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Comparing the sustainability of local versus global food supply chains

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Comparing the sustainability of local versus global food supply chains

Abstract: *In this article we compare and contrast the economic, social, and environmental impact of local and global food supply chains building upon cross-country comparisons of food chain performance in nine European countries and for seven different products. We propose a novel way of conceptualising local and global food chains taking into account the length of the chain and the degree of product differentiation. Moreover, we consider impacts at different spatial scales such as the farm, the supply chain, national and global level, and the interactions of impacts across these different levels. Our findings suggest some general patterns regarding the local vs. global performance within the social, economic and environmental dimensions. However, we also discuss the conditions of validity of comparison and conclude that food chain categorization, product differentiation strategies, trade-offs within and across different sustainability dimensions and the way of measuring indicators are important determinants of food chain performance.*

1. Introduction

In a subsistence economy all was local: land was cultivated by farmers using locally available resources. For instance, organic matter was harvested in common lands and applied to fields producing food consumed mostly by the farm household. With first and second agrarian revolutions and parallel to the transport evolution, most of farmers in Western Europe were able to produce more than they the needed and to sell large quantities outside their regions, such that specialization took place. Then, the industrial revolution and subsequent advances in science made possible moving forward to more global trade and the synthesis of inputs.

A situation in which all kinds of inputs and global trade came into the system led to disconnection between producers and consumers, and to subsequent incidents and crises. Reaction was more coordination alongside the supply chain, but the implementation of these coordination followed two different pathways: (1) more coordination and traceability through increased control using formalised procedures and (2) more coordination through a relocalisation of the system. In the control pathway, the basic configuration of the system did not change. In the relocalisation pathway, the system is reconfigured resulting in new relationships between producers, processors, retailers and consumers.

Although there is ample literature about the potential impacts of local food supply chains, comparative approaches across geographical contexts are missing (Kneafsey et al., 2013). Therefore, the purpose of this article is to compare and contrast the economic, social, and environmental impact of local and global food supply chains building upon cross-country comparisons of food chain performance in nine European countries and for seven different products. We propose a novel way of conceptualising local and global food chains taking into account the length of the chain and the degree of product differentiation. Moreover, we consider impacts at different spatial scales such as the farm, the supply chain, national and global level, and the interactions of impacts across these different levels. The remainder of the paper is organised as follows: section 2 presents the methodology, section 3 provides and overview and typology of the cases, section 4 gives an overview of the results and section 5 concludes the paper.

2. Methodology

Our meta-analysis is based on a set of 33 case studies of food supply chains that have been conducted within the framework of the European FP7 project GLAMUR (Global and local food assessment: a multidimensional performance-based approach)[1]. The case studies have been carried out in nine European countries and focus on seven food products: pork, bread, cheese, wine, tomatoes, apples and berries. For each of these products one more local and one more global food supply chain have been studied and compared in two countries respectively, using similar sets of sustainability indicators. In some countries, in addition to the local and global chains intermediary cases have been identified, such as for instance mixed and regional pork supply chains in the Netherlands and in Italy (Oostindie et al., 2015; de Roest et al., 2014) and regional bread supply chains in the UK and in Italy (Smith and Barling, 2014; Galli et al., 2015). Comparison has been carried out by identifying the most important sustainability topics and issues of a specific local-global pair. Each chosen topic, e.g. labour relations, has been represented by one or more indicator. For each product group, a cross-country assessment of the sustainability performance of local and global supply chains has been carried out, examining the most relevant topics and performance attributes, cross-cutting issues and trade-offs between different dimensions of sustainability. The case studies have been carried out using a mix of qualitative and/or qualitative methods of analysis (Schwarz and Mathijs, 2015):

- participatory evaluation (PE) in which food supply chain actors are closely involved in the research process, the choice and evaluation of performance indicators.

- Life Cycle Assessment (LCA), a quantitative method to analyse environmental impacts along the life cycle of a product, from raw material input to waste.

- metabolic analysis has been applied using the Multiscale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) approach (Giampietro et al. 2013).

- the shadow price methodology involves the pricing of impacts for which there are no markets, such as in the case of most environmental impacts.

