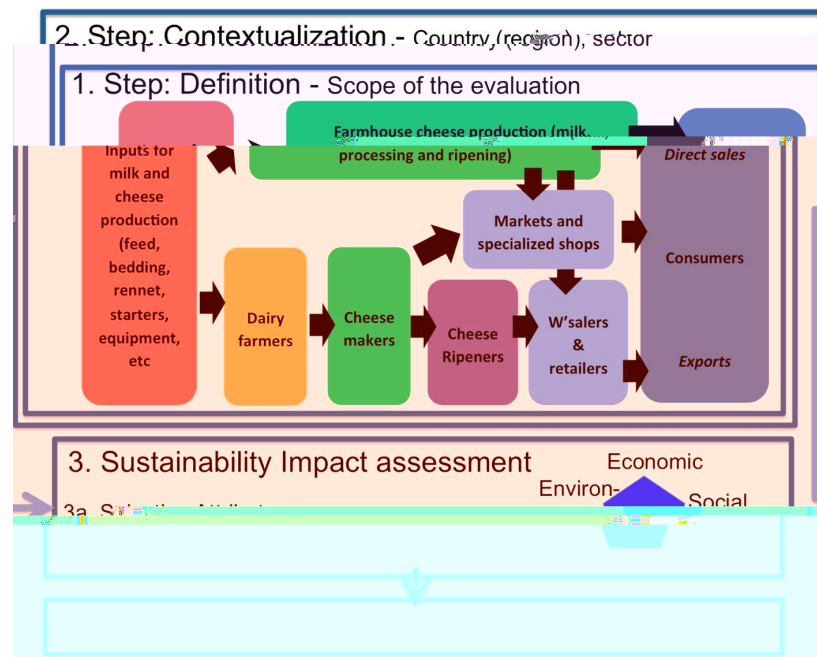
In summary, it is clear that sustainability is characterised by a dynamic series of understandings, and that the assessment of the sustainability in food chains has tended to be based on one kind of performance assessment at a time, or on one aspect of the productive or distribution chain. Hence, this study is an attempt to integrate performance assessments across five dimensions (namely, environment, social, economic, health and ethical) using attributes and indicators in order to capture and compare the performance of local and global food chains. In Glamur, 24 attributes of food chain performance were generated in a systematic and iterative process [30]. Indicators relate to the attributes by helping to measure the performance of the chain. Few studies so far have used sustainability indicators to empirically observe sustainability performance differences between local and global food chains [31]. In addition, to address multiple performance dimensions, a food chain perspective is used, considering all stages between inputs, production and consumption. This comparison recognizes the shortcoming of a lack of precisely defined distinctions between “local” and “global”. As an emblematic case of traditional food in Europe, produced both on local small-scale farms and at an industrial scale, cheese is the product selected in this paper to provide a more detailed multi-dimensional assessment of sustainability. Four cheese chains are compared in detail: a mainly local (Etivaz) and a more global (Gruyère) case in Switzerland; and a mainly local (Single Gloucester) and a dual local and global (Cheddar) case in the UK.

## 2. Analytical Framework

The process of sustainability assessments and comparison followed the framework described in Figure 1. The first step was to define the object under study, and the precise scope of the food chains used as case studies. The focus has been in accordance with the definition of a core food chain from Neven ([8], p. 11), which includes actors who have the functions of “production, aggregation, processing and distribution”. Thus, the stages of the chains most emphasised in the study are agricultural production, primary processing (milk aggregation and cheese making) and secondary processing (cheese refining). The upstream inputs stage is difficult to take into account entirely, due to the difficulty of securing information about input production and transport and the extensive interactions these processes have with many other food chains. Nevertheless, our data collection includes upstream inputs as much as possible. Packaging, export, and retailing were only marginally taken into account because of limited access to data and the very high level of interaction with other chains. The consumption stage was studied using consumer focus groups. The data collection was thus particularly oriented towards those downstream stages of the core food chain and included interviews at each stage and for each case study.

The second step included an extensive review and contextual analysis surrounding the case studies, mainly regarding their country and sector. The goal was, initially, to help in the selection of assessment criteria in relation to the context (relevance) and then to set the background for the subsequent analysis of the results. For the first goal, scientific and grey literature was retrieved and analysed in terms of how sustainability performance is perceived by actors in the public, policy, market and scientific spheres. The varied sources were analysed thematically using Nvivo 10 [32], a software package which aids qualitative analysis of text documents, in order to identify most frequent word counts and the most relevant fields for sustainability. Commonly occurring performance characterisations in the literature and media discourses were then grouped as attributes. In each country, actors’ points of view on these themes, their importance and their articulation in the food chains were reviewed through a series of interviews that helped to provide a focus for attribute generation. Twenty-two such interviews were conducted (12 in Switzerland and 10 in the UK, respectively) with actors from different backgrounds (policy, science, market, public) and different sectors, including professionals from the dairy sector. In addition, two rounds of a Delphi survey [33]

were completed in each country. Delphi is a forecasting technique used to discern common themes or shared interests between a panel of experts or specialists—in this case in the food chain—involving rounds of surveys, with each round of questions informed by findings from the preceding round. This iterative filtering process of the relevant attributes, preliminary observation and initial interviews linked to the cheese cases was essential to grasp the main issues and challenges at stake for the different stakeholders.



**Figure 1.** Schematization of the analytical framework of this study.

For the third step, the sustainability assessment, a set of attributes and indicators of performance were selected, derived from the analysis of literature and interviews with the 22 actors described in Stage 2, above. Attributes are defined as “a quality or feature regarded as a characteristic or inherent part of something” ([34], p. 13), e.g., animal welfare is an attribute. Attributes developed at national levels during the literature analysis were then unified into a list of attributes to the specific sector under study (e.g., cheese). Thus, eight attributes were selected to compare local and global UK and Swiss cheeses while keeping in mind their feasibility, relevance and multi-dimensionality (Table 1). These eight attributes were regarded as an adequate range from the 24 attributes within Glamur, spanning all five dimensions and of particular relevance to an assessment of the cheese chain in the two subject countries. Perceived differences in the environmental dimension concern “biodiversity” and “resource use”. Local systems are likely to be less resource efficient due to a limited ability to exploit economies of scale, while grazing may be more spatially extensive and follow traditional grazing regimes, thereby underpinning local biodiversity. In the social dimension, the attributes identified are “information and communication”, both within and outside the food chain, and “consumer behaviour”. The attribute “creation and distribution of added value” features in the economic dimension, but is both social and economic because it concerns the contribution of the chain to the local economy and the distribution of supply chain leverage. This attribute was regularly identified as the most important by stakeholders. The other attribute in the economic dimension is “affordability”, as the price offered to consumers is likely to be different between local and global chains. The health dimension is covered by the attribute “nutrition”, as it is interesting for consumers to see if there are health and nutritional differences between the cheeses, especially because cheese is an intrinsically high-fat food. The ethical dimension is covered by the “animal welfare” attribute, which mainly covers the ethics of milk production at farm level.

