IT-based tools for the integrated management of the food chain: the development of the cereal territorial chain of the PGI "Pane di Matera" within the Rural Development Program of the Basilicata Region by means of technological innovations

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Abstract

The purpose of the research is the analysis and implementation of an IT-based system for PGI Matera Bread food chain management and integration system. The work, developed in the context of the Integrated Project of Food chain (IPF) "Mangiare Matera: il grano, il pane, la pasta", is mainly based on the gathering and elaboration of data pertinent to the manufacturing, transformation and commercialization of PGI "Pane di Matera" food chain productions. The issues observed during the analysis have pushed the research towards the individuation of a methodology and a technology aiming to integrate a vertical with a horizontal food chain coordination. Acting upon the IT system identified and its architecture it was therefore possible to construct and test the technological HUB instrument as an ITC platform of services for the food chain and test how it influences the economic results of companies within the IPF.

Keywords
Integrated management of the food chain, Technological innovations, Coordination, IT platform

Introduction

Food chains are affected by an increasingly unbalanced distribution of values, which weakens the producers to the benefit of other stakeholders within the food chain itself.
The production step is subjected to natural causes, which condition productive and socio-economic dynamics, and it is also related to the dynamics of pricing processes and sales strategies; it is therefore the most affected step in the food chain within a fast changing and globalized agro-food system (Danel et al., 2012). This is even more clear for some branches of production marked by an extremely fragmentation of production, or a reduced value of agricultural raw material. Economic theory and agricultural policy instruments, useful when facing such food chain issues, can rarely turn into efficient solutions; this is due to the complexity of the agro-food system and to the difficulty of public decision-makers when making those instruments effective in the territory. It is due also to the peculiarity of each

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territorial food chains and to poor organization and integration between operators in the food chain, and with the stakeholder outside (Malpel et al., 2012).

Cereal food chain in the Basilicata region is still a strategic branch in the primary sector, although in recent years it has been struck by a remarkable production crisis due to national and European negative trends (INEA, 2014). In 2010, about 183.000 hectares have been allocated to cereal farming; the decrease percentage if this surface during the last 10 years is 23.8%, along with a 42.6% decrease in the number of farms (mainly family micro-enterprises). Structural data consequently affected production data, marked by decreasing trends in the long term. Total cereal production in 2010 is a little more than 40.000 tons, 13% less than in 2000 and 37% less than 2005, which was the year when different agricultural branches in Basilicata registered a peak in positive area.

The cereal sector in Basilicata is based on durum wheat production; during the last ten years, it decreased in terms of the number of farms and agricultural land (UAA - Utilized/Usable Agricultural Area), respectively of 41.8% and 32.3%. These values are remarkably higher than the national trend (33.3% 2010/2000 for number of farms; -16.5% 2010/2000 for UAA). The amount of product registered in 2010 (over 34.500 tons), associated with the subdivision of the surface according to the kind of cultivation where durum wheat occupies one fourth of the regional UAA, confirms the importance of such cultivation which contributes for almost the total amount of the Gross Salable Product (GSP) of the branch. In 2009, the production value with base prices was around 64.040.000 euros for the produced amount of 24.000 tons; in 2010 the same parameter (around 88.000) proportionate to the crop increase, shows a decrease of 86% compared to the year before, which is demonstrative of the current worrying phenomenon of the Italian wheat price contraction.

In the Basilicata region, as in the rest of Italy, the success of the cereal food chain is strictly bound to the baking industry, whose products have a good collocation on both regional and national market, especially in medium-high segments of consumers, also with good export performances. PGI (Protected Geographical Indication) "Pane di Matera" is the excellence quality item of cereal farming in Basilicata, as it represents a product that is at the same time strictly bound to the area, but also good enough to trespass the regional boundaries and conquer market share in Italy and abroad. However, according to operators this strength factor soon revealed itself being a weakness, as the PGI is still the only designation so far, even though the existing exquisite ancient wheat varieties, if conveniently recovered, could appraise the regional food chain. Consequently came the necessity to formulate adequate strategies of enhancement in order to place those products in the retail system, also through the creation of an umbrella brand.