A detailed description of the case studies is given in section **Error! Reference source not found.**. For the cross-country comparison food supply chains and sustainability performance indicators have both been categorised into subgroups in order to facilitate comparison.

Food supply chains have been categorised according to two key dimensions:

- the length of the supply chain (from short to long), encompassing both the geographical distance between producers and consumers and governance issues such as the degree of control of different actors.

- the degree of product differentiation (from bulk to differentiated) encompassing the resources, knowledge and technology employed in the production process and the territorial identity of the product, i.e. whether the location of production plays a role in shaping the product identity or not. For Belgian apples, for example, the fact that production takes place

[1] More information on the project can be found under http://glamur.eu/.

in Belgium does not add to the identity of the product, and no special local knowledge is necessary for apple cultivation (Annaert et al., 2014). For Swiss cheese, on the other hand, specific Swiss traditions and knowledge are important for securing quality of production and are used as a marketing argument (Schmitt et al., 2015a). Organic production is considered as differentiated when multiple varieties are used, agro-ecological production methods are employed, additional services are delivered to the consumer, etc.

Combining these two dimensions gives rise to four generic food supply chain strategies: (1) Long supply chain/bulk product, (2) Long supply chain/differentiated product, (3) Short supply chain/bulk product, (4) Short supply chain/differentiated product.

Regarding the categorisation of performance indicators we take into account that different kinds of indicators measure performance at different scales, for instance the farm level, the whole food supply chain, or the national economy. For this end we rely on some theoretical considerations of the MuSIASEM (Multi-scale integrated analysis of societal and ecosystem metabolism) approach (Giampietro et al., 2013) which considers impacts at different scales and interconnections between them. Contrary to MuSIASEM we do not contrast socio-economic impacts with biophysical constraints of the ecosystem due to the already complex nature of our analysis. Instead, we use the same impact levels for the economic, social and environmental dimensions. The lowest level of analysis we consider here is the farm (level n-1) which is part of a food chain (level n). Food chains or systems are part of a national economy (n+1) that includes consumers and taxpayers. Finally, the world is captured at level n+2 and refers to activities and impacts that occur globally. These global effects are often substitution effects following actions at a national level, e.g. when production of a certain product decreases in a country while consumption stays at a constant level, imports will increase.

Our analysis is carried out by reviewing the 33 food supply chain case studies and the corresponding comparative reports outlined in section 0. For each sustainability dimension (i.e. economic, social, environmental) we summarise the most important performance attributes and the main differences between local and global chains. We then compare the sustainability of local and global food supply chains across scales, first contrasting local and global supply chains following a bulk product strategy and second contrasting local chains with differentiated products to global bulk supply chains. For French wine, Swiss cheese, Italian bread and Dutch and Italian pork, instead of global bulk product chains, either regional cases exist following a differentiation pattern or global chains are differentiating. In these cases, we compare short chain/differentiated to long chain/differentiated.

3. Overview and typology of case studies

Table 1 summarises the case studies and country pairs that are included in our analysis. The categorisation of food supply chains according to the four generic food supply chain categories is depicted in Table 2. We consider this a rough categorisation as some cases are in fact in between categories such as for instance the Spanish mixed tomato supply chain and the UK regional bread chain. Below, we briefly describe the case studies and motivate our choices of categorisation.

