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**Towards more sustainable diets:
insights from firms' innovation dynamics
on new legumes-based food products.**

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Abstract

Grain-legumes are crops that both increase the sustainability of agricultural systems and food. Yet grain-legumes are currently facing lock-in and are poorly consumed in most western countries. This paper addresses why and how firms innovate to develop new grain-legumes-based food products; and questions how those innovations could help to break this lock-in. Based on transition multi-level perspective framework, we analyse several cases studies of firms in manufacturing agro-food sector, localised in France and Italia, and that have recently introduced food product innovations with grain-legumes. Those products are developed in America and/or Europe. Our main results show that all the interviewed firms are strongly aware of societal evolution towards more plant-based food diets in Europe. But their current marketing strategies are not based on nutritional and environmental benefits of legume-based products. Their main objective is to offer new, attractive and practical foods with differentiation strategy by using new raw materials. This result questions how institutions could foster those innovations in order to promote more specifically grain-legumes. This analysis helps also practitioners and public authorities to identify several breaks in developing such new food products.

Key Words: agro-food transition; grain-legumes; food product innovation; technological innovation; consumer behaviour

Introduction

Agricultural and food sectors are facing a set of intersecting challenges (Tilman & Clark, 2015; Evans, 2009). Food supply has to be increased to match the demand from a rapidly growing human population while the on-going environmental changes are a major threat to agricultural production (Godfray *et al.*, 2010). This questions the sustainability of current agricultural practices and agro-food systems, since intensive production methods are bringing human society closer to the limits of the planet's natural resources availability (Horrigan *et al.*, 2002; Von Braun, 2007). As currently promoted by the FAO, through the 2016 International Year of pulses¹, grain-legumes are crops to develop to reach stronger sustainable agro-food systems.

On the one hand, agriculture sustainability transition is not fast at all. Innovation is prevented by the locked-in dominant agro-food system based on intensive use of agro-chemicals (Vanloqueren, 2009). Rotations became shorter with the reduction of some crop species, such as legumes in favour of other crops ensuring better short-term profitability, such as cereals (Magrini *et al.*, 2016). One main consequence is a loss of biodiversity and provision of ecosystem services allowed by more cultivated diversity. In particular, legumes allow reducing the use of nitrogen fertilisers, those accounting for half of greenhouse gases in agricultural sector (Pellerin, 2013). But grain-legumes still count for less than 2% of arable land in Europe.

On the other hand, concerning food, a main problem is that our western diets are too rich in animal proteins (Ranganathan *et al.*, 2016) although the UN recommends a 1:1 ratio between animal and plant sources. The production of animal-based foods is more environmentally impactful and resource-intensive than plant-based foods, thus plant-based proteins are a good opportunity for developing more sustainable diets (Ranganathan *et al.*, 2016). Among them, grain-legumes² are richer in protein than cereal crops and then present interesting nutritional values for food (Chardigny and Walrand, 2016). But little attention has still been paid to their promotion in food, in particular in European diets that are very low in grain-legumes. Moreover even if, during the last years, the agro-food industry has been increasingly involved in supplying with new plant-based food products, most of them are based on wheat or soya, the two major crops in the world and very little ones with other grain-legumes (Guéguen *et al.*, 2016). The current consumption of grain-legumes is around 1,7 kg/year/person in France and 2,7 in Europe, although the worldwide average is 7 kg/year/person. Thus, despite their environmental and nutritional benefits, grain-legumes crops are hardly cultivated and used in France, and more largely in Europe.

Changes in agricultural production went hand in hand with those of all the other agro-food sectors. Transition to sustainability implies interconnected innovations in both the agriculture and food industry, as well as in society and consumption habits (Guyomard *et al.*, 2012). And as underlined

¹ <http://www.fao.org/pulses-2016/en/>.

² Grain-legumes belong to the Fabaceae family and cover a wide variety of species (such as pea, faba bean, lupin, soy, lentils, and beans). Their common characteristics are to fix atmospheric nitrogen, through symbiosis with soil bacteria, to produce protein-rich seeds (average of 22 to 40% protein in dry matter) harvested for feed or food. The European statistical classification distinguishes protein-rich legumes (comprising protein-rich peas, lupins and faba beans), historically oriented towards use in animal feed in the aftermath of the Second World War, from traditional dry legumes used mainly for food (lentils, peas, beans, chickpeas) and also called "pulses". Soybeans, classified as an oilseed, tend to constitute a specific category because of its dual richness in oil and protein. Voisin *et al.* (2014) provides an overview of statistical changes in cropping systems of the main legume species.

by Magrini *et al.* (2016), developing grain-legumes in agriculture calls for new market outlets for those crops. Currently some industrials are active in developing new grain-legumes based food products, responding and supporting new societal requests for sustainable diets. Thus, those product innovations could be considered as “seeds” of an agro-food sector transition toward sustainability. The aim of this study is to analyse the rationale of those firms to develop these new products and the increasing interest towards them. Our study pays particular attentions to the analysis of which nutritional and environmental issues firms rely on to develop these products, and to identify the major breaks those firms could encounter in order to give insights to public authorities for supporting such innovations.