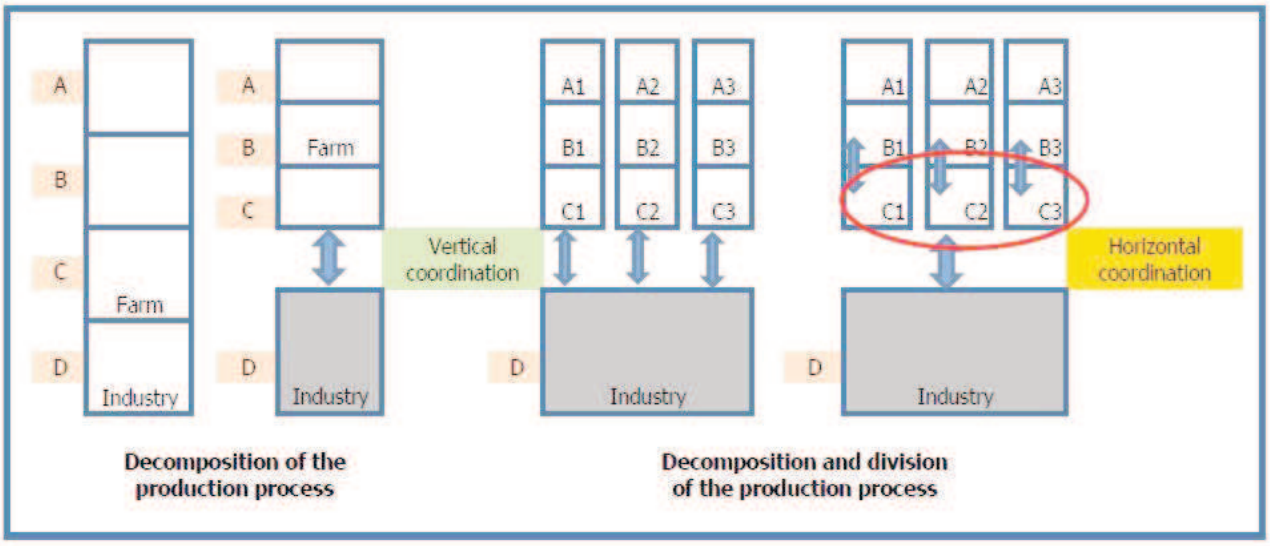
Among the weaknesses of the industry, one phenomenon is recognized to be a remarkable obstacle to the growth of competitiveness in this branch: the extreme fragmentation and pulverization in the production process, a situation that did not improve consistently through the years, which causes problems in food aggregation and concentration and, as a result, causes the loss of bargaining power towards large processing industry and inevitably leads to completion of the contracts within the food chain. Although the regional wheat production, processing farms import the main part of the product, often from foreign market, since local producers are not able to food adequate batches. The heterogeneity of features

remarkable in the wheat food is indeed the first reason to guide farmers towards standardized quality productions, regulated on the necessities of milling and pasta industry. The aim is to prevent the processing industry to import European and non-European products, which are often low quality even if cheaper and consequently lead to detriment and loss of competitiveness for local productions.
Improving and raising quality along the cereal food chain necessarily needs both the spread of appropriate cultivation techniques, and structural/logistic reorganization of stock and sales centers (INEA, 2014), that since a long time are considered inadequate.

Method

The analysis, developed within the activities supported by the Measure 124 of the RDP Basilicata Region 2007-2013(Rural Development Program Basilicata Region 2007-2013, in the Integrated Project of Food chain (IPF) "Mangiare Matera: il grano, il pane, la pasta", was mainly based on gathering and elaboration of data concerning the production, processing and sales process in the cereal food chain of the PGI "Pane di Matera". The survey was conducted through quality and quantity-focused questionnaires, and focus group conducted both within each single step of the food chain, and the creation of three different consumer groups: wheat producers, processing (mills) and bakers members of the producers association for PGI "Pane di Matera". The solution obtained, based on the results, is an IT architecture aimed to identify and support the most delicate and efficiency lacking production steps (Kaloxylos et al., 2014).
The selection of the ICT architecture implies a reflection about quantity and quality of data flows generated by the IPF member companies, and about their relevance concerning their networking processes; this reflection becomes fundamental to determine the functional form of IT architecture and its different access levels for different kinds of users (Guo et al., 2014).
Once the IT model and its architecture are individuated and combined, it has been possible to construct and test the technological HUB instrument as an ITC platform for food chain services; it was also possible to test how the platform influences the economic results of the IPF companies (Sonnino and Marsden, 2006).
More specifically, it is a survey about costs and benefits connected to the use of services relied to each step of the food chain and to the food chain as a whole, and about how the solutions found are responding to the intervention requirements. Such analysis has been conducted starting with the data coming from the field survey and economic-financial data of the food chain companies. This data will be employed when constructing a reclassified balance of the entire food chain, and redetermining the value chain (Coase, 1937).
The issues revealed during the analysis of one food chain in particular, and the evidence collected during the data gathering steps and through the exchange between companies and operators, led the research towards the individuation of a method and a technology aimed to integrate a food chain vertical coordination with a horizontal one (Fig. 1)