Table 1: Overview of cases, country pairs and methodologies

Product	Country 1	Country 2	Methodology
Pork	**Netherlands** (Oostindie et al., 2015) • Lupine pork (local) • KDV (mixed) • Global Farming Good Pork (global)	**Italy** (de Roest et al., 2014) • Cinta Senese ham (local) • Parma ham (regional) • Generic cured ham (global)	
	Comparative report: de Roest et al. 2015		PE, LCA
Bread	**UK** (Smith and Barling, 2014) • Craft bakery (local) • In-store bakery (regional) • Global chain (global)	**Italy** (Galli et al., 2015a) • The Stone Mill (local) • Tuscan Bread Sourdough (regional) • Mulino Bianco (global)	
	Comparative report: Galli et al. 2015b		PE
Cheese	**UK** (Keech et al., 2014) • Farmhouse (local) • Creamery (global)	**Switzerland** (Schmitt et al,. 2015a) • Le Gruyère (global) • L'Etivaz (local)	
	Comparative report: Schmitt et al. 2015b		PE
Wine	**France** (Touzard and Maffezzoli, 2015) • Family domains (local) • Bottled wine (global) • Bulk wine (global)	**Switzerland** (Cravero et al., 2015) • Valais (local)	
	Comparative report: Maffezzoli el al., 2015		PE
Tomatoes	**France** (Bellec-Gauche et al., 2015) • Local chain	**Spain** (Gamboa et al., 2015a) • Box scheme (local) • Mixed supply chain • Almeria (global)	
	Comparative report: Chiffoleau et al., 2015		MA
Apples	**Belgium** (Annaert et al., 2014) • Food teams (local) • Auction (global)	**Spain** (Gamboa et al., 2015b) • Box scheme (local) • Cooperative (global)	
	Comparative report: Annaert et al., 2015		LCA, MA, SP
Berries	**Latvia** (Grivins and Tisenkopfs, 2014) • Local chain • Grey chain (global) • Legal chain (global)	**Serbia** (Stojanovic et al., 2014) • Local chain • Global chain	
	Comparative report: Grivins et al., 2015		PE

PE: Participatory Evaluation, LCA: Life Cycle Assessment, MA: Metabolic Analysis, SP: Shadow Pricing

Table 2: Categorisation of food supply chains according to four generic strategies

	More bulk	**More differentiated**
Longer supply chains (Global)	BE global apples SE global raspberries LT global blueberries SP global tomatoes FR global bulk wine UK global cheese UK global bread UK regional bread IT global bread IT global pork NL global pork	 FR global bottled wine CH global cheese IT regional bread NL mixed pork
Shorter supply chains (Local)	BE local apples SE local raspberries LT local blueberries SP mixed tomatoes	 SP local tomatoes FR local tomatoes FR local wine CH local wine CH local cheese UK local cheese UK local bread IT local bread IT local pork

Pork

Pork supply chains have been analysed in the Netherlands and in Italy. In the **Netherlands**, differentiation between the local, the mixed and the global chains is mainly based on resource use and governance. The local chain is represented by the Lupine Pork chain that attempts to re-create distinctive pork qualities based on local feed sourcing, but turns out to be strongly inspired by global knowledge sourcing around how to sustain pork production and how to embed it in more global food market oriented farming activities. The global chain is represented by the Good Farming Global Pork chain that is owned by a regional farmer's organization, but follows a strongly globally oriented corporate business strategy. The KDW (Keten Duurzame Varkenshouderij) chain contains local and global aspects: Farmers initiated the relocalization of chain governance but the supply chain remains largely interwoven with global input and output markets. In **Italy**, differentiation between local and global chains is based on territoriality and resource use. The local chain is represented by the Cinta Senese ham chain using traditional local pig breeds with predominantly regional output markets. The global chain produces generic cured ham, characterised by global sourcing of raw materials, but at the same time closely interwoven with the more side-specific pork processing infrastructure, competences and skills of the Parma territory. An intermediate chain is the regional Parma ham chain that builds upon a historically rooted territorial distinctiveness of pork quality but has nowadays a global reputation and operates in global market outlets.

Bread

Wheat-to-bread supply chains have been analysed in the UK and Italy. In the **UK**, chains are differentiated primarily by distance and resource use. The local chain is represented by family-owned craft bakeries baking bread using traditional technologies. The global chain is represented by an industrial bakery sourcing both locally and globally. An intermediate chain is the in-store bakery that uses modern technology but sources wheat regionally. In **Italy**, chains are differentiated by distance and resource use. The local chain is represented by The Stone Mill, a farm that produces and processes its own wheat into bread and pasta using traditional technology. The global Mulino Bianco chain is represented by industrial bread produced using modern technology and sourcing globally. An intermediate case is the Tuscan Sourdough Bread using regionally sourced inputs and traditional technology.

Cheese

In **Switzerland**, cheese chains are differentiated primarily by area of production, volume of cheese produced and know-how and technology used. The local chain is represented by L'Etivaz, a Swiss ripened hard cheese that is produced on a farm using traditional technology and ripened in a cooperative. The global chain is represented by Le Gruyère cheese that is produced at the creamery and commercialised through retailers. In the **UK,** chains are differentiated according to volume of cheese produced, the proportion of cheese exported, and the degree of mechanisation or industrialisation. The local chain is represented by farmhouse producers of Single Gloucester and cheddar. The global case is represented by creamery producers of cheddar.