To conduct this analysis we used the theoretical framework of Multi-Level Perspective (Geels F. W., 2002). This heuristic multilevel approach combines contributions from evolutionary economics, sociology of technology, structuration theory and neo-institutional theory in order to take into account the complexity of those socio-technical changes. Based on the main inter-related topics of the MLP framework³ we analyse how innovative firms have taken into account those topics for developing their innovation products: *(a) User’s practices, (b) Scientific knowledge, (c) Markets, and particularly for our study the links between food and agricultural markets, (e) Policy-Institutions, (f) Technology, (g) Infrastructures.* Our study focuses on seven cases studies of firms in manufacturing agro-food sector, localised in France and Italia, and that have recently introduced food product innovations with grain-legumes. Those products are developed in America and/or Europe. Several open-ended interviews were carried out with CEO and/or R&D directors of those firms taken as case studies. Question concerned firms’ innovation in relation with MLP main topics, in order to understand what influence the innovation process of those new legumes-based products and which breaks they could encounter to develop such new grain-legumes based food products. We can note that we didn’t find other research analysing the firms’ food product innovation in grain-legumes sector.

Our main results show that all the interviewed firms are strongly aware of societal evolution towards more plant-based food diets. Nevertheless their current marketing strategies are not based on nutritional and environmental benefits of legume-based products, but more on the objective to offer new, attractive and practical foods with differentiation strategy by using new raw materials. Moreover, even if those innovations imply strong technological innovation processes, none of the firms deposited a patent as they prefer secrecy. This questions the diffusion of the new technologies used for those new food products, and also how institutions could support innovation in the agro-food sector to better promote grain-legumes.

The first section focuses on the theoretical background of MLP to analyse sectorial innovation. In the second section the case studies and the methodology are presented. The third section analyses the results and the last one conclude.

³ One can note that Geels gives various versions of MLP framework, but these topics are always used as main dimensions of the analysis.

1. Theoretical background

Transition towards sustainability induces systemic innovation, that means a complete change from a current system to a more environmentally sound one. Transition is a process that involves major and structural changings that may occur at different levels and as a simultaneous development of society and technology (Smit and Van Oost, 1999). Social scientists on innovation have paid important attention to transition in recent years (see for instance Lachman, 2013, for a review). Transition takes place at the level of the entire society and scholars focus on specific societal functions like transport or communication or food to analyse it.

“A transition denotes long-term change in an encompassing system that serves a basic societal function (e.g. food production and consumption, mobility, energy supply and use, communication, etc.). In a transition, both the technical as well as the social/cultural dimensions of such a system change drastically. This emphasis on the co-evolution of technical and societal change distinguishes transitions from incremental processes, which are primarily characterized by technical change (through successive generations of technologies) with relatively little alteration of the societal embedding of these technologies.” (Elzen and Wieczorek, 2005, page 651)

In this transition process firms are still main objects of the analysis as there are main actors in supplying those societal functions. Firms are crucial players in transition to sustainability as they have many assets and resources which they can use to stimulate changes (or hinder change). The specificity of transition scholars is to consider all the sociotechnical dimensions that influence firms innovation, and how firms innovation influence also the sociotechnical regime : “The content and form are given to technological developments simultaneously with the construction of their context” (Schot, *et al.*, 1994, page 1063). Then those scholars adopt a co-evolution perspective of change. Artefacts alone aren't useful to fulfil societal functions, their functionality results by the combination of material and immaterial elements like technology, markets, regulation, user's practices, infrastructures, cultural meanings that Hughes' metaphor of seamless web (Hughes, (1987) usefully describes. This combination of elements that fulfil socially valued functions such as transportation, energy supply, communication and feeding has been conceptualized with the term of socio-technical system (B. Elzen, F. W. Geels, K. Green, 2004).

Bringing together contributions by evolutionary economics and innovation studies with cultural studies and science and technology studies, transition to sustainability via system innovation is intended by transition management's scholars as “a transition from one socio-technical system to another”⁴, a radical process of change that involves many of its components. System innovation involves technology substitutions, co-evolution and the emergence of new functionalities (B. Elzen, F. W. Geels, K. Green, 2004). New technology emerges, diffuses and then replaces the older existing technology. Changes occur in all components of socio-technical system, not only on the supply side but also on the user side, in a co-evolution of socio-technical system components: users'

⁴(cit p.2 Geels, F. W., 2005. Technological transitions and system innovations: a co-evolutionary and socio-technical analysis. Cheltenham, UK; Northampton, Mass.: Edward Elgar Pub.)

practices, laws, infrastructures and cultural meanings. As a result of this transition, system innovation could articulate new functionalities (Abernathy and Clark, 1985).

