



World Sustainability Forum 2014 – Conference Proceedings Paper

Sustainability Performance of Local vs Global Food Supply Chains: a Comparative Assessment for Bread in Italy

Francesca Galli^{1,*}, Fabio Bartolini¹, Gianluca Brunori¹, Oriana Gava¹, Andrea Marescotti²

¹ Department of Agriculture, Food and Environment, University of Pisa, Via del Borghetto, 80, 56124, Pisa, Italy

² Department of Economics and Management, Via delle Pandette, 9, 50123, Firenze, Italy

E-Mails: francesca.galli@for.unipi.it (F. G.); fabio.bartolini@unipi.it (F. B.); gianluca.brunori@unipi.it (G. B.); oriana.gava@for.unipi.it (O. G.); andrea.marescotti@unifi.it (A. M.);

* Author to whom correspondence should be addressed; Tel.: +39-339-648-0259; (francesca.galli@for.unipi.it)

Received: 2 September 2014 / Accepted: 21 October 2014 / Published: 1 November 2014

Abstract: There is an increasing interest in the potential of local foods and short food supply chains to overcome the unsustainable practices of global/industrial food supply chains. The opposition between local and global food systems is being questioned together with the actual sustainability performance of food chains. The assessment of the sustainability of food chains is challenged by the multiple dimensions to be considered, the diversity of actors involved, and the lack of a shared methodology. This paper presents a preliminary result of the EU research project Glamur (Global and Local Food Assessment: a multidimensional performance based approach) and develops a comparative assessment among three wheat-to-bread chains in Italy in relation to their degree of localness and different dimensions of sustainability. We develop a comparative assessment on two critical attributes of sustainability: nutritional value of bread and biodiversity preservation. The assessment is based on a set of indicators selected within a DPSIR framework. This allows to shed light on synergies and tradeoffs between local and global chains and potential paths for sustainability improvement.

Keywords: sustainability assessment, supply chain, local, global, bread, biodiversity, nutrition

1. Introduction

Local food supply chains are increasingly being considered by policy and decision makers in government, industry and civil society organizations, for their potential to overcoming the drawbacks of global and more industrialized chains (e.g. Forssell and Lankoski, 2014; Maye and Ilbery 2006; Selfa and Qazi 2005, O'Hara and Stagl 2001). Local food chains are varied in nature and practice and exist all over the world in a wide variety in both commercial and non-commercial settings, showing a different degree of complexity, ranging from informal agreements up to more structured organizational forms (e.g. Renting et al. 2003, Ilbery and Maye 2005; Galli and Brunori, 2013). The opposition between local and global food systems is being questioned as not always clear and unambiguous (Hand and Martinez, 2010; Durham et al. 2009). This adds to a lack of a shared and comprehensive assessment on the actual sustainability of food chains, due to different sets of challenges: first, a shared definition of local and global supply chains, second the need for suitable indicators and data for the assessment, and third the lack of a common and robust methodology.

As part of the EU research project Glamur¹ - currently challenged with shedding light on the assessment of food supply chains sustainability performance - this contribution has the objective of exploring the connections between sustainability performance and the localness or globalness of wheat-to-bread supply chains. To this end, we develop a comparative assessment on three bread supply chains of different “lengths” across two critical dimensions of sustainability: nutritional value of final products and biodiversity preservation. The assessment is based on a set of indicators framed within the DPSIR model and derived from expert interviews and literature analysis. We will identify the critical steps of the chains where sustainability performance differs across the three chains and discuss synergies and tradeoffs between local and global chains and potential paths for sustainability improvement.

The next paragraph draws from and expands a literature analysis on biodiversity and nutrition in relation to the wheat-to-bread chain. Paragraph 3 presents the adopted methodology. Results and discussion are presented in paragraphs 4.1 and 4.2, respectively addressing the DPSIR framework applied to the bread chain and the assessment of the three cases selected based on indicators previously identified. Conclusions follow.

2. State of the Art: Key Sustainability Attributes for the Wheat to Bread Chain

The assessment of the bread supply chain's sustainability impacts has a relevant role within the literature on sustainability performance of food supply chains (Gava et al., 2014) due to the fact that the wheat-to-bread supply chain covers a variety of local/global contrasts. Wheat is a standardized commodity, traded on the global market and forms an ingredient which requires a double processing to be turned into bread, pasta or confectionery. The use of locally sourced wheat as opposed to imports from distant producers poses challenges and opportunities in reconnecting staple crop producers, commercial bakers and consumers (Hills et al. 2013). Large scale, industrial milling and baking processes have different implications in comparison to local, artisanal bread making in environmental

¹ Global and Local food chain Assessment: a Multidimensional performance-based approach (GLAMUR, 7th Framework Program, grant agreement no: 311778).

terms (Andersson and Ohlsson, 1999) and technology adopted (Mondal e Datta, 2008). Bread is a staple food within almost any diet across the world that can be either highly standardized or highly diversified, even within the same country, according to context and habits. In both cases, affordability and food security issues interact with nutritional quality and healthy diet demands (Capacci et al. 2012). In the last two decades the gap between staple crop producers, processors and consumers is gradually bridging across the EU. Such trend is confirmed by the emergence of Protected Designations of Origin (PDO) and Protected Geographical Designations (PGI) for bread as well as the proliferation of spontaneous initiatives promoting local milling and baking, traditional wheat varieties, local wheat supply.

Systematic literature reviews on the wheat-to-bread chain (Galli et al., 2014; Gava et al. 2014) link sustainability assessment to the different stages of the supply chain and to a set of attributes across different dimensions of sustainability (i.e. economic, social, environmental, health and ethic). Attributes of sustainability are defined as features inherent to the five sustainability dimensions (see Kirwan et al, 2014 for further details on attribute definition and selection). Galli et al. 2014 identify a set of sustainability issues which discriminate among bread chains of different lengths. Results highlight that among other critical issues, nutritional value and preservation of biodiversity play a key role for the sustainability definition of several steps of the supply chain. Thus the assessment of sustainability performance of local and global bread supply chains should be developed considering these two attributes. Furthermore, biodiversity and nutritional value of bread have relevant implications on other sustainability attributes, such as efficiency, technological innovation, resource use and environmental impact, territoriality depending on the discourse referred to (Kirwan et al. 2014, p.78).