**Table 1.** Indicators for the sustainability assessment of cheese supply chains.

Dimension	Attributes	Indicators	Definition (Categories or Method of Measurement)
Economic	Affordability	Ability to provide food at acceptable prices	Average of prices found in the market for each cheese in £/kg. Assessed on a linear benchmark between LP <sup>1</sup> 23.36 CHF/kg or 25 £/kg to HP <sup>1</sup> 7.75 CHF/kg or 4 £/kg as the given cheese prices in the Swiss/UK markets.
		Price perception of consumers	Scale of 0 to 4, according to perception of consumers: 0 = very expensive; 1 = expensive; 2 = neither expensive nor good value; 3 = perceived to be good value. 4= very affordable.
	Creation and distribution of added value	Producers' business profit	Yearly income of cheesemakers and milk producers in CHF/year. Linear benchmark between LP 40,000 CHF to HP 100,000CHF. Proxy used in the UK: Farmer to retailer wholesale price. Benchmark on a linear scale from LP 0 £ to 10 £ (HP, price for the most expensive cheese in our case study range).
		Distribution of price between actors	Index calculated according to FAO [35] Gini coefficient taking into account the price at each stage of the chain. Linear benchmark between LP 1 and HP 0.
		Contribution to the economy of the region	Number of Full-time equivalent jobs per tons of cheese produced. Linear benchmark according to sample's minimum and maximum. CH including farm and cheese factory: LP 1.47 to HP 18. UK in cheese factory: LP 0 to HP 0.4.
Social	Information and Communication	Communication along the chain	Perception of actors of each stage of the value chain between 1 (satisfactory) and 0 (not satisfactory).
		Availability of Information	6 points scale from a sum of the following categories each scoring 1: website available, personal contact, tastings, newsletter, point of sale information, use of social media.
		Product Labelling	Scored from 0 to 5 from a sum of the following categories each scoring 1 if present in addition to legal requirements: nutrition, ingredients, sourcing/provenance, ethical information and production practices.
	Consumer Behavior	Cooking practices	Qualitative indicator discussed within consumer focus groups.
		Taste preference	Qualitative indicator discussed within consumer focus groups.
		Convenience	Qualitative indicator discussed within consumer focus groups.
		Willingness to pay	Qualitative indicator discussed within consumer focus groups.

Table 1. Cont.

Dimension	Attributes	Indicators	Definition (Categories or Method of Measurement)
Environment	Resource Use	Soil management practices	5 points scale (score 1 each of 5): absence of mineral fertilization; soil sampling; pH management; eco-friendly tillage practices; reduced application of agro-chemicals.
		Material consumption practices	2 points scale in CH: Quantity of concentrate feed in cows’ ration on a linear benchmark from LP 1600 to HP 0 kg/cow/year; Recycled material used on three stages of value chain. 4 points scale in the UK: concentrates bought in/avoided; renewable energy sources installed; energy saving practices evident; own land used for fodder production.
		Waste reduction and disposal	4 points scale: Presence of a policy or strategy of waste reduction; Reusing material (biomass); whey reclamation; and Recyclable material used (CH) or water re-use practices (UK).
	Biodiversity	Landscape management practices	7 points scale in CH: Ecological compensation surface on farm; wild habitat connections; wildflower strips, nesting aids or ecological structures; multi species trees; wildlife habitats or edge of a forest; delayed or adapted mowing; ecological management of pests and weeds. 4 points scale in the UK: membership of agri-environmental schemes; presence of buffer zones; habitat management; systematic approach to biodiversity.
		Diversity of production	3 points scale in CH: Several productions and crops in rotation; number of breeds in herd (LP 1, HP 3); locally adapted, rare or traditional crops, breeds or trees. 4 points scale in the UK with additional category: practice of mixed cropping, agroforestry, intercropping or crop-livestock.
Health	Nutrition	Salt content	Salt content of cheese (gr/100gr) on a linear benchmark from LP 2.6 to HP 0.4.
		Fat content	Fat content of cheese (gr/100gr) on a linear benchmark from LP 49.18 to HP 17.5.
		Fat types	Saturated Fat content of cheese (gr/100gr) on a linear benchmark from LP 41.6 to HP 5.
		Calcium content	Content of calcium in mg/100g on a linear benchmark from LP 675 to HP 1200.
Ethical	Animal Welfare	Animals density	Animal stocking density per hectare of grazing pasture from LP 3 to HP 0.5.
		lifetime of dairy cows	Average age of the cows in the herd at the time of slaughter from LP 3 to HP 10.5.
		Time spent on pasture	Time spent on pasture by the cows on a linear benchmark. CH: in proportion of hours over the year from LP 0% to HP 50%; UK: in proportion of the days of the year from LP 0% to HP 100%.

<sup>1</sup> LP = lowest performance; HP = Highest performance (on the benchmark sale).



The selection of these attributes was an iterative process between the UK/Swiss researchers and stakeholders and took into account the feasibility of measuring a performance for these attributes on the cheese chains under study. The selection of the indicators for assessing each attribute was made according to data availability in the existing time frame, and scoring feasibility. Moreover, indicators with a plausible difference between local and global chains (relevance) were chosen. Existing lists of sustainability assessment indicators (SAFA, RISE, *etc.*) (The FAO's Sustainability Assessment of Food and Agriculture (SAFA) guidelines and the Response-inducing Sustainability Evaluation (RISE) framework develop indicators at the firm/firm level) were consulted as they give insights into how such indicators have been measured elsewhere, and what benchmarks are usually applied to them, or could be adapted. Additional indicators were created where necessary and referred to for consultation with relevant stakeholders. The knowledge of national contexts and an iterative process of selection between the UK and Switzerland research teams led to the creation of a final list of relevant and comparable indicators.

The measurement of these indicators on the cheese chains was realised through data collection via semi-structured interviews with the food chain actors or via secondary sources (actors' websites and available documents, sector-specific statistics, *etc.*). Data were both qualitative and quantitative, depending on the requirement of the indicators (see Table 1). In Switzerland, 11 interviews were conducted with farmers-cheesemakers in the local chain. In the global chain, which is much larger, 53 milk producers, 18 cheesemakers, four cheese ripeners and the Inter-branch Organization were interviewed. In addition, one input company and five retailers were interviewed or sent questionnaires by e-mail. In the UK, 12 interviews were conducted with milk producers, cheesemakers and marketing and retailing professionals covering global and local chains. The absence of co-operatively structured agricultural organisation in England, as well as the process of intensive dairy industry consolidation taking place at the time of the research, resulted in a smaller English sample compared to Switzerland.

Once chain data had been collected, performance scores were calculated in relation to indicator benchmarks delineating minimum and maximum performance (see Table 1). These benchmarks were either available from standardized indicators, or could be adjusted according to context justification and consultation with stakeholders. Benchmarks are essential for the comparison of performance between food chains, because they illustrate a degree of deviation from performance averages.

Table 1 shows the final selection of attributes and indicators used to compare global and local cheese chains in Switzerland and the UK.

### 3. Case Studies

The framework of analysis of the different food chains is represented by Figure 1 and shows the stages of the chains that were considered. Each of the food chains under study follows one or more of the channels represented and is described in more detail in the following sub-sections. The framework denotes some flexibility and possible transitions between the local and the global, even within food chains.

#### 3.1. Swiss Cheeses

The first case is the Swiss cheese called L'Etivaz, after the Alpine village where it is matured following summer milk production by cows grazing the mountainside meadows, in the care of farmers in their chalets (Alp). Just under 70 families in 10 villages produce this hard, raw-milk cheese and have formed a cooperative, which in turn owns the ripening cellar and forms the main governance structure. For example, the cooperative decides on the rules specified in the "book of requirements" and adherence with Protected Designation of Origin (PDO) requirements. L'Etivaz must be produced between 1000 and 2000 metres above sea level, from May to October. The milk is transformed into cheese every day by heating it over a wood fire inside copper cauldrons. The cheese is then delivered several times per week to the L'Etivaz cooperative where it is ripened for 4.5 up to 30 months for the hardest variety [36]. In 1999, L'Etivaz became the first Swiss non-wine product to obtain PDO



status [37]. In Figure 1, L'Etivaz follows the upper channel (farmhouse cheese production), with the particularity that ripening is not done individually but by the cooperative, which then distributes the cheese (445 tonnes/year) via sales channels including direct sales, specialised shops, national supermarkets and export.