The literature on innovation suggests that new entrants tend to develop radical niche-innovations, while incumbent firms develop more incremental innovations. This view has served the multi-level perspective, a main approach of socio-technical transition studies.

1.2 Multi-Level Perspective to understand transition

Transitions scholars have developed the multi-level perspective (MLP) as an analytical frame for the empirical study of radical socio-technical innovation (Rip, 1998). To understand the complexity of socio-technical transition, this heuristic multilevel framework combines contributions from evolutionary economics, sociology of technology, structuration theory and neo-institutional theory. A transition is considered as a non-linear process resulting from the interaction of changes at three analytical levels: *Socio-technical regimes*, *Socio-technical landscapes*, *Technological niches*.

Socio-technical regimes

MLP presents the socio-technical regimes dimension as: « *the rule set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures.* » (Rip, 1998, p. 340) Rules are broadly embedded: users, suppliers, financiers, policy makers, various societal groups, researchers and not only engineer's community share regime's rules and exert influence on technological innovation process. Yet, *Socio-technical regime* is the set of routines and rules followed by social groups that provide to socio-technical system's creation and reproduction.

Socio-technical systems stability have been analysed by scholars under the concept of *path-dependency* and *lock-in*. Acknowledging "*that system innovation literature has not paid much attention to the transition from one system to another*"⁵, Geels contributes to the analysis considering the role of regime's rules and network of actors in providing system's resilience: "*By providing orientation and co-ordination to the activities of relevant actor groups, ST-regimes account for the stability of ST-configurations. This stability is of a dynamic kind, meaning that innovation still occurs but is of an incremental nature. In evolutionary terms, ST-regimes thus function as selection and retention mechanism*". (Geels F. W., 2002 *Cit p.1260*) .

Social groups form sub-regimes and are rather autonomous but interdependent with the others; the stable actor networks and the connections and co-evolution of sub-regimes are ensured by social groups' activities, which are coordinated and regulated by aligned rules, structures, practices. This leads to interlinked trajectories on multiple dimensions of socio-technical systems, such as technology, scientific knowledge, infrastructure, cultural meanings, industry networks, policy, market and user preferences.

⁵*cit. pag.910* (Geels F. W., From sectoral systems of innovation to socio-technical systems. Insights about dynamics and change from sociology and institutional theory, 2004)

Trajectories' alignment shows how the socio-technical regime, forming the "deep structure" of a dominant socio-technical system (Geels F. W., From sectoral systems of innovation to socio-technical systems. Insights about dynamics and change from sociology and institutional theory, 2004), enhances path dependency and lock-in mechanisms. As examples, sunk investments in competencies, infrastructures and instruments (Christensen, 1997.), cognitive routines that bind engineers (Nelson and Winter, 1982), regulations and standards (Unruh, (2000).) etc. that lock the socio-technical system and discourage radical innovations (Geels F. W., 2002). Socio-technical regime represents the "rules" that affect actors' actions, resulting in system's elements reproduction.

Socio-technical landscape.

The socio-technical landscape is the higher level, the broader context that exerts influence on niche and regime dynamics (Rip and Kemp, 1998) and may create opportunities and exerts pressure to foster regime transition. This level is the *external* environment that comprehends demographical trends, environmental problems, societal values, cultural trends, macro-economic developments and political ideologies. As the metaphor of landscape suggests, it is formed by profound structural tendencies and evolves slowly; it cannot be easily influenced by the other levels, especially in the short term, but even if socio-technical landscape tend to be stable, some shocks could occur, such as wars, quick changes in oil prices or critical environmental crisis.