Figure 1 – Coordination of food chain



Source: own elaboration

The two types of coordination present substantial differences that can integrate with each other, improving the global system efficiency:
horizontal coordination, consisting in the reunification of the "same" steps of the manufacturing process in a single decision unit when carried out by different companies ("divided");
vertical coordination, consisting instead in the alignment of distinct and consecutive steps of the manufacturing process through different levels of agreements made between autonomous decision units.
The combination of these two organization forms leads to the fusion in the circulating coordination, inside which it is possible to realize a reunification of similar steps, aligning them to consecutive and/or preceding steps. Within the governance system, it is possible to integrate the IT innovation, which can increase the efficiency in data and goods/service flows management.
It is clear the necessity of coordinating in an accurate way the manufacturing processes of the different companies placed all along the food chain, also through these innovative methodologies, to increase the interdependence degree between the decision centers of manufacturing units.
In the case of the relation between the agricultural and industrial step, this means an increase of coordination and control requirements, along with a faster adaptation of the following:

- *Factors of production;*
- *Size* of product batches;
- *Supplies* and their *price and quantity;*
- *Delivery time and method;*

Incorporated services will be added to this list; they often include most of the value added of the whole food chain. For each one of these steps, will be examined also quality and quantity of data about processes, products, data exchange methods, and value distribution

methods.

Therefore, some questions are raised about the reasons that should motivate the companies to get over the pure market paradigm, committing to stronger and more innovative forms of collaboration, that often imply sharing highly valuable (both in quantity and quality) data package with competitors, suppliers and clients. In which situation is it convenient to trust the market or forms of coordination between different companies, instead of realizing that peculiar operation internally? Why companies, in coordinating vertically, employ certain mechanisms? The *Transaction Costs Theory (TCT)* tries to identify the reasons that determine the companies' decision of producing internally ("make") or "buying" goods, technology and know-how. The first reflection consists in considering that the market environment, hence operators and companies present the following features:

Bounded rationality: individuals act as intentionally rational agents, even though within the boundaries that make their actions and forecasts defective, because of the existing limits in cognitive, revision, and technical abilities, and because of the time at their disposal to gather information and make decisions

Opportunistic behavior: individuals act for personal interest, pushed to deceit and fraud; e.g. omitting useful information for the counterpart, or altering information, abusing the counterpart conviction.

If market operators and companies had at their disposal unbounded rationality and at the same time had no tendency to commit opportunistic behavior, the market would have the chance to function at cost zero, and the information flow value would be extremely low. But this is not reality works, so when a company relies to the market to buy services, goods or know-how it implies in any case the market costs (transition costs); such costs are not to be sustained when the company decides to produce internally the products and/or services it needs (Coase, 1937) (Williamson, 1975) (Williamson, 1985).

This theory gave rise to numerous applications and elaborations (Ménard and Valceschini, 2005) essentially based on the principle according to which market transactions entail costs that may concern:

ex-ante costs: costs sustained by the company to individuate the counterpart;

ex-post costs: costs sustained by the company for the execution of the contract, for the control of the transaction to be carried out in the negotiated terms, control costs to verify and avoid opportunistic behavior; losses associated to bad construction contract.

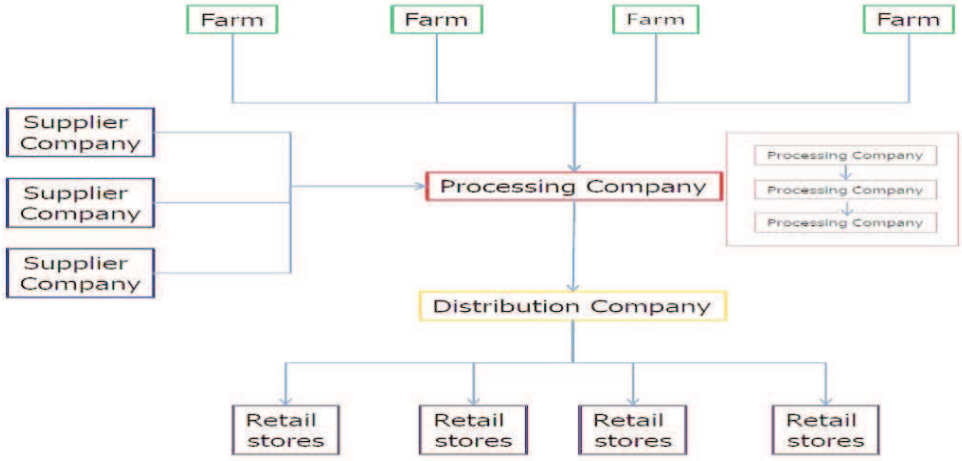
In case of transaction costs, bounded rationality and opportunistic behavior, turning to the market is not always the most efficient or less expensive solution.