The supply chain of Le Gruyère cheese starts with around 2300 dairy farmers who supply milk twice a day to a Gruyère creamery. PDO criteria restrict the supply distance between the milk producers and the creamery to 20 kilometres. A total of 168 creameries process the unpasteurised milk daily and complete the first four months of the ripening process in their cellars. A significant proportion of creameries producing Le Gruyère are in rural villages and are small-scale enterprises, but they have tended to become bigger and fewer over time because of economic restructuring. Thereafter, cheeses are transferred to the cellars of nine bigger ripening companies for the remaining period of maturation, which ranges from five to 18 months. The PDO conformation is managed by an Inter-branch Organization (Inter-Profession du Gruyère (IPG)) situated in the town of Gruyères. Like the process for L'Etivaz PDO conformation, the specifications for Le Gruyère also apply strict rules regarding cows' feed, milk treatment, area of production and the final product characteristics such as size, shape, taste and nutritional values. The quantity is set to around 30,000 tonnes a year (highest production of a cheese type in Switzerland). The IPG rules that the milk and cheese production as well as the first four months of ripening must happen in the production area, which is located in five different cantons of south-west Switzerland. Final ripening and consumption, however, happens across the whole country and 42% of the cheese is exported.

### 3.2. UK Cheeses

The local scale of cheese production in the UK is represented by two cheddar producers and two producers of Single Gloucester who follow a farmhouse model of production (upper channel in Figure 1); whereas the global scale is represented by two larger scale cheddar producers (who follow the lower channel of production described in Figure 1).

By definition, "farmhouse producers" are all small-scale. The Single Gloucester producers in the sample have an annual output of 5 tonnes and 12 tonnes, respectively; whereas the farmhouse cheddar producers are larger, producing 75 and 200 tonnes, respectively. The principal ingredient, milk, is produced from the cheese producers' own herds, which must incorporate Gloucester cows in the case of Single Gloucester cheese. This was one of the rules decided when the PDO for this cheese was created, principally as a means to preserve Gloucester cattle. Farmhouse cheddar producers, based in the counties of Cornwall, Devon, Somerset, and Dorset, also benefit from a PDO under the name "West Country Farmhouse Cheddar", although not all producers make use of it. The other key ingredients tend to be global in origin. In terms of outlets, all the producers sell at least some of their cheese directly to the end consumer. The smaller producers sell none of their produce to supermarkets, whilst larger producers in the sample sell between 20% and 60% of their produce to supermarkets. Only one of the farmhouse producers exports their cheese (around 30% of their production).

In comparison, the two global producers examined are much larger firms with annual cheese outputs of 4000 and 22,000 tonnes, respectively. While the two producers have quite different marketing channels, the global chain is broadly similar to the farmhouse chain in terms of inputs (starters, salt and rennet) and their geography. However, there is a significant difference in terms of the milk supply, which in the creamery cases is sourced from a wide range of milk producers. In one case, 31 suppliers are used and more than 200 farms supply another creamery. There are also noticeable differences in terms of the outlets used, with the majority of the output going to large-scale supermarkets, as well as to the catering industry and a small proportion for export. The cheese manufacturing process is also much more industrialised than in the small-scale farmhouse chains. Cheddar may be produced anywhere, with the result that it is also widely imported and exported.

### 3.3. The Four Cheeses on a Local to Global Continuum

As the objective of this study is to assess the sustainability of supply chains depending on their association with local or global scales, the relative emphasis on local and global scales was analysed for all four chains (Table 2). It is clear that Single Gloucester has the most local chain, while Farmhouse Cheddar and L'Etivaz use more local or regional chains. Le Gruyère and creamery Cheddar are the most global chains. Cheddar, in particular, has a global chain due both to the large quantities produced but also its worldwide production locations: non-farmhouse cheddar is not territorially defined. However, at the same time, both cheeses contain some elements of localness, best illustrated by PDO farmhouse cheddar and some of the small Le Gruyère creameries that operate at a local scale. Thus, a high level of hybridity between local and global in the food chains studied is evident.

**Table 2.** Global and local emphasis of the cheese case studies.

Criteria	Single Gloucester	Farmhouse Cheddar	L'Etivaz	Le Gruyère	Creamery Cheddar
Distance between milk production and Ripening; (km) <sup>1</sup>	0	0	13.6	39.4	33.8
Average Number of steps in the chain (from production to place of sale) <sup>1</sup>	1 to 2	1 to 3	1 to 5	2 to 8	1 to 4
Proportion of cheese exported <sup>1,2</sup>	Very small	Usually small, but can be up to 30%	30%	42%	19% (2013)
Proportion of direct sales <sup>1</sup>	20%–25%	<10%	7%	4%	0%
Volume of cheese produced (tonnes in 2014) <sup>2</sup>	100	n/a (12,000 PDO records for 1993)	445	29,342	279,000 (including farmhouse cheddar)
Number of cheese producers <sup>2</sup>	6	n/a	68	168	n/a
Number of milk suppliers per cheese factory <sup>1,2</sup>	Own milk	Own milk	Own milk	8 to 50	n/a
Global inputs in the chain	salt, rennet, cloths, animal feed, energy	Salt, cloths, animal feed, energy	Rennet, animal feed, fuel	Rennet, animal feed, energy	Salt, rennet, animal feed, energy
Governance structure and link to the territory	PDO	PDO (not always taken up)	Cooperative, PDO	Inter-branch organization, PDO	Generic
Degree of mechanisation of production	low	low	very low	high	very high

<sup>1</sup> Numbers from own interviews with a sample of producers in the value chains. <sup>2</sup> Numbers covering the whole value chains and available from secondary sources [37–40].

## 4. Results and Interpretation

The quantitative results (Table 3) suggest that local food chains generally perform better, as the local Swiss chain performs better than the more global Swiss chain in 60% of the indicators and the local UK cheese performs better than the UK global chain in 55% of indicators. L'Etivaz cheese has the highest performance in all cheeses for 43% of indicators.

In the economic dimension, one important aspect for sustainability is the contribution of the value chain to the local economy, as was assessed by the number of jobs provided. The local UK cheese has the highest performance in this indicator (jobs provided per tonne of cheese). This is also the case for L'Etivaz in Switzerland, as both local cheeses' production are labour intensive. Both global chains, however, have the ability to provide the cheese at a lower price, an aspect appreciated by consumers. The industrial Cheddar is especially cheap compared to the other cheeses (£9.76/kg (at the time of the research, €1 = approx. £0.75) when all others are between £12/kg and £18/kg), but as a counterpart, it is also very mechanized and provides few jobs per tonne produced. The perception of the price, however, is different for consumers in Switzerland and the UK. Indeed, the consumers' focus groups

revealed that consumers tend to value the quality of cheese more in Switzerland and look out for quality designations on both the Swiss cheeses. Most major cheeses on the Swiss market carry a PDO certification, which is more readily recognised by consumers than it is in the UK.

**Table 3.** Sustainability performance of the case studies: data (see Table 1) and scores (in %) for indicators of performance in Switzerland and the UK.