2.1 Biodiversity and the wheat-to-bread chain

The sustainability attribute “Biodiversity” refers to the ability of food supply chains to preserve genetic, species or ecosystem variation within an area, or a stock of natural resources (Kirwan et al., 2014, p. 77) which entails the effects that a food supply chain has on the survival of different animal and vegetal species within a certain spatial environment surrounding the areas where the productive process takes place. As opposed to wild biodiversity - focused on the animals and vegetal species that are not directly used in the process - domestic biodiversity concerns the traditional animal and vegetal varieties used, at the end of the chain, as food for human beings, or differently utilized in the process. The preservation of domestic biodiversity is often linked with the local dimension of the chain: local food chains are considered as situations where food diversity can be better granted, preserved, valued and improved (Kirwan et al., 2014, p. 77). Global chains are considered in some cases as the areas where local varieties can find a market that gives economic sustainability to the food chain. Nevertheless, global chains are often thought to force standardization of varieties and productions, hence leading to the extinction of local less productive varieties, and to biodiversity reduction. On the opposite, and with a different approach, the global character is seen in the possibility to have access to external technology to improve the quality of the species, with beneficial effects in ecological, economic and health terms (Colombo and Grando, 2014).

For the purpose of the present paper, “biodiversity” refers to the genetic variability of plants and the conservation of genetic resources. Soft wheat (*Triticum aestivum* L.) with an overall annual

production of about 714 million tons (FAOSTAT, 2013) is one of the most important crops in the world. The Italian and European wheat production has strongly developed during the last century due to the introduction of mechanization and the use of new cultivation technologies and the intense genetic improvement activity (widely implemented in Italy). Over time, and particularly in the last century, bread has undergone profound changes due to the genetic improvement of wheat and the developments of milling and baking technologies. Grains are the most widely cultivated agricultural products (half the world suitable land area is devoted to their cultivation) due to high adaptability to different environments, easy storability and transportability, beyond high yields and richness in carbohydrates.

The modern cultivars of soft wheat are the result of a selection process implemented by farmers who carried out a form of “unscientific” plant breeding. The first cultivated wheat species were mainly local breeds (i.e. landraces) selected by the farmers themselves, probably because of higher yields and other characteristics. This process of “domestication” of wheat (i.e. the process of genetic selection, which changes features of wheat, by turning wild varieties into domesticated ones) has originated the current crop species. The intensive breeding programs conducted after World War II, led to the complete replacement of traditional breeds with new cultivars with reduced height (semi-dwarf), high yields, high protein content (i.e. gluten, which is a determinant for the baking process), and to be grown in very different environments, although modified with agronomic interventions (i.e. technological and chemical inputs). Modern varieties are “pure” in the sense that all plants of the same variety are equal, with a consequent decrease of the genetic variability (internal to each wheat variety) of wheat, which influences in turn the future adaptability, and the evolution of this crop. In practice, domestication of wheat, if one hand has improved the yields and the agronomic characteristics (Benedettelli, 2013; Calderini et al. 1995), on the other hand, has caused a narrowing of the genetic base of the *Triticum* genus (genetic erosion) (Bonnin et al. 2014, Bonneuil et al. 2012). This erosion has been further increased by the modern systems of breeding resulting in a higher vulnerability to environmental stress, pests and diseases (Nevo 2011). Modern varieties have reversed the relationship environment-plant: it is no longer the plant that fits the environment, but it is the environment that must be adapted to the plant, through the different agronomic interventions (Benedettelli, 2013).

Traditional and ancient varieties have been appreciated for their characteristics of high adaptability to pedo- climatic conditions, of relative tolerance to fungal diseases, no need for added nutrients (the longer roots allow them for a higher absorption from soil), suitability to compete with weeds for their tall size. These features have proved to be effective in organic and biodynamic farming systems, or low input agriculture (Dawson et al., 2012). Because of the lack of varieties for organic agriculture, associations of organic farmers in several European countries have begun cultivating landraces and historic varieties, effectively practicing *in situ* conservation of agricultural biodiversity (Chable et al. 2014; Malandrin and Dvortsin, 2013). Moreover, it has been tested that increasing crop genetic diversity in bread wheat (*Triticum aestivum*) fields brings benefits to farmland biodiversity (Chateil et al. 2013).

Ancient varieties are also relevant in relation to the re-discovery and production of traditional types of breads, linked to the historic place production according to social and cultural traditions (Gallo et al., 2009). These emerging experiences are currently of interest for the realization of short chains that include the recovery, protection, cultivation and processing *in situ* of historic varieties linked to the territory and the environment. Such breads are often produced with natural leavening and

characterized by higher nutritional profile and quality. In recent years, the genetic improvement in bread wheat takes into account qualitative aspects and nutritional value of crops and is focused on the development of improved varieties in terms of content in bioactive substances essential to provide nutritional benefits to the consumer (www.healthgrain.org). Innovation pathways aim at increasing the content of these components in wheat although the selection of these elements is particularly difficult due to the interaction between genotype and cultivation environment. Di Silvestro et al. (2012) comparatively evaluate the agronomic performance and the nutrient and phytochemical composition of old and modern Italian wheat genotypes grown under low-input management. Results highlight that, under low-input conditions, ancient genotypes may equal modern ones in terms of agronomic traits and additionally provide nutraceutical value-added wheat grains.

2.2 Nutritional value of bread

Nutritional value of bread is a central feature of the sustainability performance of the wheat to bread chain. Our state of art is largely based on a review of Dewettinck et al. (2008) and Goesaert et al (2005). According to the Oxford dictionary, bread is “*food made of flour, water, and yeast or another leavening agent, mixed together and baked*”. In the Italian legislation, bread is defined as “*the product obtained by the partial or total cooking of a dough raised and prepared with wheat flour, water and yeast, with or without the addition of common salt (sodium chloride)*” (Law 4 July 1967, n. 580). During all steps of breadmaking, complex chemical, biochemical and physical transformations occur, which affect and are affected by the various flour constituents. In addition, many substances are nowadays used to influence the structural and physicochemical characteristics of the flour constituents in order to optimise their functionality in breadmaking (Dewettinck et al. 2008). Nutrition value of bread is affected by three dimensions a) nutritive value of component cereals; b) processing and storage of wheat, flour and bread; c) conservation.

Concerning the first aspect, soft wheat is the most important cereal for breadmaking, mainly due to its better baking performance in comparison with other cereals. However, other cereals may add nutrition value and for this reason they can be added to soft wheat in the bread formula. Nutrient composition of bread cereals is 50-80% carbohydrate, proteins (8-12%), lipids (1,5-7.0%) and micronutrients. Carbohydrates can be classified into two categories: available and unavailable. Available carbohydrates are digested and absorbed by humans, and include starch and soluble sugars. Unavailable carbohydrates, also called dietary fibre, are not digested, but its mechanical action is very important for good health. Cereal proteins, mainly composed of gliadins and gluten proteins, have a lower nutritional value than in other foods, as lack of essential amino acids, particularly lysine and threonine. Rye and barley have a higher content of high nutrient proteins than wheat. Lipids are composed of essential fatty acid, mainly palmitic and linoleic acids. Phospholipids and glyco- or galactolipids are contained into the cell membranes. Bread lipids are important as they contain important micronutrients. Cereals contain several micronutrients, such as B vitamins, biotin, folic acid. Pantothenic acid and vitamine C are not present in significant amounts. As fats are a minor component of cereals, fat-soluble vitamins A, D, E, K are minor constituents. Cereals are rich in phosphorus, calcium, magnesium, potassium, zinc and copper, while the level of sodium – before processing – is relatively low. Among minerals there are also Phytic Acids, which are considered an antinutritional

factor. Also phytoestrogens are contained into cereals. Table 1 provides a synthesis of the effects of these components on nutrition.