Wine

Wine supply chains have been studied in France and in Switzerland. Local and global wine chains are differentiated primarily by distance, production volumes and governance. In **France**, the local chain is represented by family domains that commercialise a relatively large share of their output through local markets. In the global bulk wine chain, growers sell their grapes to large cooperatives that produce the wine and sell it through a variety of channels. An intermediate case is a global bottled wine chain, in which wine is produced by domains or small cooperatives, but commercialised globally. In **Switzerland**, the local chain is represented by Valais-based domains that grow grapes, produce wine and sell it using local outlets.

Tomatoes

In **Spain** all tomato supply chains follow organic production principles. Differentiation of local and global chains is based on distance, governance and resource use. The local chain consists of a network of small scale agro-ecological farmers, producing a diversity of seasonal vegetables that are sold directly to the consumer. In the global chain, tomatoes are grown in greenhouses in Almeria and commercialised through various channels. An intermediate chain is characterised by a medium size farmer, producing tomatoes outdoor in semi-diversified farms and selling them through an organic wholesale cooperative. In **France**, the local tomato chain involves outdoor organic production and local sale channels.

Apples

Apple supply chains have been studied in Spain and in Belgium. Local-global differentiation is mainly based on distance and governance issues. In **Spain**, the local chain is represented by small agro-ecological farmers producing organic apples and selling them directly to consumer groups. In the global chain, organic apples are sold through wholesale channels. In **Belgium**, the local chain produces apples organically and sells them to consumer groups. In the global chain, apples are produced using integrated production techniques and commercialised through a cooperative auction.

Berries

Blueberry and raspberry chains have been analysed in Latvia and in Serbia. In **Latvia**, local and global blueberry chains are differentiated by distance, governance and resource use. The local chain is represented by individuals picking and selling blueberries. The global chain is represented by a large, technologically advanced enterprise processing wild blueberries. In addition, an intermediary global grey chain is considered in which part of the blueberries are bought by a big company at unofficial collection points. In **Serbia**, raspberry chains are differentiated by distance and governance. The local chain consists of small farms producing and selling raspberries, while the global chain is oriented mainly at the export of frozen raspberries.

4. Results

In the following sections we present the results of our meta-analysis of the performance of local and global food supply chains. The results are structured by sustainability dimension, i.e. economic, social, and environmental impacts.

4.1. Economic dimension

In the economic dimension, the main topics that have been analysed are related to the creation and distribution of value added and the contribution to economic development.

First, local and global chains differ regarding the creation and distribution of value added which can be created either by cutting variable costs by becoming economically more efficient or by adding supplementary characteristics to a product (e.g., organic production methods, territoriality, taste) leading to a higher price. The analysed case studies support the general view that global chains primarily use the first strategy while local chains primarily use the second strategy. However, there is no general pattern regarding the amount of value added: In some cases, such as the pork supply chain, French tomatoes and Swiss wine, local chains seem to create more added value than their global counterpart. In other cases, such as the cheese supply chains and Spanish tomatoes, the global chains create more value added. Concerning the distribution of added value along the supply chain, farmers in local chains generally receive a higher share (Chiffoleau et al., 2015; Maffezzoli et al., 2015; Schmitt et al., 2015b; Grivins et al., 2015). One exception is Serbian raspberries, where localness does not imply that the supply chain is shorter and as a result, farmers in the local chain do not have more control of the value added capture (Stojanovic et al., 2014).

Second, the contribution of food supply chains to economic development might happen through increasing value added or through the generation of employment. Firms can grow without increasing employment but by using more capital (technology) thus increasing labour productivity. Moreover, how value added and jobs contribute to economic development depends on the scale of analysis: Local supply chains may contribute primarily to local economic development while global supply chains may contribute to economic development elsewhere. Generally, the trade-off between labour productivity and employment generation in local and global chains is supported by the case studies considering this topic (Annaert et al., 2015; Chiffoleau et al., 2015; Grivins et al., 2015; Maffezzoli et al., 2015; Schmitt et al., 2015b): Local chains generally use more labour per unit of land use but as a result have a lower labour productivity than global chains. The apple and tomato case studies show some exceptions: In the global Spanish apple case study, more labour is used compared to the local chain, but particularly at the retail stage. Thus, if a farmer assumes the retail stage herself and directly sells the produce to the consumer, this reduces employment elsewhere. Moreover, labour productivity is higher in the local Spanish apple chain.