On the basis of all this, the project aimed to the fine tuning of a software architecture that can manage process/product information flows, with the purpose of minimizing transition costs within the food chain.

The reference functional system was obviously the food chain organization system; however, the definition of the model and, in particular, of the instruments aiming to guarantee the relation between the different elements of complex production reality, interrelated with each other at several levels, led to the choice and use of technological solutions that provide maximum operation flexibility (but without disregarding safety and accuracy rules and restrictions), and support collaborations also different from food chain realities (e.g. collaborations that are increasingly important in so-called company networks).

The methodology selected is therefore a food chain digital integration system, including all the services and the applications realized to describe and interrelate the constitutive segments of an food chain, and constitutes the part of prototype application exclusively dedicated to the food chain participating companies and government organs of the chain itself (BtoB users).
The access levels to the platforms are controlled in order to emulate both the segment of each company within the food chain and the role played by the user within his company; the input and the management of data is also arranged (all the data from which is necessary starting to create a system of knowledge management).

Figure 2: Scheme of the IT System adopted



Source: own elaboration

Results

The research led to the construction of a database containing all the information about the companies involved in the project, divided by macro-areas: primary production, primary transformation and final transformation. After defining the food chain functioning model and the test activities/spot checks carried out with testing companies, the technological HUB sustainability was verified, checking in which ways it was going to influence transaction costs bound to some raw material passages within the food chain and to the optimization of production processes.
A further result was obtained by the improvement of relations between operators and by an overall improvement of retail structure internal of the cereal food chain of PGI "Pane di Matera". The main technical-economical results obtained through the implementation of the platform and of the innovative organisation methodology are listed as follows.

Farming phase

The analysis carried out during the farming phase led to analysis the number of cereal farms belonging to IPF, verifying through questionnaires before and after interventions the unitary

costs per hectare in the IPF durum wheat area allocated to milling and to PGI bread production.

Table 1: Costs of the farms belonging to the sample IPF "Mangiare Matera"

	Costs (€)	Costs after platform introduction (€)
Mechanical manufacturing		
Soil preparation	200.00	190.00
Sowing/transplanting	45.00	43.65
Fertilizer distribution	60.00	56.40
Pre-emergency weed killer distribution	30.00	28.20
Post-emergency weed killer distribution	30.00	28.20
Fungicide/insecticidedistribution	45.00	42.30
Manufacturing costs/Ha	***410.00***	***388.75***
Variablefactors of production		
Basal dressing (phosphorus. organic)	60.00	58.20
Basal dressing (potassium)	60.00	58.20
Top dressing (nitrogento)	40.00	38.80
Total costs/Ha	***980.00***	***932.70***

Source: own elaboration

The results of this survey are listed in the charts (Table 1). The savings for production inputs are around 4% and for manufacturing are around 3%. This result was made possible thanks to the overall improvement of the farming input efficiency obtained by administering day-by-day specialist consulting performed by expert technicians, retrieving data about the cultivations from the operators through the platform, and gave tailored fertilization and manufacturing plans.
An additional element that contributed to lower the medium costs/Ha was made possible through the chance for the companies to associate when buying farming inputs (seeds, fertilizer, phytosanitary products. etc.) so that they could obtain better prices.
When crossing the saving data obtained by the company, which is around 47€/Ha with the platform maintenance costs, calculated during design phase around 350€ per year per company it is clear how, just considering the saving on management costs, this means for a medium sized company of 20Ha, an efficiency return in the amount of 596€. This increase of efficiency still does not consider possible sales improvements offered by the permanence within a food chain context along with other operators that, in view of disciplinary and chain arrangements, can lead to obtain higher medium prices per wheat quintal.

Milling phase

During the milling phase, the introduction of the platform concerned the relations of the Mill with the farming supplier. Technical consulting administered to the farmers have been produced in collaboration with the mill technicians in order to let them try to construct with the farmer a better input raw material. An additional advantage element was to better coordinate the raw material fooding phases, reducing the stands in service areas and the

blockage of the storage capacity.
The analysis carried out was partial and random because it concerned a small percentage of the entire productive capacity of the mills. Hence, this analysis is to be considered, in this phase, not thorough and susceptible to corrections. In any case, the data gathered present very important elements for reflections about a possible efficiency returns within the phase of primary transformation of raw material (Table 2).