Indicators	L'Etivaz		Le Gruyère		Farmhouse UK		Creamery UK	
	Data	Score	Data	Score	Data	Score	Data	Score
Ability to provide food at acceptable prices	21	15	179	35.3	18.3	32	9.8	73
Price perception of consumers	3	75	3	75	1	25	2	50
Producers' business profit	67,437	45.7	76,723	61.2	6.7	66.5	2.5	24.5
Distribution of price between actors	0.25	74.8	0.2	79.9	0.25	75	0.34	66.2
Contribution to the economy of the region	11.4	59.9	5.8	26.2	0.4	91.3	0.01	1.25
Communication along the chain	0.9	90.3	0.8	76.4	1	100	0.6	60
Availability of Information	5	83.3	6	100	3	50	3.5	58.3
Product Labelling	3	60	3.50	70	3.35	67	3.75	75
Soil management practices	3.15	63.1	1.45	29	4	80	2	40
Material consumption practices	1.1	36	0.7	22.8	4	100	4	100
Waste reduction and disposal	2.3	57.1	2.6	65.8	4	100	4	100
Landscape management practices	2.2	31.4	2.8	40.2	4	100	4	100
Diversity of Production	1.15	38.3	0.9	29.7	1	20	1	20
Salt content	1.45	52.3	1.6	47	1.7	39.2	1.8	38.2
Fat content	31.5	55.7	32.8	51.5	35	55.3	34	52.1
Fat types	18.9	62.1	19.5	60.5	24.5	46.8	21.8	54.3
Calcium content	1027	67.1	827	29	740	12.4	739	12.2
Animals density	0.5	99.3	1.8	46.3	1.75	50	2.8	8
Lifetime of dairy cows	7.8	63.3	6.8	51.1	8.5	73.3	7	53.3
Grazing time	72.3	72.3	64	64	62.5	62.5	66	66

Another major indicator concerning socio-economic aspects is the distribution of value along the value chain. This indicator has been assessed using a similar formula to the Gini coefficient [35], which gives a value between 0 and 1 according to how different the revenues are, with 1 being a totally unequal situation. All four cheeses score close to an equal distribution of value, with the industrial cheddar being the most unequal. The case for L'Etivaz was, however, that the farmers-cheesemakers get the highest share. In the case of the largest cheddar creamery, distribution is surprisingly equal because the creamery is owned by a dairy farmers' cooperative.

In Table 3

benchmark range. Table 1 shows, in the salt indicator example, the highest possible performance within the range (*i.e.*, lowest quantity of salt per 100 g of cheese) is 0.4 g per 100 g. The lowest performance limit is 2.6 g per 100 g of cheese. L'Etivaz, with a salt content of 1.45 g/100 g is close to the half-way point in the performance range, and thus has a numerical performance score of 52.3%. To summarise, attributes have been used to characterise performance, indicators allow performance to be qualitatively or quantitatively assessed, and benchmarks specify the level of performance. Although for most dimensions the performance of the local chain is higher than its global counterpart, there are also notable differences between the Swiss and UK cases. This is the case for the social dimension where strategies concerning labelling, communication and food chain arrangements are different between the countries. In Switzerland, the L'Etivaz cooperative and IPG, which are both linked to the PDO, are structures that set rules about the meeting points and communication mechanisms in the chains. With these structures in place, 90% of actors in the L'Etivaz chain were satisfied about the communication within the chain, and 76% of actors were satisfied in the Le Gruyère chain. Farmers in the Le Gruyère chain expressed the issue that they had little or no contact with refiners and retailers. The much bigger size of the chain thus seems to limit some exchanges. Both scores are still much higher than for the industrial cheddar in the UK (60%), which does not have such structures in place. The farmhouse cheeses however noted 100% satisfaction, although the structure of the chain is very different and mostly working as single actors operating the whole chain. This structure of the chain is also the reason that UK farmhouse cheeses rely predominantly on direct sales and thus communicate more information directly per person rather than having much information available on labels or other media; this may also be why they score lower in “availability of information”. Le Gruyère, by contrast, bases its strategy upon having a lot of information available online or on other media (including sponsoring, *etc.*), or on the label, similar to the industrial cheddar, which has the most information on the label. L'Etivaz also has restrained information on the label and relies much more on direct sales. It turns out that the availability of information on the Swiss cheeses is globally higher and this could contribute to the consumers recognising the high quality of the products in relation to its price.

The scores of performance in the environmental dimension also show a difference between the Swiss and UK cheeses, as well as between the local and global cheeses. However, both local chains conduct practices that are more ecological concerning soil management in comparison to their global counterpart. The diversity in the production was higher in Switzerland compared to the UK, with farmers more used to cultivating several other crops, although the Single Gloucester farmers are the only ones to have specifically included a rare breed in their herds.

A major issue often raised by experts and actors was the question of animal feed as a global input in the food chain. When the cows are grazing almost round the clock, their feed is based mostly on local roughage in contrast to animals in stalls. This links the issues of resource use and animal welfare to biodiversity, including in the country of origin of the feed. Farmers in the local cheese chains tended to use less animal feed concentrates.

The geographical conditions also directly affect other kinds of environmental performance. Soil management in steep areas is rather limited, and tillage, pesticides and fertiliser applications are thus almost non-existent for farmers in the local Swiss chains. In terms of resource use, the main energy resource in L'Etivaz is local wood, used for heating the milk. The input for calorific energy is thus very local. For other sources of energy (including electricity), cheesemakers rely on diesel generators. In the other chains, producers rely on the national electricity grids, which may require global fuels or uranium. Global chains may prove more efficient in their electricity use thanks to their economies of scale, but this has not been measured in this study.

Water is abundantly available in the area of L'Etivaz; in fact, farmers complained that they regularly have to drain their land. The “water use” indicator was thus not included in the selection of indicators, as data is firstly unreliable, as farmers do not monitor their water use; and secondly, a benchmark is extremely hard to set for a resource use when the resource is present in excess. A comparable situation applied in the areas studied in the UK.

In the health dimension, nutritional values revealed that both cheeses in Switzerland contain less salt and fat and more calcium than in the UK. Cheese processing is, however, similar. This is surprising as consumers in the UK expressed more concern for healthy food compared to Switzerland, while it seems that levels of fat and salt remain higher. The nutritional values of the local cheeses tend to be slightly better than the global cheese but the difference is minimal and the local UK cheese actually has a higher fat content than the global UK cheese. It is also clear that the performance in the ethical dimension is higher for both local chains concerning the only attribute in this dimension—animal welfare.

## 5. Discussion

In this section, results are discussed in further detail. In particular, the variations in national and scale context are analysed. The selection and analysis of the case studies, and especially the interaction with and between the cheese chain actors, confirmed that the local–global binary is too simple a framework for analysis. This is because, firstly, both chains reveal aspects of hybridity in practice, and secondly, because there are variations in context—such as food quality governance mechanisms, price expectations and understandings of nutrition and national topography—which reveal important features of performance in each chain not fully evident in quantitative performance scoring alone.

### 5.1. *The Local to Global Continuum*

The oversimplification of the local–global binary has already been noted by several authors [41,42]. However, in trying to delineate the two types of supply chains, this research highlights a number of creamery and farmhouse characteristics, as outlined in Section 3 and Table 2, above. In addition to distance between the points of production and consumption, distinctions are made for other factors, such as the relative quantities produced, the degree of mechanisation of production, and the location of input and sales markets. Social factors also distinguish farmhouse and creamery chains, such as the type of link (e.g., direct or indirect) between producers and consumers and traditional know-how. A typology along a farmhouse–creamery continuum more accurately describes the distinction between the chains, rather than a simple local–global split. Indeed, this typology appears to be the key element of distinction in the cheese sector. The local cheeses in our sample are all produced in an artisanal way and involving at least some direct contact with consumers. By contrast, both global cheeses are produced by creameries with modern installations and at much bigger scales (see Table 2). The usefulness of a continuum rather than a binary distinction was confirmed by several factors: some local cheeses in the study are also exported worldwide and some international inputs are present in their production, such as rennet [43]. Small proportions of Le Gruyère are also sold directly to consumers and sometimes made in small village creameries. Ultimately, both global and local channels exist in all the cheese chains studied here, especially in relation to upstream production inputs and downstream sales channels.

### 5.2. *Governance and PDO Aspects*

Supply chain governance represents an additional facet of local–global hybridity, as well as a point of comparison between the two subject countries. It is notable, for example, that PDO is an EU designation that non-member Switzerland applies to identify quality, territorial integrity and particular forms of food chain organisation in the market. In the UK, while the PDO is used by some farmhouse producers to guarantee territoriality and production processes, the label is not widely recognised, nor does it signify food chain collaboration as in the Swiss model. Where farmhouse cheddar is exported, a PDO logo may be less successful than the labelling of county/regional identity or the reputation of the individual producer, in creating perceptions of quality.