Table 1 - Synthesis of the effects of bread nutrients on health.

	Positive effects	Negative effects	Differences
Starch and soluble sugars	Sources of energy	Glycaemic response	White bread has a higher Glycaemic Index, whole grain lower
Dietary fibre	Increases faecal weight, bulk and softness, increases the frequency of defecation and reduces the intestinal transit times		
Proteins	Contribution to protein needs		
Lipids	Reduction of cholesterol absorption and improving the lower digestive tract environment		
Micronutrients	Vitamins, phosphorus, zinc, magnesium	Potassium sodium, Phytic acid	Bran has a higher content of phytic acid

Source: author's elaboration based on Dewettinck et al. 2008.

For what concerns storage and processing, these phases may decrease or increase the levels of the bioactive compounds in grains and also modify bioavailability of these compounds (Slavin et al., 2001). Processing steps of interest are milling and bread-making. In addition, storage can also alter the bioavailability of nutrients in cereals or cereal products. Storage of flour can reduce vitamins to a large extent. After baking, the process of staling starts, consisting in a process of retrogradation of starch.

To be turned into bread, cereals have to be first transformed into flour through the milling process, that separates the different components of grains. Nutrients are distributed unevenly among grain components: the endosperm is rich in starch, bran is rich in dietary fibre and proteins, the germ is a rich source of oil tocopherols, sugars, protein and B vitamins. Thus nutritional value of the flour depends on the extraction rate from the grain, beyond temperature of the milling process.

To increase the palatability and breadmaking quality of bread, a part of the components is taken out. White flour corresponds to an extraction rate of 75% or less, as all the bran and germ are removed. (van der Kamp et al, 2014) This means that nutritional value of white bread (bread made of white flour) is lower than bread made with whole meal flour bread.

The breadmaking process consists of three stages: mixing, fermentation and baking. During baking, starch undergoes a process of gelatinisation, which creates a fraction of resistant starch, not digestible. During the three stages, depending on the conditions of the process (pH, temperature, time of heating), there is a loss of vitamins. Nutritional value can change consistently whether yeast or sourdough are used. The difference between yeast and sourdough is microbial composition, as yeast is composed only of saccharomycetes and sourdough is also composed of lactobacillus. "Sourdough fermentation can influence the nutritional quality by decreasing or increasing levels of compounds, and enhancing or retarding the bioavailability of nutrients" (Poutanen et al., 2009; Katina et al. 2005).

Consumer perception of bread and flour nutritional value is a strictly related issue explored by literature (Dewettinck et al., 2008; Hellyer et al. , 2012; Mialon et al., 2002; Annett et al., 2008). Main results show that consumer quality perception of bread is mainly determined by sensory and health

attributes and that the healthy perception about nutrition could be influenced by written information. However, in these papers participants did not purchase the products being examined. Mancino et al. (2008) provide a different set of insights by examining why consumers increased their consumption of whole grains in the US after the publication of the 2005 Dietary Guidelines. The insight they provide draws on Ippolito and Mathios (1990), in that it is suggested that public policy lead to food manufacturers introducing new and differentiated products that consumers readily adopted. However, Golan and Unnevehr (2008) note that competition between food manufacturers in terms of health attributes need not result in healthier food products entering the market place.

Health and nutrition claims play a key role in the information asymmetry between producers and consumers (Stranieri et al. 2010). EU Directive 90/496 identifies two types of label information: ‘nutrition labeling’ (energy value, protein, carbohydrate, fat and fibre content) and ‘nutrition claims’ extolling particular nutrition properties. Regulations on nutrition information are different between countries. The US National Labeling and Education Act (1994) made nutrition labeling mandatory for almost all packaged food products, providing specific standards for the appearance of such labeling (Nayga, 1996; Golan et al., 2000). In the EU, both nutrition labeling and nutrition claims are still voluntary, but, according to Directive 90/496, if a nutrition claim appears on a label or in advertising, nutrition labeling becomes compulsory, albeit with a certain degree of freedom about the labeling. However, Regulation 1924/2006 introduced a mandatory scheme for using nutrition and health claims for food products, requiring specific standardized claims in line with the nutrition properties. The annex of Regulation 1924/2006 provides both a list of permitted nutrition claims and the relative conditions to be followed in order to use these cues. The 24 claims identified by the regulation can be grouped into the following nine categories (see Table 2). Consumers’ reaction to health claims depend on the type of product and on characteristic of consumers (Wills et al., 2012)

Table 2 - Nutrition claim permitted by Regulation 1924/2006

Nutrition Claim	Specification
Energy	Low energy, energy reduced, energy free
Fat	Low fat, fat free, low saturated fat, saturated fat free
Sugar	Low sugar, sugar free, with no added sugar
Sodium	Low sodium/salt, very low sodium/salt, sodium/salt free
Fibre	Source of fibre , high fibre
Protein	Source of protein, high protein
Vitamin	source of vitamins and/or minerals, high vitamins and/or minerals
Nutrient	contains nutrients or other substances, increased nutrients, reduced nutrients
light and naturally/natural.	N/A

Source: Regulation 1924/2006

Dewettinck et al (2008) identify the following trends in bread industry: fresh-baked and artisan products are still very popular but mass-produced specialty breads are strong competitors. Frozen dough and part-baked allow to sell fresh bakery all day (Inoue and Bushuk, 1992). Breads containing whole grain, multi-grain or other functional ingredients are becoming more important (see also Van

der Kamp et al., 2014; Sumanac et al., 2013). On this regard, the emerge of life stage nutrition (i.e. products formulated to reflect the nutritional requirements of particular consumer subsets, e.g. children or women) is expected to be the path of various initiatives and innovations, also for bakery products (Dewettinck et al, 2008; Young, 2001).

Also the production of dietetic breads of which gluten-free and sodium-reduced bread are the most important. Gluten-free breads have been produced to satisfy the requirements of those affected by gluten intolerance.

Bread is considered to be one of the most important sources of dietary salt. Reduced sodium breads have been developed to help maintain a healthy heart and circulation (Young, 2001). In fact excessive salt presence is related to blood pressure and cardiovascular diseases and, among other countries, Italy has been found to exceed reference values, thus should consider a salt-intake reduction program, especially in bread due to its high per capita consumption (Quilez and Salas-Salvado, 2012).