In Table 3 we compare the performance of local and global supply chains that both follow a bulk product strategy. Economically, a pure shortening strategy entails farmers keeping on producing the same commodity using the same production structure. Activities carried out by other actors previously are now carried out by the farmer or the consumer. As a result, farmers will assume a higher share of the value added, but less value added—and thus less jobs—will be created. Consumers may benefit from lower prices, but at the same time governments raise less tax revenues. To the extent that some downstream activities created value (and maybe jobs) globally, this value also decreases.

Table 3: Economic dimension: comparison of local and global food supply chains following a bulk product strategy

Level	Description	Local	Global
n+2	World	Less value added and jobs elsewhere	More value added and jobs elsewhere
n+1	Country	Low food price Less tax revenues	High food price More tax revenues
n	Food supply chain	Less value added per kg Less labour employed	More value added per kg More labour employed at retail
n-1	Farms	High share of lower value added	Low share of higher value added

When farmers not only shorten supply chains but also differentiate, resulting in a different production structure relying more on local resources, effects are different. Now, more value added is created, but this value added is embedded in the product itself, i.e. a higher quality. As a result, low-priced commodities of a global bulk chain are being compared to high-priced, high-quality products of a local chain producing a differentiated product (Table 4). Using local resources may generate positive externalities and spill-overs at different scales, both privately and publicly. Private benefits at the farm level may be lower costs due to a better functioning ecosystem or higher revenues from non-agricultural activities (e.g. agri-tourism). Generally, farmers capture a higher share of the value added because of shorter supply chains compared to global bulk chains.

Moreover, the value added per kg of a product is higher in local chains. Public benefits at higher scales such as the country level may be generated through community-level ecosystem services (e.g. off-site erosion control) or the stimulation of non-agricultural activities. Because of the short supply chain, local chains following a differentiation strategy lead to less added value and job generation elsewhere.

Table 4: Economic dimension: comparison of local chains following a product differentiation strategy and global food supply chains following a bulk product strategy

Level	Description	Local	Global
n+2	World	Less added value and jobs elsewhere	More value added and jobs elsewhere
n+1	Country	High food price Non-agricultural benefits (e.g. tourism)	Low food price
n	Food supply chain	More value added per kg at farm level More labour employed	Less value added per kg at farm level Less labour employed, more capital
n-1	Farms	High share of lower value added Spill-overs to non-agricultural activities	Low share of low value added

4.2. Social dimension

In the social dimension, the topics investigated the most have been information & communication and food security.

First, supply chain performance regarding information and communication has been studied for bread (Galli et al., 2015b), cheese (Schmitt et al., 2015b) and wine (Maffezzoli et al., 2015). Information and communication encompasses two dimensions: communication within the chain and communication to the consumer. The evidence on intra-chain communication is mixed: in some cases there is more communication in local chains (cheese), in others there is no difference between local and global chains (bread). There is also no clear pattern regarding communication with the consumer. In some cases, local chains provide more information (e.g., bread in Italy, wine), in other cases, local chains provide less information (bread in the UK, cheese). Differences in performance related to information and communication depend strongly on the nature of the relationships between the various actors, including the final consumer, and the marketing efforts of global chains. Moreover, the higher the number of actors involved, the more complex are communication processes. As a result, communication may be organised through branch organisations and inter-branch platforms. Advances in ICT have the capacity to strongly improve information exchange both within chains and with the consumer.