The structure of the food chain, and especially the arrangements between actors, play an important role in its governance, its degree of localness and its sustainability performance. Whether via collective organisations such as producer cooperatives (L'Etivaz), or an inter-branch organization (Le Gruyère),

or looser commercial associations such as the West Country Farmhouse Cheesemakers, it has been possible for producers in both countries to distinguish their cheeses using PDOs. Clearly, national regulations concerning PDOs relating to the qualities of particular cheeses vary. In Switzerland, for example, all PDO cheeses must be made from raw milk but there is no official national expectation in respect of the distance over which milk is transported to the creamery, or from which breed of cow milk should be sourced. Swiss PDO cheeses however always define their zone of production including different degrees of milk production, cheese transformation and ripening. In the UK, PDO cheddar production is regionally restricted and the PDO for Single Gloucester makes some prescriptions about dairy cattle breeds. The rules of production and designation pass through an administrative agreement but have primarily to be proposed and accepted by representatives of the PDO food chain. The PDO sign is thus not necessarily synonymous with a high degree of localness in the chain. The PDO registration can, however, be a useful tool for (re)localising the food chain if this is the collective intention of the producers developing the PDO specification.

In this sense, the strategy of actors in both Swiss cheese chains and the UK farmhouse producers using PDO certification, is to promote a production process that is territorially embedded with varying degrees of collective management of the food chain. The Swiss cheeses integrate a high level of common management including advertising, pricing, communication, selling, *etc.* for which each member pays a contribution. Considering the working schedules of small artisanal producers, this is critical. In the UK, local cheese examples studied, the marketing strategy is far more individual (and horizontal) and each producer also handles cheese maturation and sales. The global UK cheese chain, by contrast, has no territorial anchorage or integrated food chain strategy and thus no PDO.

The differing strategies and uses of PDOs between UK and Switzerland are also reflected in the opinion of consumers and are visible in their perception of price. In Switzerland, even though some PDO criteria impose only broad restrictions on geographical distance, the PDO label was associated by consumers in our focus group with qualities of localness, including a higher intrinsic quality and controlled sourcing of inputs, justifying a higher price.

These different forms of governance in the food chains, and strategies regarding communication to consumers, are clearly reflected in the “information and communication” performance attribute. In general, it can be said that the presence of an integrated food chain organisational structure, such as that evident in the PDO cases, or of a collective strategy, increases sustainability in terms of communication, solidarity, the preservation of knowledge and regulated working times. Governance is thus more significant than the degree of localness in terms of sustainability and can contribute to the preservation or enhancement of localness in the chain.

PDOs also contribute to the maintenance of agricultural and handicraft activities in rural regions, and cheeses with PDO labels have already been shown to have an impact on job-creation and landscape preservation in mountain areas in comparison with areas without such productions [44]. PDOs are thus also a factor of long-term survival for some small-scale producers.

### 5.3. Distribution of Value, Employment and Mechanization

In terms of economic sustainability, geographical designations of origin and localness may allow producers to maintain their traditional production processes, because they return higher profits for the milk and/or cheese produced. Farmhouse cheesemakers have developed diverse marketing channels, including direct or niche marketing strategies, where they can charge prices which reflect their costs of production, and where consumers are more willing to pay for certain qualities, as shown by the “perception of price” indicator [1,45]. These strategies could be interpreted as economically inefficient compared to the value adding strategies adopted by creamery cheesemakers. The latter use, for example, highly efficient industrial processes which require a much lower and technically specialised labour input per unit of production compared to farmhouse cheesemakers. Traditional farmhouse production systems by contrast perform a diversity of tasks, often relying on family labour, and the



time this takes limits the production levels for farmhouse producers, despite relatively long working days (77 h per week in the summer in the L'Etivaz case, for example).

In absolute terms, the small scale of farmhouse cheesemakers means that they employ fewer people overall, compared to creameries. Larger creameries such as Gruyère and Cheddar can be significant contributors to a region's economy, depending on the range of their milk suppliers, direct and indirect employment and tax revenues, although this was not accounted for in our study.

The poorest performance in terms of contribution to the regional economy was the largest cheddar creamery, although this was counterbalanced by the affordability of its cheese products (it was the cheapest cheese in the sample). Creameries have indeed developed optimal systems of production intended to minimise production costs and to operate in a market principally controlled by a small number of competing retailers. Their strategy is based on the reduction of raw material costs (most notably milk) which can lead to milk production delocalisation, rather than a reduction in logistics costs, because not all logistical operations in the chain are in the control of the creamery. Production at this scale also carries extra risks during periods when the consistency of local supply is affected and, consequently, inter-regional sourcing is a feature of larger UK creameries.

Le Gruyère cheese, with its PDO, is a cheese with specific production contexts that enable it to be considered "artisanal". It is viewed as affordable domestically and actors higher up the Le Gruyère chain have made some efforts to reduce the trend of decreasing value added being returned to farmers.

In terms of trade-offs, an industrial production strategy thus offers affordability for consumers but in the main reduces the share of the added value and profits producers receive for their products. It also encourages a degree of disconnection from the territory of production in favour of production efficiency. Local and regionally embedded production (in this case farmhouse cheeses and Le Gruyère) can, by contrast, support a higher level of jobs per unit of cheese produced and potentially bring revenues to rural communities who suffer from reduced buying power [46].

#### 5.4. Nutrition and Quality

The different modes of production (farmhouse and creamery) present distinguishable strategies regarding nutritional quality. Farmhouse and artisan cheese producers argue that cheese is inherently a relatively high fat content food and that a certain level of salt is also necessary in order to ensure that the cheese's taste is appealing. Salt was also mentioned as a crucial element for the processing and maturation of the cheese; indeed, an overly low level of salt could lead to food safety concerns [47]. Generally, local and artisan producers will produce cheeses with levels of fat and salt varying seasonally and between each batch of production; Goy *et al.* [48] found significant variance above the medium values indicated. Farmhouse producers argue that traditionally-produced cheese is high in protein and calcium, and that cheese should not be eaten to excess, as well as being part of a well-balanced diet.

On the other hand, it is clear that industrial cheese producers control fat and salt content in more

their willingness to pay. This is where local products have an advantage, as Paloviita ([50], p. 1504) found that the most important local food attributes for consumers is related to socio-cultural aspects, including “trust, familiarity, personal contact and nostalgia”. This is related to typical taste and direct contacts and influences consumers’ perception of health and price related issues. Comparing affordability and quality in absolute terms may therefore be misleading, as the most critical factor for health sustainability is consumer behaviour.

#### *5.5. Animal Welfare, Resource Use, Topography and Ecology*

Cheese quality, and more specifically, the quality of the milk (including, for example, the ratio of fatty acids) is dependent on production strategies at the farm level [51]. Altitude also plays a role in improving fat quality [52] and explains the higher performance of L’Etivaz in terms of nutritional values. The fat content of the milk is also strongly related to the cattle breeds present in the herds. Cows like Jersey or Montbéliardes will produce more fat and protein per kg of milk than a higher milk yielding Holstein cow. This directly influences the suitability of the milk for cheese making and the efficiency of coagulation. The farmer’s decision in favour of one breed of cows is linked to many factors other than the nutritional content of cheese. In the case of Single Gloucester cheese, the collective strategy behind the PDO was directed towards the preservation of the rare Gloucester dairy breed. An unspecified proportion of the herd has to comprise Gloucester cows, a robust breed which is adapted to extensive grazing. In Switzerland, breed selection is guided by a combination of the preferences of individual farmers and Alpine topography, where robust breeds are also an asset. For environmental sustainability, Capper and Cady [53] have shown that the carbon footprint of breeds such as Jerseys are 20% lower than Holstein in the case of cheese production. It is also important to note that studies have shown that the largest environmental impact within the cheese chain, by far, comes from the milk production stage rather than from the transport of cheese [54,55]. In the context of local–global comparison, it is notable that the strategies of farmers in relation to animal husbandry and production systems have far more impacts than the distances in the food chain, although both factors are related.