Another recent trend is related to sourdough leavening. Use of sourdough is of expanding interest for improvement of flavour, structure and stability of baked goods. Cereal fermentations also show significant potential in improvement and design of the nutritional quality and health effects of foods and ingredients. In addition to improving the sensory quality of whole grain, fibre-rich or gluten-free products, sourdough can also actively retard starch digestibility leading to low glycemic responses, modulate levels and bioaccessibility of bioactive compounds, and improve mineral bioavailability. Cereal fermentation may produce non-digestible polysaccharides, or modify accessibility of the grain fibre complex to gut microbiota. It has also been suggested that degradation of gluten may render bread better suitable for celiac persons (Poutanen et al., 2009; Moroni et al. 2010).

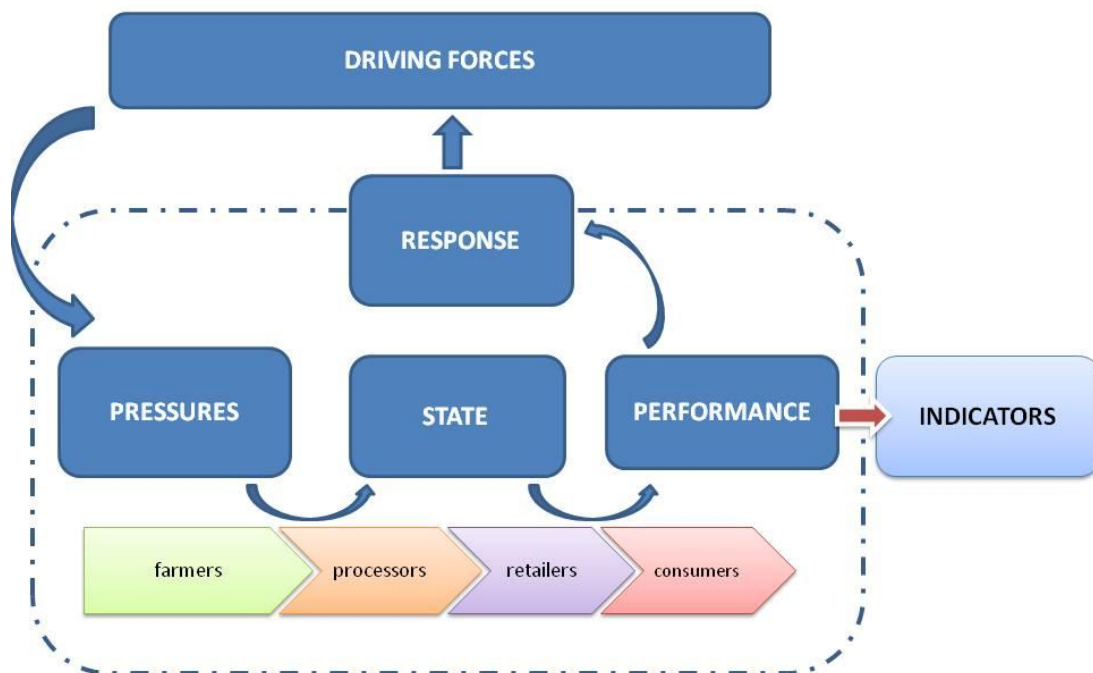
3. Methods

Based on the state of the art on wheat-to-bread chain sustainability performance we develop a comparative analysis on two attributes: biodiversity and nutritional value of bread. To this end, the applied methodology can be defined in two steps: 1) the definition of a DPSIR framework which allows to systematize interrelated issues that explain the performance of the bread supply chain; 2) the implementation of the framework to three bread supply chains, in Italy, of which we present a qualitative comparative assessment.

To promote a common understanding of sustainability problem by experts, stakeholders and decision makers, it is essential to understand the system characteristics, including the complex feedbacks between drivers and impacts. The DPSIR (Driving forces, Pressure, State, Impact, Response) widely used by the European Environment Agency (EEA) and for sustainability assessment (Smeets and Weterings, 1999; Ness et al. 2010), describes the effects of driving forces on the consequences in terms of sustainability performance focusing on the links between DPSIR elements. The conceptual framework allows to identify causal relationships of the sustainability performance and to clarify the steps in the causal chain thus indicating potential ways for policy action. The DPSIR represents a systems analysis view: social and economic developments exert pressure on the environment and, as a consequence, the state of the environment changes. This leads to impacts on e.g. human health, ecosystems and materials that may elicit a societal response that feeds back on the driving forces, on the pressures or on the state or impacts directly, through adaptation or curative

action. We adapt the DPSIR components (as visualized in Figure 1) to the steps of a generic bread supply chain (i.e. input production, agricultural phase, milling, baking, distribution). Thus, given a set of common Drivers (political, social, economic, technological, affecting both local and global value chains; e.g. differential in wages), we identify Pressures (how local and global value chains are managed, which are the actors' practices affecting the attribute, e.g. degree of delocalization) and States relative to each step of the supply chain. These in turn have an Impact on nutrition and biodiversity (on which we focus in the present work). Such Impact is captured by a set of Performance indicators, selected based on literature analysis and expert judgement elicited during in-depth interviews (see Paragraph 4.1 and the list of experts interviewed available in the Annex). Following a set of responses is identified, which in turn will feed back on Driving forces.

Figure 1 – DPSIR Framework



The second step entails the identification of three Italian wheat to bread supply chains of different lengths and comparative assessment based on the previously selected indicators. Concerning the second step (i.e. selection of the supply chains for the assessment), the distinction between local and global supply chains is articulated around four aspects: i) physical/geographical distance among the steps of the supply chains; ii) governance and organization issues, in particular the distribution of power among local and global actors; iii) the resources, knowledge and technologies employed in the production process; iv) the role of territory in shaping the identity of the product. In the real world, local and global often overlap, because the same firm can operate both in local and global chains, or because some characteristics of the production/marketing process have local and global features at the same time. Based on these four dimensions we have identified and analyzed three bread supply chains in Italy - a local, a regional and a global bread chain - in order to explore the relevant sustainability attributes according to their length

4. Results

4.1 Biodiversity and Nutritional Value framed within the DPSIR

The core of the following table are the supply chains' performance on biodiversity and nutrition. The columns indicate, from left to right, the drivers, common to all steps of the bread chain, which determine pressures and states specific to each step of the supply chain. The impact on biodiversity and nutrition, which is captured by a set of indicators of performance, generates responses which in turn feed back on drivers.