Second, the case study teams have analysed food security issues. While food security is generally considered to capture four elements (FAO, 2002), namely food availability, food access, food utilization and food stability, the present research only considered food access, that is, affordability and availability of food. Affordability refers to consumer prices and is a direct result

of the previous discussions: global supply chains are often more economically efficient and are able to offer their produce at lower and thus more affordable prices, but in local chains there are fewer intermediaries that need to earn a profit which also influences the final price. So the effect depends on the margin captured by the farmer: local chains may charge the same price as supermarkets, such that affordability is not affected. Various case studies find evidence that support these various effects of food affordability: Global chain cheese is cheaper mainly because of labour efficiency and large production volumes (Schmitt et al., 2015b). In the case of apples and tomatoes, local chains provide the product at lower prices (Annaert et al., 2015; Chiffoleau et al., 2015). For tomatoes and apples, food availability was captured by the amount of time a product was available for the consumer. For apples, no differences were found, as storage is used in both local and global chains (Annaert et al., 2015). Tomatoes from global chains are also available in winter as a result of production in heated greenhouses (Chiffoleau et al., 2015). However, tomatoes sold through the global chain during winter are not more affordable than local tomatoes in summer.

When comparing the performance and effects of local and global food supply chains that both follow a bulk product strategy, a less clear pattern can be observed for the social dimension than for the economic dimension (Table 5). Effects are strongly dependent on the number of intermediaries, the nature of the product and the size of the chain. For the pure shortening strategy, i.e. more local and more global chains both sell bulk products, informal relations replace formal procedures resulting in different social mechanisms. This may sometimes be to the advantage of the local chain, for instance if direct contact with the consumer leads to better communication. Sometimes it may lead to the disadvantage of the local chain if for example more informal labour is employed which is less socially protected. Food prices are likely to be lower in the local bulk chain, as there are no intermediaries that take a profit margin, thus potentially enhancing food security. This effect however depends on the access of poor consumers to local chains.

Table 5: Social dimension: comparison of local and global food supply chains following a bulk product strategy

Level	Description	Local	Global
n+2	World	na	na
n+1	Country	Lower food price	Higher food price
n	Food supply chain	No contracts more likely Trust-based compliance Direct communication to consumer	Official contracts More legal compliance Mediated communication to consumer
n-1	Farms	Labour conditions more risky	Better labour conditions more likely

na: not available

When local supply chains sell differentiated products, communication becomes more important. In Table 6 we compare local chains producing a differentiated product to global bulk chains. As in local bulk product chains there is more direct communication and trust-based compliance in the local chain versus mediated communication and legal compliance in the global chain. However, this strongly depends on the differentiation strategy. Product differentiation often involves labelling, also for the local chain, which formalises compliance procedures. In addition, reputation

becomes more important, such that the likelihood of bad labour conditions decreases. In fact, labour conditions may become more resilient in local chains as exemplified in the Dutch pork case (Oostindie et al., 2015). Regarding consumer prices, a differentiated product is per definition more expensive than a bulk product. But as consumers have the choice between local and global chains, food security will not be affected at higher levels of analysis.

Table 6: Social dimension: comparison of local chains following a product differentiation strategy and global food supply chains following a bulk product strategy

Level	Description	Local	Global
n+2	World	na	na
n+1	Country	High food price	Low food price
n	Food supply chain	No contracts more likely Trust-based compliance Direct communication	Official contracts More legal compliance Labels
n-1	Farms	Labour conditions more likely to be resilient	Better labour conditions

na: not available

4.3. Environmental dimension

In the environmental dimension, the topics investigated the most are biodiversity, resource use and pollution.

First, biodiversity has been captured in the case studies by various indicators ranging from the diversity of crops and varieties to landscape management practices. For three teams (wine, bread and tomatoes) local or regional supply chains perform better than their global counterparts, although for French wine there is a difference in biodiversity between global bottle-based chains (more diversity) and global bulk chains (less diversity). For the cheese and apple teams, there are no differences between local and global or differences are small.

Second, resource use and pollution are captured in the case studies by energy use and greenhouse gas emissions (which are strongly related to energy use). A similar pattern is observed as with the employment-efficiency trade-off: global chains tend to consume fewer resources per unit of product than local chains, what could be called ecologies of scale. In other words, global chains employ more resource efficient transformation, transportation and cooling facilities resulting in less greenhouse gas emissions per unit of product. This was observed in the cases of apples and tomatoes (Annaert et al., 2015; Chiffoleau et al., 2015), while results were mixed for wine, as they depended on the technologies used for bottling and transportation (Maffezzoli et al., 2015). In the wine case studies, water and material use and also the use of environmental mitigation measures have been considered, while the cheese cases considered soil improvement practices, material use and waste reduction and disposal. No significant differences between local and global chains were found expect for soil improvement practices that were used more by local chains. However, this is to a great extent related to soil type and slope. For the pork cases differences in resource use and pollution between local and global chains can be observed, mostly in favour of the local chains (de Roest et al., 2015). In the Netherlands, local chains are more resource efficient when considering the use of water, fossil energy and land, and their contribution to euthrophication potential and greenhouse gas emissions are lower than in global