In the case of L’Etivaz, steep Alpine slopes cannot be cultivated and are used as pasture during the summer. It is also the case that extended pasture constitutes a traditional and cultural landscape that is attractive to tourists and consumers [56,57]. These environments can create market value through animal grazing for the production of a high added-value product associated with the landscape. Pasture topography is also important in the case of Le Gruyère cheese, but only in those mountainous parts of the production area.

The terrain is an important factor in the perception of the local or global nature of these food chains, as it strongly influences the origin of feeding inputs. It was seen in this study that local Swiss cheeses tend to use less imported feed and more grazing. In the UK, farmhouse producers asserted that they minimise (or in one case do not practice any) supplementary feeding, partly as a cost-management strategy, but also because pasture-based grazing is regarded as having a critical effect on animal welfare and therefore milk quality. However, all cheesemakers clearly have an interest in the link between animal nutrition, health and milk quality, and in both of the creameries studied here regular contact between the companies and their suppliers was evident to discuss pasture and cattle management. More generally, global dairy production systems are suggested to have a higher carbon footprint than local grass-based systems [58,59], but the effect depends on milks yields [60] and input contexts [4]. Further quantitative analysis of this question is required. It is clear that cheese producers apply different strategies to influence animal welfare, particularly as the time spent on pasture for feeding is a positive strategy for the cows’ welfare. The use of more robust breeds also positively influences the cows’ life expectancy and health [61].

Finally, subsidies and agricultural policies also affect any comparative assessment of environmental sustainability. Both countries’ agricultural policies provide agricultural subsidies related to environmental performance, but the amounts given (per farmer) and the link to environmental

performances are more directly influential in Switzerland. However, our study did not reveal greater environmental performance for Swiss farmers, but this may be due to the very limited ecological data available in the UK case, or to the choice of categories for creating the indicators. Swiss agricultural policy since 2014 has started to tackle the issue of imported concentrated feed by subsidising grassland surface and limiting concentrate use as part of the conditions for being able to access subsidies. That is why the Swiss average of concentrate consumption is lower than what can be observed in some other European countries [62]. However, it should be noted that the import of concentrates has increased drastically over the past 20 years because the agricultural policy previously discouraged farmers from growing fodder cereals in Switzerland. A view expressed by UK dairy farmers in this study was that ecological knowledge of farms was largely anecdotal—farmers indicated their broad knowledge of local wildlife, based on a close familiarity with their land and passing observations in the course of their work—but they do not keep formal records unless the farm is within a designated habitat/landscape, or part of a higher level agri-environmental programme. Additionally, voluntary aspects of ecological land management were affected by the dramatic drop in milk prices during 2014–2015.

### 5.6. Methodological Discussion

As the discussion of the results shows, the comparison of local and global performances relied on the analysis of the contextual differences and factors that influence sustainability performance within the different attributes along the local to global continuum. Exclusive consideration of the quantitative scores would not support a multi-dimensional analysis and would miss some important contextual details; not least because the list of indicators considered can rarely be exhaustive in such assessments. The complementary qualitative approach applied here is especially useful, because it allows the consideration of broader contexts of value chain performance. The participatory data collection via interviews with stakeholders and consumer focus groups has been especially enriching in this case. The preliminary interviews and initial desk-research helped to frame the analysis of different chains and were crucial in selecting the performance attributes used in the comparative analysis. These capture highly important contextual differences, which complements and provides qualification for the performance analysis done on the basis of quantitative data. As Peano *et al.* ([63], p. 6725) also experienced, “the holistic vision inherent in the definition of sustainability creates many difficulties when applied to systems with an elevated complexity” and the inclusion of stakeholders is one of the only ways to overcome this complexity.

However, a participatory comparison process is demanding in terms of data collection and results should be analysed cautiously, especially in the environmental dimensions, where more exhaustive methodologies like LCA provide more detailed comparisons. Short-comings can, however, arise quickly in such methodologies and the purpose of this paper is to give consideration to the broader context and important country-specific contextual factors. The importance of PDO schemes or topography, for example, are essential to understanding performance differences. The qualitative aspects of this study allowed such factors to be taken into account in the analysis.

## 6. Conclusions

Consumers express a renewed interest in local and territorially distinctive foods, and perceive them as more sustainable. The consumer data analysed for this paper indicates that local cheese is connected with attributes of better quality, is consumed both habitually and on special occasions, and at least some consumers are willing to make special efforts to buy it directly from the producer. The cheese chain data revealed two further major conclusions. Firstly, cheese chains in Switzerland and the UK often present hybrid arrangements in term of local and global scales. They can have a localised production system using imported feed and manufacturing inputs, or sell cheese both directly in the local market, in national multiple retailers (supermarkets) and in the export market. A binary distinction is thus not possible and all cheese case studies here are situated on a local (farmhouse)/global (creamery) continuum.

In terms of establishing which parts of the farmhouse/creamery continuum are more, or less, sustainable, the method of assessing a high diversity of sustainability indicators has not generated clear results. However, it appears that there are more relevant questions to sustainability than “is eating local better?” because it always depends on how the local is produced, which inputs it is linked to and in which marketing channels it is embedded. The answer will never be generalizable to all cases of local food and this is why the debate is still on-going. It is important, furthermore, to emphasise, that the research presented in this paper is not designed to be replicable—it is illustrative of a research process which has explored the contextual complexities of a multi-dimensional food chain sustainability assessment of cheese in two European countries. There are, however, food chain performance elements that tend to be inherent in localised systems and that have the potential to be taken up in larger systems of production. Having food chain actors organised within collective strategic arrangements may bring socio-economic benefits, especially for the production stages of the chain. Moreover, systems localising their inputs avoid out-sourcing substantial environmental impacts and can make better use of local resources, thereby contributing to landscape preservation and rural development. These systems also tend to be better adapted to their local environment and can trigger multiple benefits for tourism, added value, diversity and health. On the other hand, global systems are themselves sometimes localised, particularly at the level of production, and some global cheese chains started as local chains that were successful enough to scale-up. Le Gruyère, for example, has retained some local characteristics in the process. Reaching a bigger scale, however, brings substantial benefits in terms of economic efficiency, also making the cheese more affordable and accessible to consumers. Some environmental benefits might also be reached thanks to the economies of scale, but the application of other methodologies, such as LCA, are more suitable for assessing this quantitatively. The contribution to the regional economy in terms of jobs seems to promise greater benefits in the global chain due to the large quantities of production. However, local chains offer more jobs per tonne of output and are better able to keep traditional jobs and know-how in rural regions.

The sustainability assessment methodology used here had the goal to cover multiple dimensions of performance. This approach was useful for identifying trade-offs between sustainability goals in cheese chains and in revealing links between localness and sustainability. However, no scale of food chain can outperform all others in all dimensions and be considered the most sustainable scale. The sustainability performance of global and local chains is therefore relative and depends ultimately on actors’ strategies rather than on their degree of localness or globalness.

**Acknowledgments:** All authors warmly acknowledge the work and support of students and colleagues at FiBL (Anaëlle Tanqueray-Cado, Laurette Gratteau, Virginia Cravero, Ulysse Le Goff) and at CCRI (Dilshaad Bundhoo) who contributed to data collection and previous reports that led to this paper. Thanks also to Johan Six at ETHZ for providing feedback on the paper. We also wish to thank very warmly all people who gave their time during interviews at all stages of each value chain. We also thank the European Commission for providing funding for this research (GLAMUR project) through the Seventh Framework Programme for research, technological development and demonstration under grant agreement number 311778.