Table 3 – DPSIR framework adapted to the wheat-to-bread supply chain in relation to Nutrition and Biodiversity

DRIVERS	Supply chain stage	PRESSURE	STATE	IMPACT	Indicators*	RESPONSE
<p>Consumption</p> <p>Increased population</p> <p>Changing consumption habits</p> <p>Health and safe food</p> <p>Industry</p> <p>Industrialization of production processes</p> <p>Globalization and international trade</p> <p>Agriculture</p> <p>Changes in production processes and Input use</p> <p>Society</p> <p>Environmental sustainability</p> <p>Social/Ethical sustainability</p>	Input production	<p>Increased food demand</p> <p>Development of wheat varieties with higher yields</p> <p>Market concentration in input industry</p> <p>Patenting and certification of seeds</p>	Decreased genetic variability of soft wheat	Biodiversity and Nutritional value of cereals	<p>Varietal diversity :</p> <p>Number of varieties registered in genebanks, Share of top cultivars in total area (OECD 2001),</p> <p>Varietal diversity indexes:</p> <p>- SW (Shannon) (Martynov et al. 2006, Brennan et Bialowas 2001)</p> <p>- Es (Simpson)</p> <p>- J (Pielou) (Meul et al. 2005)</p> <p>Allelic diversity:</p> <p>H (Nei index) Khlestkina et al. 2004, Bonneuil, 2012, Roussel et al. 2004 and 2005; Huang et al., 2007)</p>	Recovery of ancient landraces for genetic improvement
	Farmers	Intensification of farming practices	Monoculture and standardized farming practices			<p>Saving seeds and breeds and exchange practices among farmers</p> <p>Search for ancient wheat varieties with higher yields</p> <p>Payment for provision of ecosystems services by agriculture (CAP)</p>

Millers	<p>Need for longer storability of flour</p> <p>Need to protect from microbial risks</p> <p>Need to move grain and flour among continents</p>	<p>Long storability (years)</p> <p>Faster milling process</p> <p>Highly processed flour (00, 0 types)</p>	Biodiversity and nutritional value of flour	<p>Flour milled per hour</p> <p>Extraction rate</p> <p>Presence of kernel in the flour</p> <p>Presence of ancient wheat varieties in flour (Di Silvestro et al. 2012)</p> <p>Wholegrain, multigrain (Van der Kamp et al. 2014)</p>	<p>Fortification of flour</p> <p>Fibres addition to white flours to obtain whole-meal,</p> <p>Recovery of traditional milling practices and/or advanced technologies (i.e. slower milling, stone milling)</p>
Bakers	<p>Need for a very elastic and resistant dough</p> <p>Speeding up the baking process</p>	<p>Use of flour mix with high gluten levels</p> <p>Addition of wheat gluten to dough</p> <p>Use of sourdough leavening</p> <p>Continuous baking process</p> <p>Addition of starters to speed up leavening</p>	Nutritional value of bread	<p>Nutritional value of cereals: carbohydrates, protein, lipids and micronutrient (Dewettink et al., 2008, Goesaert et al., 2005)</p> <p>Discontinuous vs. discontinuous baking process</p> <p>Use of Sourdough (Poutanen et al, 2009; Katina et al. 2005)</p> <p>Addition of gluten to improve flour strength</p> <p>Addition of starters to speed up leavening</p> <p>Addition of functional ingredients</p> <p>Salt level (Quilez and Salas-Salvado, 2012)</p> <p>Use of preservatives</p>	<p>Re-introduction of sourdough leavening</p> <p>Innovations in sourdough technologies to scale up and standardize</p> <p>Improved nutritional value of bread (functional ingredients)</p> <p>Use of health claims</p>
Retailers	<p>Search for longer shelf life</p> <p>Consumer demand for fresh bakery</p> <p>Downward pressure on prices</p>	<p>Aseptic packaging techniques</p> <p>Frozen dough</p> <p>Standard features of bread</p>	Nutritional value of bread	<p>Health claims (Stranieri et al, 2010)</p> <p>Consumers' willingness to pay (Wills et al, 2012)</p> <p>Traceability of final product (Barling et al. 2009)</p>	

* Indicators that do not have a reference in the literature have been defined on the basis of expert advice (see Annex for details)

Source: authors' elaboration

4.2 Comparative assessment on the Italian bread chains based on indicators

The following table summarizes the local/ global dimensions of the three supply chains analyzed according to the four criteria of discrimination between local and global (par. 3).

The global chain supplies an industrially pre-packaged bread led by Barilla company, a multinational that stands as one of the top Italian food groups, leading company for pasta production, bakery products and processed sauce market of continental Europe, and the flatbread market in Scandinavia. The group employs a workforce of over 15.000 people and has an annual turnover of 4 billion euro (2012) in 49 production plants (14 in Italy and 35 abroad), including 9 mills that provide the majority of raw materials required for the Group's production of pasta and a part of the supply of flour for oven-baked goods. Products are exported to over 150 countries: the plants provide an annual production of nearly 3 million tons of foodstuff that are consumed worldwide under various labels. Out of its various brands, Mulino Bianco is a leader in the sector of industrial pre packaged bread in Italy. Such industrially produced bread is present on the market in several versions and is marketed exclusively in Italy. 126 tons of "Pan Bauletto" per day are produced in two plants in the north and south of Italy. The 400 grams format, packed in a plastic bag, is sold through supermarkets and retailers for a price that ranges approximately from 80 cents (promotion price) to 1,25 euro (i.e. from 2 to 3 euro per kg, supermarket price).

The regional supply chain is identified as intermediate case between global and local supply chains. The new born Protected Designation of Origin for Tuscan Bread (waiting to be officially approved after the objections period) states that Tuscan Bread has to be produced (exclusively) with soft grains grown within Tuscany region borders according to the Product Specification of the "Pane Toscano DOP" (Tuscan Bread PDO). Also the processing stages of milling and baking must take place within the region, while commercialization is mostly regional and national and eventually global, (as it can be exported) provided that the PDO is certified. The product has been commercialized with the mark "Tuscan Bread Consortium, Natural Leavening", waiting for official approval of the PDO. On average 20 tons per year have been produced and the price ranges between 3 and 3,50 euro per kg.

The third case is an extremely local bread supply chain. The entire supply chain takes place on the same farm, situated in the province of Pisa (rural area in central eastern part of Tuscany) from cultivation of grains to milling, baking and final sale of bread loafs (among other bakery products). This family farm extends for more than three hundred hectares, and employs today 12 full time workers. It turned to organic agriculture in 1987, then started to experiment with the cultivation of ancient varieties of wheat and gradually decided to invest in on farm milling and baking facilities. This bread is made with the double rising leavening method and the use of fresh yeast and brewer's yeast (the latter only 1%). The flour is type 1 (semi-integral) and is made of several varieties of ancient wheat. The price is 3,9 euro per kg.