chains. In Italy, the same pattern can be observed for water use, but not for energy and land use, as global chains use less energy and land and emit less greenhouse gases.

In Table 7 we compare the environmental performance of local and global bulk food supply chains. Environmentally, a pure shortening strategy without product differentiation entails farmers keeping on producing the same commodity using the same production structure, but often at a smaller scale. Activities carried out by other actors (e.g., packaging, cooling, transportation) previously are now carried out by the farmer or the consumer herself. As a result, the higher amount of resources and energy consumed per unit of product in the local chain due to the transportation of lower volumes of food is likely to compensate any saving in 'food miles' (if at all). Differences in on-farm biodiversity and pollution are not likely as in local and global bulk product chains there is no real difference in production method. In the long run, local chains may have an incentive to invest in good practices, due to their direct relationship with the consumer, while global chains tend to comply with minimum standards imposed by retailers or the state.

Table 7: Environmental dimension: comparison of local and global food supply chains following a bulk product strategy

Level	Description	Local	Global
n+2	World	na	na
n+1	Country	More external resources could be depleted per product	Less external resources could be depleted per product
n	Food supply chain	Low resource efficiency	High resource efficiency
n-1	Farms	More likely to invest in good practices	Compliance to standards

na: not available

When local chains also adopt a differentiation strategy, taking care of the environment is likely to be part of the differentiation activities. As a result, local chains are likely to result in more biodiversity, less pollution and less depletion of external resources at different scales, when compared to global bulk chains (Table 8). However, these results are offset when analysing impacts per unit of product, as generally yields are lower, such that more land needs to be used to produce the same amount of produce. This land may be used elsewhere, leading to a higher depletion of external resources globally.[2] Like in the economic dimension, these differences will disappear when global chains also start applying differentiation strategies.

[2] Of course, the relative size of the effect may be very different: the local effect may be significant at local level, while the global effect may be diluted at the global level.

Table 8: Environmental dimension: comparison of local chains following a product differentiation strategy and global food supply chains following a bulk product strategy

Level	Description	Local	Global
n+2	World	More external resources depleted	Less external resources depleted
n+1	Country	Less external resources depleted More land needed	More external resources depleted Less land needed
n	Food supply chain	High external resource efficiency Low external inputs Higher biodiversity	Low external resource efficiency High external inputs Lower biodiversity
n-1	Farms	Low throughput, less environmental stress	High throughput, more environmental stress

4.4. Trade-offs

Cutting across the comparison of local and global cases, trade-offs between different impacts arise. These trade-offs may be related to a local versus global approach, but this is not necessarily so. The identification of trade-offs in the analysed case studies was not easy due to the static nature of the analyses: generally, trade-offs only come to the surface when an actor tries to change one or more parameters. As a result, trade-offs were identified based on the comparison between local and global chains, on an implicit basis. Trade-offs have been found both within sustainability dimensions and between dimensions.

First, there is a trade-off between labour productivity and job creation. Higher labour productivity generally leads to lower costs and food prices (leading to better food security) and better labour conditions (lower workload due to mechanisation and automation), but as a result less jobs are created. Local chains tend to employ more people at the farm level, often at the expense of employment downstream, but often these farm jobs involve more hard work, although job satisfaction is likely to be higher than in global chains.

Second, there is a trade-off between efficiency and diversity. This is best seen when looking at agrobiodiversity, that is, the amount of different varieties used on a farm. Generally, this has better effects on the resilience of the chain and likely also on biodiversity in general, but at the expense of yield efficiency and thus costs and prices.