**Author Contributions:** An iterative process between both teams was used for the case study selection, the choice of the list of indicators and attributes and design of interviews. Emilia Schmitt participated to all stages of the research and coordinated the selection of indicators as well as the data collection in Switzerland and data analysis. She also wrote the biggest part of the paper. Dominique Barjolle contributed to the selection of the case studies in Switzerland, provided significant help in the contact with respondents and participated in the formulation of the analytical framework and review of the paper. In the UK, all authors participated in the selection of case studies and indicators. Daniel Keech conducted the major part of data collection. He and Damian Maye revised and wrote significant parts of the paper. James Kirwan was the coordinator of the cheese case studies in the GLAMUR project, as well as reviewing the paper.

**Conflicts of Interest:** The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

## Abbreviations

The following abbreviations are used in this manuscript:

CH	Confederatio Helvetica (Switzerland)
IPG	Interprofession du Gruyère (Inter-branch organization for Le Gruyère)
LCA	Life Cycle Analysis
PDO	Protected Designation of Origin
RISE	Response-inducing Sustainability Evaluation
SAFA	Sustainability Assessment of Food and Agriculture
UK	United Kingdom

## References

- Adams, D.C.; Salois, M.J. Local *versus* organic: A turn in consumer preferences and willingness-to-pay. *Renew. Agric. Food Syst.* **2010**, *25*, 331–341. [[CrossRef](#)]
- Feldmann, C.; Hamm, U. Consumers' perceptions and preferences for local food: A review. *Food Qual. Preference* **2015**, *40*, 152–164. [[CrossRef](#)]
- Hinrichs, C.C. The practice and politics of food system localization. *J. Rural Stud.* **2003**, *19*, 33–45. [[CrossRef](#)]
- Edwards-Jones, G. Does eating local food reduce the environmental impact of food production and enhance consumer health? *Proc. Nutr. Soc.* **2010**, *69*, 582–591. [[CrossRef](#)] [[PubMed](#)]
- Fraser, E.D.G. Food system vulnerability: Using past famines to help understand how food systems may adapt to climate change. *Ecol. Complex.* **2006**, *3*, 328–335. [[CrossRef](#)]
- Born, B.; Purcell, M. Avoiding the Local Trap: Scale and Food Systems in Planning Research. *J. Plan. Educ. Res.* **2006**, *26*, 195–207. [[CrossRef](#)]
- Report of the World Commission On Environment And Development: Our Common Future. Available online: <http://www.un-documents.net/our-common-future.pdf> (accessed on 27 April 2016).
- Neven, D. *Developing Sustainable Food Value Chains. Guiding Principles*; FAO: Rome, Italy, 2014.
- Morrissey, J.E.; Dunphy, N.P. Towards Sustainable Agri-Food Systems: The role of Integrated Sustainability and Value Assessment Across the Supply-Chain. *Int. J. Soc. Ecol. Sustain. Dev.* **2015**, *6*, 41–58. [[CrossRef](#)]
- Velten, S.; Leventon, J.; Jager, N.; Newig, J. What Is Sustainable Agriculture? A Systematic Review. *Sustainability* **2015**, *7*, 7833–7865. [[CrossRef](#)]
- Van Cauwenbergh, N.; Biala, K.; Biolders, C.; Brouckaert, V.; Franchois, L.; Garcia Ciudad, V.; Hermy, M.; Mathijs, E.; Muys, B.; Reijnders, J.; *et al.* SAFE—A hierarchical framework for assessing the sustainability of agricultural systems. *Agric. Ecosyst. Environ.* **2007**, *120*, 229–242. [[CrossRef](#)]
- Pathak, H.; Jain, N.; Bhatia, A.; Patel, J.; Aggarwal, P.K. Carbon footprints of Indian food items. *Agric. Ecosyst. Environ.* **2010**, *139*, 66–73. [[CrossRef](#)]
- Weber, C.L.; Matthews, H.S. Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environ. Sci. Technol.* **2008**, *42*, 3508–3513. [[CrossRef](#)] [[PubMed](#)]
- Ostrom, E. A general framework for analyzing sustainability of social-ecological systems. *Science* **2009**, *325*, 419–422. [[CrossRef](#)] [[PubMed](#)]
- Bloom, J.D.; Hinrichs, C.C. Moving local food through conventional food system infrastructure: Value chain framework comparisons and insights. *Renew. Agric. Food Syst.* **2011**, *26*, 13–23. [[CrossRef](#)]
- Jackson, P.; Ward, N.; Russell, P. Moral economies of food and geographies of responsibility. *Trans. Inst. Br. Geogr.* **2009**, *34*, 12–24. [[CrossRef](#)]
- Clarke, N.; Cloke, P.; Barnett, C.; Malpass, A. The spaces and ethics of organic food. *J. Rural Stud.* **2008**, *24*, 219–230. [[CrossRef](#)]
- Müller, B. *Food Miles or Poverty Eradication?: The Moral Duty to Eat African Strawberries at Christmas*; Oxford Institute for Energy Studies: Oxford, UK, 2007.
- Morrison-Saunders, A.; Pope, J. Conceptualising and managing trade-offs in sustainability assessment. *Environ. Impact Assess. Rev.* **2013**, *38*, 54–63. [[CrossRef](#)]
- Binder, C.; Schmid, A.; Steinberger, J.K. Sustainability solution space of the Swiss milk value added chain. *Ecol. Econ.* **2012**, *83*, 210–220. [[CrossRef](#)]