Table 4 – Local and global aspects of the bread chains selected

LOCAL VS. GLOBAL	WHEAT-TO-BREAD CHAIN	CASES SELECTED
1. Physical / geographical distance	Place of cultivation of wheat with respect to milling, baking, distribution and consumption	Barilla: global/national Tuscan bread PDO: regional Farmer: local
2. Governance: degree of control of “local actors” and “global actors”	Social distance between millers and bakers with respect to farmers and consumers	Barilla controls the supply chain Tuscan Bread PDO is based on a contract agreement between regional stakeholders Farmer has control over most part of the chain
3. Resources, knowledge and technologies	Technology of milling and baking process. Mix of ingredients used.	Barilla produces an industrial and standardized product Tuscan Bread PDO is defined by the product specification, produced on an industrial scale but with artisanal features Farmer provides high technology plant for milling and baking, thus allowing wheat and germ preservation. It can be anyhow defined artisanal
4. Role of territory in shaping product identity	Quality attributes of bread in relation to territorial typologies	Barilla: no explicit relation to territory Tuscan Bread PDO has a strong territorial identity based on PDO specification Farmer’s bread is linked to territory but not explicitly

Source: authors’

On the basis of the previously identified indicators we compared the three bread supply chains (see Table 5).

Table 5 – Qualitative assessment on biodiversity and nutritional quality

Supply chain level	Indicators	Global	Regional	Local
Farmers and Farmers consortia	Varietal diversity	low	medium	high
	Saving of seeds	no	no	yes
	On farm eco-system management	N/A	low	high
Millers	Presence of ancient wheat varieties	no	medium	high
	Kernel in flour	no	yes	yes
	Whole grain, multi grain	yes	no	yes
	Milling rate	no	yes	yes
Bakers	Discontinuous leavening	no	yes	yes
	Sourdough	no	yes	yes
	Additives to improve flour strength	yes	no	no
	Starters to speed up leavening	yes	no	yes
	Addition of functional ingredients	yes	no	no
	Salt level	low	no	low
	Use of preservatives	yes	no	no
Retailers	Health claims	yes	yes	no
	Traceability	no	yes	no

Source: authors’

Biodiversity assessment across the three chains indicates that the local supply chain has the best performance, with reference to varietal diversity of wheat used for bread. The farmer's bread is made of only ancient varieties of soft wheat (i.e. Verna, Frassineto, Inalettibile, Gentilrosso, Abbondanza e farina di grani duri Tilmilia, Cappelli, Taganrog, Etrusco), which also have a higher allelic variability (i.e. genetic) than modern varieties. The farmer doesn't use certified seed, but adopts organic farming of cereal's landraces and participatory varietal selection and breeding (Malandrin and Dvortsin, 2013). The farmer is involved in a network of seeds exchange with other farmers (i.e. Rural Seed Network) which also allows to take part to European level projects aimed at developing new strategies for organic and low-input integrated breeding. Presence of ancient wheat varieties is also connected to a higher nutritional value of flour used for bread processing (Di Silvestro et al. 2012).

Nutritional value of bread is the results of the interaction of several aspects, from seed selection, wheat, production and the processing stages. Again regional and local chains seem to perform better on nutritional value of bread. At the milling stage, one of the most relevant aspects that qualify the nutritional value of flour is the presence of the kernel. Processing methods aimed at preserving integral the wheat germ, disappeared in commercial flours. The wheat kernel is a concentrate of nutrients such as amino acids, fatty acids, mineral salts, B vitamins and tocopherols (vit. E). This is removed along with the outer shells during the milling process, ripping off the wheat flour of a large part of its fibers, vitamins and minerals. This operation is necessary for organoleptic reasons, but also to increase storage time length, given that the fatty acids contained in the germ go rancid in a short time. This is why the amount of flour milled per hour (i.e. milling rate) is another indicator used: it indicates how much nutritive value can be retained through the milling process. At the baking stage, sourdough leavening has crucial implications on nutritional, organoleptic and durability qualities. Moreover, the sourdough leavening and the presence of lactic acid bacteria are able to 'digest' the gluten, decreasing its toxicity, compared to the usual industrial fermentation with baker's yeast. Sourdough leavening is connected to a discontinuous production process, which imply waiting periods that do not suit industrial needs of a continuous production. Moreover the sourdough, obtained from the fermentation of cereal flour (usually wheat) and water, often facilitated by the addition fruit or bran or other elements, requires specific treatments and conservation (and almost daily care) which must be managed in parallel to bread production. Concerning how nutritional value is communicated at the retail stage, when the product finally reaches the consumer, there is large difference among the cases considered, obviously due to the different scales. We notice that the only product that guarantees full traceability is the regional supply chain, from seed to consumer, also because it is regionally bounded by definition and explicitly ruled through the PDO specification.

5. Conclusions

The relevance of local food supply chains lies in their potential in overcoming the drawbacks of global chains in sustainability terms. This contribution has explored the connections between sustainability performance and the localness or globalness of wheat-to-bread supply chains. We developed a comparative assessment on three bread supply chains of different lengths across two critical dimensions of sustainability: nutritional value of final products and biodiversity preservation.

The first step has framed a set of performance indicators, identified from academic literature and expert advice, within the DPSIR framework. This allowed us to highlight for each step of the supply chain, the critical issues that explain the performance in terms of the sustainability attributes considered. The second step has focused on three supply chains in Italy to see how the indicators previously identified fit in each context, the main differences and obstacles for improvement.

Biodiversity and nutritional value of bread are interlinked attributes: varietal diversity of wheat, which has a value per se, and is crucial for the territorial definition of the product, is also beneficial in terms of nutritional value. Furthermore, nutritional value of bread is the result of the first and second processing stages. The milling determines the value of the raw material, by deciding the amount of nutrients left in the flour (i.e. the kernel). However the maintenance of the kernel in conventional flour seems to be a major obstacle for industrialized production processes. The baking stage intervenes in different ways, which are deeply influenced by the scale of the operation and the production methods. The exploitation of the potential of sourdough leavening, with the consequent adjustments required by the production process is crucial in defining the quality features of the final product. It is in synergy to the necessity of adding functional ingredients “ex post” (as it is increasingly happening in industrial supply chains).

Biodiversity and nutritional values of the final product are the result of several decisions to be taken in the subsequent stages of the bread supply chain. Thus a closer agreement (alternative to the total integration within the same farm, as in the local case) among the actors of the chain, as it happens in the regional case, may be beneficial. This also represents a source of inspiration for the global supply chain, which could exploit new ways of interaction with the supply chain actors and new processing technologies to increase its sustainability.