Third, there is a trade-off between price and quality. Higher chain productivity leads to lower prices, but possibly less attention to product quality. Products may be available year-round and out of season at affordable prices, but with lower nutritional quality. However, one should be cautious to generalise any differences between local and global chains, as this trade-off depends on what quality attributes are being considered. For instance, nutritional quality (e.g., salt and fat content) may be better controlled in global chains.

Fourth, there is a trade-off between biodiversity, pollution and resource use. Large-scale operations may save resources and particularly energy and land per unit of product, but at the

expense of a high pressure on the land being used, leading to higher pollution and less biodiversity per unit of land.

Fifth, there is a trade-off between informal trust-based approaches versus formal procedures. Informality may lead to more flexibility in labour relations and in relations vis-à-vis the consumer and even resilience, but may also result in less transparency and even misuse through a lack of compliance with legal procedures.

5. Discussion and conclusions

In this article, we have synthesised the findings of the comparison of local and global food supply chains concerning their economic, social and environmental impact for seven products or product groups: apples, berries, bread, cheese, pork, tomatoes and wine. Regarding economic impacts, farmers in local chains have been found to generally receive a larger share of value added compared to farmers being involved in global chains. Moreover, local chains generally use more labour per unit of land use but as a result have a lower labour productivity than global chains. Regarding social impacts the evidence is mixed. There is no clear pattern regarding communication and information and food security implications of local versus global food supply chains. Regarding environmental impacts, local food supply chains largely outperform their global counterparts. However, it is very difficult to generalise these patterns, as the comparison of local and global food supply chains is not straightforward, mainly due three reasons. First, local and global are no clear-cut categories and difficult to define and categorise, as local chains have many global elements and vice-versa, giving rise to many hybrid situations such as for example the regional bread supply chains and mixed pork and tomato chains. Recently, Smith Taillie and Jaacks (2015) point to the false dichotomy between localism and supercenterism (i.e., global supply chains) as for example supermarkets account for an increasingly large share of local product sales in the US (Martinez et al. 2010). This relates to our second point: food supply chain strategies influence performance evaluation. For instance, when global chains apply product differentiation strategies, effects between local and global may even be opposite. Third, trade-offs within and across the various sustainability dimensions apply, such that no superior strategy that scores well on all dimensions can be identified. In addition, trade-offs also occur across different scales. The final valuation of these impacts depends strongly on the target person such as supply chain actors, consumers and their preferences. Fourth, difficulties related to measuring performance indicators consistently make an evidence-based approach very difficult. Earlier, Edwards-Jones et al. (2008) concluded that natural-science approaches looking primarily at technical and environmental issues should be supplemented with social-science approaches for a holistic assessment of local and global chains. However, our analysis has shown that the implications of this conclusion are more far-reaching than the former authors may have envisaged. A holistic evaluation implies that a multi-method approach should be used when evaluation sustainability performance and that participatory approaches and context-specific information are key to correctly interpreting results. The case studies that have been analysed have followed such an approach and the individual studies provide a much more holistic approach than the synthesis in this report that has tried to carry out a meta-analysis.

Nonetheless, one of the reasons for not finding clear-cut evidence of local versus global performance might stem from the application of different methodologies across case studies (Schwarz and Mathijs, 2015) and the definition of performance indicators. Especially the participatory evaluation method which has mostly been applied for food supply chain evaluation

is very open and flexible. This is of advantage for analysing different supply chain configurations, different sustainability aspects, and integrating different views but the approach is highly context dependent and each food chain assessment needs to include a 'thick' context description in order to put the research results into a broader framework. Analysis of environmental impacts has often been carried out by LCA. While in the comparative reports similar sets of indicators have been compared, there might be differences across product groups. For instance, biodiversity has been measured as the average frequency or presence of species conservation practices in the wine case studies (Schmitt et al., 2015b). For tomatoes, biodiversity has been measured as the number of different crops per hectare on the farm (Chiffoleau et al., 2015). Obviously, such differences in indicators may lead to different results when comparing supply chain performance. Although this might pose a limitation to the cross-country comparison of results, it also shows that the results of a local-global comparison strongly depend on indicator definition and choice of methodology. In addition, the involvement of different supply chain actors with different interests and values also indicates different perspectives on sustainability performance. This would call for an approach that is not only multi-method and multi-scale, but also multi-criteria, allowing for applying different weights to different sustainability dimensions or characteristics.

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