Table 2: Costs of milling phase before and after intervention.

	Raw material Kg	**Operation cost €/kg**	**Manufacturing waste Kg**	**Product return KG**	**By product return KG**	**Operation cost/platform €/kg**
Raw material receiving	100	0.35				0.25
Pre-cleaning / Storage	100	0.1				0.1
Cleaning	100	0.1	4	96	1.5	0.099
Ensiling + conditioning	100	0.03				0.03
Milling + flours	100	0.12	1	68	28	0.11
Storage + blending	100	0.01				0.01
Packaging	100	0.25				0.2
Storage packedproduct	100					
Trasportation	100	0.7				0.65

Source: own elaboration

As deducible from the information summed up in the chart, the highest efficiency returns were obtained in the raw material receiving and final product transportation phases. This last result is due to the coordination made possible between mills and bakeries trough the platform and the consequent elimination of wasted time between the bakery order and the preparation and dispatching by the primary transformation. The costs reductions seen during the other manufacturing phases are not statistically or economically relevant, as was observed during the focus groups, because such variations can occur in any case and the basically depend from factors external to the manufacturing process (humidity, machine settings, etc.).
The final cost advantage is therefore calculated around 0.15€ per Kg of final product, which is an important result in the milling branch, where profit margins are extremely low.
To this kind of return, has to be added an incidental enhancement of the product, deriving from food chain arrangements aimed to improve the PGI "Pane di Matera" and its product placement. Such policy, if carried out in a food chain perspective, will surely bring advantage to all operators trough an increase of product value along all the phases, from manufacturing to sales.

Bread-making phase

Contrary to previous phases, bakers could not get technical-economic advantages after the platform introduction. The only organisation advantage was an improvement in raw material storage management, ant in the timing related to flour orders.

Table 3: Bread making costs before and after intervention

	Raw material kg	Operation cost € / kg	Manufacturing waste KG	Product return KG	Operation cost after platform €/kg
Flour receiving	100	0.55	0.5	0	0.55
Raw material storage	100	0.05	0.1		0.05
Raw material storage (flour dosage)					
Dough kneading	100	150	1	140	150
Baking	100	70.5	0	100	70.5
Slicing	1	0.03	0.002	0.998	0.03
Adding preservatives	0	0	0	0	0
Packaging	1	0.12	0	1	0.12
Packaging (metaldetector)	0	0	0	0	0
Transportation and sales	100	0.15	0	100	0.15

As deducible from the chart, the bakers did not notice any manufacturing cost advantage. Such a problem could have been solved by including the buyers of the final product (supermarkets, chains, DO etc.) in the project and in the platform system, so that the efficiency would have been implemented also in the logistic phase of storage and orders management. Such policy would surely have brought saving at least in the packaging, transportation and sales phases. Focus groups with bakers declared the perception of the utility of the IT instrument as a mean of communication and promotion of the final product to be an irrefutable element. Indeed, through the IT instrument the bakers took the chance to transmit informative content directly to the final consumers interested to the product PGI "Pane di Matera", and above all had the chance to guarantee to possible international buyers transparency criteria and traceability, not even imaginable so far.

Conclusions

The implementation of an IT based system for food chain management and integration can represent a really useful instrument for evaluation and improvement of cooperation levels between companies involved in a certain food chain, and also to individuate the correct functional model for its organisation and, more generally, of a territorial production system, with the aim to generate a competitive advantage for the operators, especially in the manufacturing phase. Empiric evidence demonstrate that such a system is a useful

instrument for destruction of peculiar kinds of costs, improving information flows and operation transparency within the food chain.
An additional element for reflection highlighted by the research is surely bound to the effects that can be generated by the implementation of this methodology and management innovations towards the increase of human capital in the companies, and their inclination for innovation.
As already indicated in the passage about the final transformation phase, the inclusion inside the system of the sales process is an essential element for the complete optimization of all the processes. Involving the consumers and the sales network, the ripple improvement effects would reflect on all the stakeholders, improving the efficiency of the overall system.
The research work, in conclusion, determines an overall evaluation also on the real capability of the IPF instrument to fulfil the purpose for which it was arranged in RDP 2007-2013 and in particular for Measure 124: this evaluation will certainly be useful for stakeholders and policy makers right before the program 2014-2010 is about to start, with particular reference to the EIP and Operation Groups development.

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