Despite the high variability of situations among food supply chains, this work has attempted to define a methodological pathway to compare sustainability issues between different supply chain typologies. Further research is needed to fine tune the methodology and extend the assessment to other relevant sustainability issues – and corresponding indicators - connected with the ones analyzed, by widening the set of relevant case studies. Furthermore the definition of priorities (i.e. weights) on the indicators relevant to the different perspectives will allow a multi-criteria comparison

Acknowledgments

The research reported in this paper was funded by the EU within the project Global and Local food chain Assessment: a Multidimensional performance-based approach (GLAMUR, 7th Framework Program) Further information is available on the following website <http://www.glamur.eu/>. The views expressed in this paper are entirely those of the authors

Conflict of Interest

The authors declare no conflict of interest

References and Notes

- Andersson, K.; Ohlsson, T. Life cycle assessment of bread produced on different scales. *The International Journal of Life Cycle Assessment*, **1999**, 4.1: 25-40.
- Annett, L.E.; Muralidharan, V. ; Boxall, P.C.; Cash, S.B.; Wismer, W.V. Influence of health and environmental information on hedonic evaluation of organic and conventional bread. *Journal of Food Science*, **2008**, 73 (4): 50–57.
- Barling, D., Sharpe, R., Lang, T. Traceability and ethical concerns in the UK wheat-bread chain: From food safety to provenance to transparency. *International Journal of Agricultural Sustainability*, **2009**, 7 (4), pp. 261-278.
- Benedettelli, S.; Ghiselli, L.; Martinelli, T. *Pane Nuovo da Grani Antichi. Evoluzione delle varietà di grano, della tecnica molitoria e panificatoria*, a cura di Castioni, F.; Moretti R. Amministrazione Provinciale di Siena, Pacini Editore, Siena, 2013.
- Bonneuil, C., Goffaux, R., Bonnini, I., Montalent, P., Hamon, C., Balfourier, F., Goldringer, I. A new integrative indicator to assess crop genetic diversity Ecological Indicators, **2012**, 23, 280-289.
- Bonnin, I., Bonneuil, C., Goffaux, R., Montalent, P., Goldringer, I. Explaining the decrease in the genetic diversity of wheat in France over the 20th century *Agriculture, Ecosystems and Environment*, **2014**, 195: 183-192.
- Calderini, D. F., Dreccer, M. F., & Slafer, G. A. Genetic improvement in wheat yield and associated traits. A re-examination of previous results and the latest trends. *Plant Breeding*, **1995**, 114(2), 108-112.
- Capacci S., Mazzocchi M., Shankar B. The regional price of junk foods relative to healthy foods in the UK: indirect estimation of a time series, 1997-2009. In: 86th Annual Conference of the Agricultural Economics Society, University of Warwick, UK. 2012: 16-18.
- Chable, V.; Dawson, J.; Bocci, R.; Goldringer, I. Seeds for Organic Agriculture: Development of Participatory Plant Breeding and Farmers' Networks in France. In *Organic Farming, Prototype for Sustainable Agricultures* (pp. 383-400). Springer Netherlands. 2014.
- Chateil, C.; Goldringer, I.; Tarallo, L.; Kerbiriou, C.; Le Viol, I.; Ponge, J. F.; Salmon, S.; Gachet S.; Porcher, E. Crop genetic diversity benefits farmland biodiversity in cultivated fields. *Agriculture, Ecosystems & Environment*, **2013**, 171, 25-32.
- Colombo, L.; Grando, S. National level report - ITALY. 2014, Roma: FIRAB
- Dawson, J. C., Serpolay, E., Giuliano, S., Schermann, N., Galic, N., Chable, V., Goldringer, I. Multi-trait evolution of farmer varieties of bread wheat after cultivation in contrasting organic farming systems in Europe. *Genetica*, **2012**, 140(1-3), 1-17.
- Dewettinck, K., Van Bockstaele, F., Kühne, B., Van de Walle, D., Courtens, T. M., & Gellynck, X. Nutritional value of bread: Influence of processing, food interaction and consumer perception. *Journal of Cereal Science*, **2008**, 48(2), 243-257.
- Di Silvestro, R., Marotti, I., Bosi, S., Bregola, V., Carretero, A. S., Sedej, I., Mandic, A.; Sakac, M; Benedettelli, S.; Dinelli, G. Health promoting phytochemicals of Italian common wheat varieties

- grown under low input agricultural management. *Journal of the Science of Food and Agriculture*, **2012**, 92(14): 2800-2810.
- Durham, C.A.; King R.P.; Roheim, C.A. Consumer Definitions of ‘Locally Grown’ for Fresh Fruits and Vegetables. *Journal of Food Distribution Research*, **2009**, 40, 56-62.
- Forsell, S., Lankoski, L. The sustainability promise of alternative food networks: an examination through "alternative" characteristics, *Agriculture and Human Values*, **2014**. Article in Press.
- Galli F., Bartolini F., Brunori G., Colombo L., Gava O., Grando S., Marescotti A. Sustainability performance of food supply chains: a participatory assessment for bread, LI *Italian Society of Agricultural Economics (SIDEA) Conference “La PAC 2014-2020: scenari per i sistemi agroalimentari e rurali europei”*, Benevento 18 e 19, 2014, Italy.
- Galli, F.; Brunori, G. (eds.) Short Food Supply Chains as drivers of sustainable development. Evidence Document. Document developed in the framework of the FP7 project FOODLINKS (GA No. 265287). Laboratorio di studi rurali Sismondi. 2013. Available online http://www.foodlinkscommunity.net/fileadmin/documents_organicresearch/foodlinks/CoPs/evidence-document-sfsc-cop.pdf (accessed on 4/10/2014).
- Gallo, G., Lo Bianco, M., Bognanni, R., Saimbene, G., Orlando, A., Grillo, O., Saccone, R., Venora, G. Durum wheat bread: Old sicilian varieties and improved ones. *5th International Technical Symposium on Food Processing, Monitoring Technology in Bioprocesses and Food Quality Management*, **2009**, pp. 1128-1138.
- Gava, O.; Bartolini, F.; Galli, F.; Brunori, G. Sustainability of local versus global bread supply chains: a literature review. In 2014 Third Congress, June 25-27, 2014, Alghero, Italy (No. 173096). *Italian Association of Agricultural and Applied Economics (AIEAA)*.
- Goesaert, H., Brijs, K., Veraverbeke, W. S., Courtin, C. M., Gebruers, K., & Delcour, J. A. (2005). Wheat flour constituents: how they impact bread quality, and how to impact their functionality. *Trends in Food Science & Technology*, **2005**, 16(1), 12-30.
- Golan, E., Kuchler, F. Mitchell, L. Economics of food labelling’, *Journal of Consumer Policy*, **2001**, 24: 117–184.
- Golan, E.; L. Unnevehr Food product composition, consumer health, and public policy: introduction and overview of special section Food Policy, **2008**, 33: 465–469.
- Hand, M. S., & Martinez, S. Just what does local mean. *Choices*, **2010**, 25(1): 13-18.
- Hellyer, N. E., Fraser, I., Haddock-Fraser, J. Food choice, health information and functional ingredients: An experimental auction employing bread. *Food Policy*, **2012**, 37(3), 232-245.
- Hills, K.M.; Goldberger, J.R.; Jones, S.S. Commercial bakers and the relocalization of wheat in western Washington State. *Agriculture and Human Values* **2013**, 30(3): 365-378.
- Ilbery, B., Maye, D. Alternative (shorter) food supply chains and specialist livestock products in the Scottish–English borders. *Environment and Planning*. **2005** A 37(5): 823–844
- Inoue, Y., Bushuk, W. Studies on frozen doughs 2. Flour quality requirements for bread production from frozen dough. *Cereal Chemistry* **1992**, 69, 423e428
- Ippolito, P.M.; Mathios, A.D. Information, advertising and health choices: a study of the cereal market. *RAND Journal of Economics*, **1990**, 21 (3): 459–480.
- Katina, K., Arendt, E., Liukkonen, K.-H., Autio, K., Flander, L., Poutanen, K.. Potential of sourdough for healthier cereal products. *Trends Food Sci. Technol.* **2005**, 16, 104–112.
- 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, University of Gloucestershire, 2014.
- Malandrin, V.; Dvortsin, L. Participatory Process of Agroecological Innovation in organic cereal breeding: a case study from Italy. In Fourth International Scientific Symposium “*Agrosym 2013*”, Jahorina, Bosnia and Herzegovina, 3-6 October, **2013**. Book of Proceedings. (pp. 719-725). Faculty of Agriculture, University of East Sarajevo.
- Mancino, L.; Kuchler, F.; Leibtag, E. Getting consumers to eat more whole-grains: the role of policy, information, and food manufacturers. *Food Policy*, **2008**, 33: 489–496.