21. Food and Agriculture Organization of the United Nations (FAO). *SAFA Sustainability Assessment of Food and Agriculture Systems Guidelines*; FAO: Rome, Italy, 2013.
22. López-Ridaura, S.; van Keulen, H.; van Ittersum, M.K.; Leffelaar, P.A. Multiscale methodological framework to derive criteria and indicators for sustainability evaluation of peasant natural resource management systems. *Environ. Dev. Sustain.* **2005**, *7*, 51–69. [[CrossRef](#)]
23. Binder, C.; Feola, G.; Steinberger, J. Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. *Environ. Impact Assess. Rev.* **2010**, *30*, 71–81. [[CrossRef](#)]
24. Nardo, M.; Saisana, M.; Saltelli, A.; Tarantola, S.; Hoffman, A.; Giovannini, E. *Handbook on Constructing Composite Indicators: Methodology and User Guide*; Organisation for Economic Co-operation and Development (OECD): Paris, France, 2008.
25. Bockstaller, C.; Guichard, L.; Keichinger, O.; Girardin, P.; Galan, M.-B.; Gaillard, G. Comparison of methods to assess the sustainability of agricultural systems. A review. *Agron. Sustain. Dev.* **2009**, *29*, 223–235. [[CrossRef](#)]
26. Bossel, H.H. *Indicators for Sustainable Development: Theory, Method, Applications*; International Institute for Sustainable Development: Winnipeg, MB, Canada, 1999; Volume 68.
27. Stauffacher, M.; Flüeler, T.; Krütli, P.; Scholz, R.W. Analytic and dynamic approach to collaboration: A transdisciplinary case study on sustainable landscape development in a swiss prealpine region. *Syst. Pract. Action Res.* **2008**, *21*, 409–422. [[CrossRef](#)]
28. Hammond, R.A.; Dubé, L. A systems science perspective and transdisciplinary models for food and nutrition security. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 12356–12363. [[CrossRef](#)] [[PubMed](#)]
29. Berrah, L.; Clivillé, V. Towards an aggregation performance measurement system model in a supply chain context. *Comput. Ind.* **2007**, *58*, 709–719. [[CrossRef](#)]
30. Brunori, G.; Galli, F.; Barjolle, D.; van Broekhuizen, R.; Colombo, L.; Rougoor, C.; Giampietro, M.; Kirwan, J.; Lang, T.; Mathijs, E.; *et al.* Are local food chains more sustainable than global food chains? Considerations for assessment. *Sustainability* **2016**, in press.
31. Smith Taillie, L.; Jaacks, L.M. Toward a Just, Nutritious, and Sustainable Food System: The False Dichotomy of Localism. *J. Nutr. Issues Opin.* **2015**, *145*, 1380–1385. [[CrossRef](#)]
32. *Nvivo 10*; QSR International: Burlington, MA, USA, 2013.
33. Ilbery, B.; Maye, D.; Kneafsey, M.; Jenkins, T.; Walkley, C. Forecasting food supply chain developments in lagging rural regions: Evidence from the UK. *J. Rural Stud.* **2004**, *20*, 331–344. [[CrossRef](#)]
34. Kirwan, J.; Maye, D.; Bundhoo, D.; Keech, D.; Brunori, G. *GLAMUR WP2—Scoping/Framing General Comparative Report on Food Chain Performance (Deliverable 2.3)*; Countryside and Community Research Institute: Gloucestershire, UK, 2014.
35. Bellù, L.G.; Liberati, P. *Analyse D'inégalité: L'indice de Gini*; FAO: Rome, Italy, 2006. (In French)
36. Federal Office for Agriculture (FOAG). *Cahier des Charges*; FOAG: Bern, Switzerland, 2004. (In French)
37. L'Etivaz AOP. La Coopérative. Available online: <http://www.etivaz-aoc.ch/letivaz/la-cooperative> (accessed on 4 September 2015). (In French).
38. Interprofession du Gruyère (IPG). *Rapport Annuel 2014*; IPG: Pringy, Switzerland, 2014; (In French and German).
39. Department for Environment, Food & Rural Affairs. Protected food name: West Country Farmhouse Cheddar cheese (PDO). Available online: <https://www.gov.uk/government/publications/protected-food-names-west-country-farmhouse-cheddar-cheese-pdo> (accessed on 20 May 2012).
40. Agriculture and Horticulture Development Board. UK Dairy Product Production. Available online: [http://dairy.ahdb.org.uk/market-information/processing-trade/dairy-product-production/uk-dairy-product-production/#.Vo\\_EjDaMEop](http://dairy.ahdb.org.uk/market-information/processing-trade/dairy-product-production/uk-dairy-product-production/#.Vo_EjDaMEop) (accessed on 22 December 2015).
41. Feagan, R. The place of food: Mapping out the 'local' in local food systems. *Prog. Hum. Geogr.* **2007**, *31*, 23–42. [[CrossRef](#)]
42. DuPuis, E.M.; Goodman, D. Should we go 'home' to eat?: Toward a reflexive politics of localism. *J. Rural Stud.* **2005**, *21*, 359–371. [[CrossRef](#)]
43. Schmitt, E.; (ETH Zurich, Zurich; Forschungsinstitut für biologischen Landbau (FiBL), Frick, Switzerland); Barjolle, D.; (ETH Zurich, Zurich, Switzerland); Six, J.; (ETH Zurich, Zurich, Switzerland). Assessing the degree of localness of food value chains. Unpublished Work, 2016.



44. De Roest, K.; Menghi, A. Reconsidering ‘traditional’ food: The case of Parmigiano Reggiano cheese. *Sociol. Rural.* **2000**, *40*, 439–451. [[CrossRef](#)]
45. Dogan, B.; Gokovali, U. Geographical Indications: The Aspects of Rural Development and Marketing Through the Traditional Products. *Procedia Soc. Behav. Sci.* **2012**, *62*, 761–765. [[CrossRef](#)]
46. La Trobe, H.L.; Acott, T.G. Localising the global food system. *Int. J. Sustain. Dev. World Ecol.* **2000**, *7*, 37–41. [[CrossRef](#)]
47. Goy, D.; Häni, J.-P.; Piccinali, P.; Wehrmüller, K.; Jakob, E. Salt and its significance in cheese making. *ALP Forum Agroscope* **2012**, *59*, 1–20.
48. Goy, D.; Piccinali, P.; Wechsler, D.; Jakob, E. Caractérisation du gruyère AOC. *Agroscope* **2011**, *536*, 1–30. (In French)
49. National Farmers’ Union. *Compete to Grow: A Vision and Strategy for the British Dairy Industry*; National Farmers’ Union: Stoneleigh, TX, USA, 2012.
50. Paloviita, A. Consumers’ sustainability perceptions of the supply chain of locally produced food. *Sustainability* **2010**, *2*, 1492–1509. [[CrossRef](#)]
51. Ceotto, E. Grasslands for Bioenergy Production: A Review. In *Sustainable Agriculture*; Lichtfouse, E., Navarrete, M., Debaeke, P., Véronique, S., Alberola, C.E., Eds.; Springer Science + Business Media: Berlin, Germany, 2009; pp. 141–151.
52. Collomb, M.; Büttikofer, U.; Sieber, R.; Jeangros, B.; Bosset, J.-O. Composition of fatty acids in cow’s milk fat produced in the lowlands, mountains and highlands of Switzerland using high-resolution gas chromatography. *Int. Dairy J.* **2002**, *12*, 649–659. [[CrossRef](#)]
53. Capper, J.L.; Cady, R.A. A comparison of the environmental impact of Jersey compared with Holstein milk for cheese production. *J. Dairy Sci.* **2012**, *95*, 165–176. [[CrossRef](#)] [[PubMed](#)]
54. Berlin, J. Environmental life cycle assessment (LCA) of Swedish semi-hard cheese. *Int. Dairy J.* **2002**, *12*, 939–953. [[CrossRef](#)]
55. Kim, D.; Thoma, G.; Nutter, D.; Milani, F.; Ulrich, R.; Norris, G. Life cycle assessment of cheese and whey production in the USA. *Int. J. Life Cycle Assess.* **2013**, *18*, 1019–1035. [[CrossRef](#)]
56. Wiskerke, J.S.C. On Places Lost and Places Regained: Reflections on the Alternative Food Geography and Sustainable Regional Development. *Int. Plan. Stud.* **2009**, *14*, 369–387. [[CrossRef](#)]
57. Holloway, L.; Cox, R.; Venn, L.; Kneafsey, M.; Dowler, E.; Tuomainen, H. Managing sustainable farmed landscape through ‘alternative’ food networks: A case study from Italy. *Geogr. J.* **2006**, *172*, 219–229. [[CrossRef](#)]
58. Lindenthal, T.; Amon, B.; Markut, T.; Kirner, L.; Zollitsch, W. Greenhouse gas emissions from selected Austrian dairy production systems—model calculations considering the effects of land use change. *Renew. Agric. Food Syst.* **2010**, *25*, 316–329.
59. Zimmermann, A. Optimization of Sustainable Dairy-Cow Feeding Systems with an Economic-Ecological LP Farm Model Using Various Optimization Processes. *J. Sustain. Agric.* **2008**, *32*, 77–94. [[CrossRef](#)]
60. Schader, C.; Jud, K.; Meier, M.S.; Kuhn, T.; Oehen, B.; Gattinger, A. Quantification of the effectiveness of greenhouse gas mitigation measures in Swiss organic milk production using a life cycle assessment approach. *J. Clean. Prod.* **2013**, *73*, 227–235. [[CrossRef](#)]
61. Bland, J.H.; Grandison, A.S.; Fagan, C.C. Effect of blending Jersey and Holstein-Friesian milk on Cheddar cheese processing, composition, and quality. *J. Dairy Sci.* **2014**. [[CrossRef](#)]
62. Wijnands, J.H.; van Berkum, S.; Verhoog, D. *Measuring Competitiveness of Agro-Food Industries. The Swiss Case*; OECD Food, Agriculture and Fisheries Papers No. 88; OECD Publishing: Paris, France, 2015.
63. Peano, C.; Tecco, N.; Dansero, E.; Girgenti, V.; Sottile, F. Evaluating the Sustainability in Complex Agri-Food Systems: The SAEMETH Framework. *Sustainability* **2015**, *7*, 6721–6741. [[CrossRef](#)]