- Maye, D.; Ilbery, B. Regional economies of local food production: Tracing food chain links between “specialist” producers and intermediaries in the Scottish–English borders. *European Urban and Regional Studies*, **2006**, 13(4): 337–354.
- Mialon, V.S.; Clark, M.R.; Leppard, P.I.; Cox, D.N. The effect of dietary fibre information on consumer responses to breads and ‘English’ muffins: a cross-cultural study. *Food Quality and Preference*, **2002**, 13: 1–12.
- Mondal, A. and Datta, A.K. Bread baking—a review. *Journal of Food Engineering* **2008**, 86.4: 465–474.
- Moroni, A. V., Arendt, E. K., Morrissey, J. P., Bello, F. D. Development of buckwheat and teff sourdoughs with the use of commercial starters. *International journal of food microbiology*, **2010**, 142(1), 142–148.
- Nayga, R. M. Determinants of consumers’ use of nutrition information on food packages’, *Journal of Agricultural and Applied Economics*, **1996**, 28, 303–312.
- Ness, B., Anderberg, S., Olsson, L. Structuring problems in sustainability science: The multi-level DPSIR framework *Geoforum*, **2010**, 41 (3), pp. 479–488.
- Nevo E. Triticum. In: Kole C (ed) *Wild crop relatives: genomic and breeding resources, cereals*. Springer, Berlin, 2011, pp 407–456.
- O’Hara, S.U.; Stagl, S. Global food markets and their local alternatives: A socio-ecological economic perspective. *Population and Environment. A Journal of Interdisciplinary Studies* **2001** 22(6): 533–554.
- Poutanen, K.; Flander, L.; Katina, K. Sourdough and cereal fermentation in a nutritional perspective. *Food Microbiology*, **2009**, 26(7), 693–699.
- Quilez, Joan, and Salas-Salvado, J. Salt in Bread in Europe: Potential Benefits of Reduction. *Nutrition Reviews* **2012**, 70 (11): 666–78.
- Renting, H.; Marsden, T.K.; Banks, J. Understanding alternative food networks: exploring the role of short food supply chains in rural development. *Environment and Planning* **2003** A 35(3): 393–411.
- Selfa, T., Qazi, J. Place, taste, or face-to-face? Understanding producer–consumer networks in “local” food systems in Washington State. *Agriculture and Human Values*, **2005**, 22(4):451–464.
- Slavin, J.L., Jacobs, D., Marquart, L. Grain processing and nutrition. *Critical Reviews in Biotechnology* **2001**, 21: 49–66.
- Smeets, E., Weterings R. Environmental indicators: Typology and overview. EEA, Technical report No 25. **1999** On-line at: http://www.geogr.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Workshops/FEEM/Indicators/EEA_tech_rep_25_Env_Ind.pdf
- Stranieri, S.; Baldi, L.; Banterle, A. Do Nutrition Claims Matter to Consumers? An Empirical Analysis Considering European Requirements. *Journal of Agricultural Economics* **2010**, 61 (1): 15–33.
- Sumanac, D.; Mendelson, R.; Tarasuk, V. Marketing Whole Grain Breads in Canada via Food Labels. *Appetite*, Marketing to Children - Implications for Eating Behaviour and Obesity: A special issue with the UK Association for the Study of Obesity (ASO), **2013**, 62 (March): 1–6.
- Van der Kamp, J. W., Poutanen, K., Seal, C. J., Richardson, D. P. The HEALTHGRAIN definition of ‘whole grain’. *Food & nutrition research*, **2014**, 58.
- Wills, J. M.; Storcksdieck S.; Bonsmann G.; Kolka, M.; Grunert, K.G. European Consumers and Health Claims: Attitudes, Understanding and Purchasing Behaviour. *Proceedings of the Nutrition Society* **2012** 71 (02): 229–36.
- Young, J. Functional bakery products: current directions and future opportunities. *Food Industry Journal* **2001**, 4, 136–144.

Annex – Actors interviewed (alphabetical order), employing institution or enterprise, position and type of interview.

Actor	Institution/enterprise – Position	Type of interview
Stefano Benedettelli	Department of Food Production Science and Environment, University of Florence – Associate Professor of Plant Genetics	Narrative
Guido Calò	Barilla – Quality and Food Safety Director “Bakery”	Semi-structured
Roberto Ceccuzzi	Farmers’ cooperative of Siena, Agricultural production – Agronomist	Structured
Marzio Domenici	Domenici’s bakery – Owner	Structured
Rosario Floriddia	Floriddia’s farm – Owner and manager	Structured
Ugo Giambastiani	Giambastiani’s milling plant – Legal representative	Structured
Roberto Pardini	Consortium for the Promotion and Protection of Tuscan Bread – Director	Structured
Luca Ruini	Barilla	Semi-structured
Angela Zinnai	Department of Agriculture Food and Environment, University of Pisa – Associate Professor of Food Science and Technology	Semi-structured