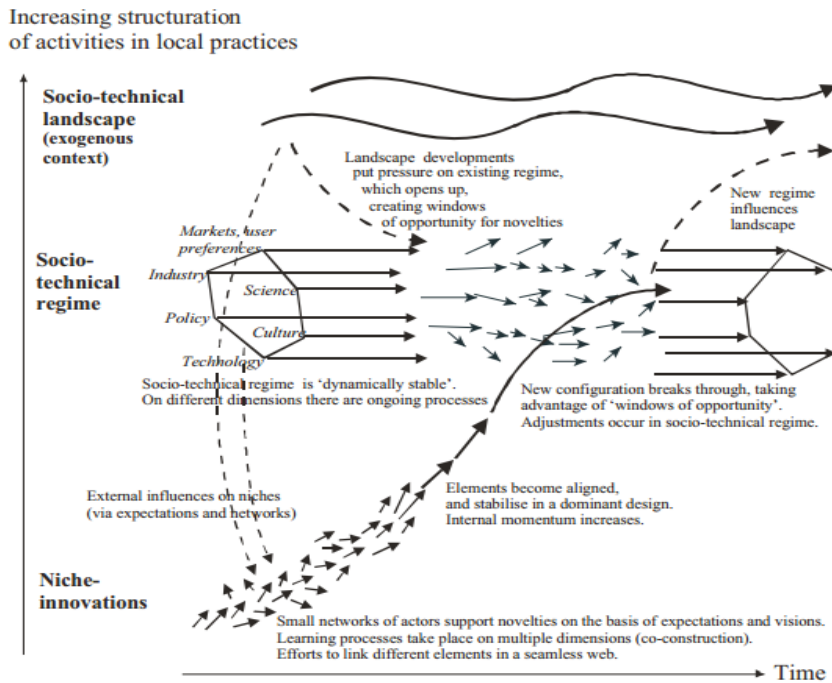
Technological niches

Niches are alternative sociotechnical systems composed of outsider actors, holders of challenges for the future (Kemp, *et al.*, 1998). Niche's actors are not locked-in by routines, rules and standards like incumbent regime's actors; thus, they're able to innovate in a more radical way, mobilizing different knowledge and competencies. Considered the *innovation loci*, niches could foster new products development as well as technological, procedural, organizational or regulatory innovation.

Transition's dynamic

The alignment between and within the three nested levels account for stability but also for transition from one system to another. General dynamic of socio-technical transition derives from the interaction of processes in the three nested levels: - niche innovations build up internal momentum, -modifications in socio-technical landscape level exert pressure on the socio-technical regime, - as a result of regime's destabilisation, windows of opportunity for niche innovations open. A radical novelty could develop inside a niche; after its consolidation, it can diffuse in incumbent socio-technical system. In this case, a novelty is capable to break regime's lock-in and a transition phase opens. Niche development is enabled by some processes: the articulation of a shared view for the future that guide innovation and tend to attract resources and interest from external actors, the building of the social networks that support niche's innovation and the learning and articulation process that occur in all the dimensions of this alternative socio-technical system.

Figure 1 Transition Dynamics (in Geels, 2004)



MLP approach was effectively used for many case studies that describe historical transition in cargo handling (Van Driel and Schot, 2005), industrial production, aviation, as well as land transport (Geels, 2005) and shipping (Geels F. W., 2002). MLP is also used to analyse “transition in the making” in (Verbong & Geels, 2007; Hofman & Elzen, 2010), biogas (Raven, 2004), mobility and electric cars (Nykqvist and Whitmarsh, 2008; Van Bree *et al.*, 2010; (Geels *et al.*, 2011); and also agro-food systems, notably as regards organic food (Smith, (2007) pig husbandry (Elzen *et al.* 2011) or alternative food networks (Rossi & Brunori, 2010, (Brunori *et al.* 2011)for instance. But little attention has been paid on meatless transition in agro-food sector. We propose to analyze how firms currently innovate on legumes-based food products, taking into account these different dimensions of socio-technical regime that could shape their innovation process.

2. Materials and methods

We’re not intentioned to review all the sorts of products with grain-legumes on the market. The purpose of this study is to select new food products on the market that, potentially earning an important place in everyday life menus, and could significantly contribute to the re-discover of grain-legumes in human diet and, in consequence re-launch their cultivation in more sustainable cropping systems. We select seven case studies to conduct open-ended interviews with CEO and/or R&D managers in agro-food manufacturing firms, that have launched new grain-legumes-based food products during the last ten years with access to large-scale retail channels (like supermarkets).

2.1 Interview's guide

Interviews focus on the reasons for which firms decided to develop and launch on the market their innovative legumes-based products, and to understand how the different dimensions of Socio-Technical Regime influence this process. We provided a list of questions that explore all the spectrum of that dimensions (Geels, 2002) adapted to our subject.

(a) *User's practices*

The questions were on the perception of the firm of consumers' expectations and practices; the aim is to understand why the company decided to develop such product and how the product itself could influence user's practices too. Did they take into account nutritional and environmental issues related to pulses?

(b) *Scientific knowledge*

The topic was to understand how *scientific knowledge* has been mobilized in research and development processes. For example, did the company establish partnerships with institutions, universities, nutrition services or did they do all the process with internal resources? Which are the nutritional aims that guided product's formulation?

(c) *Markets*

Market positioning and how consumers and markets respond to it is a key to analyzing innovative capacity of these products. We asked questions about pricing differences with traditional products, chosen segment and distribution channels. Moreover, we wanted also to know what kind of acceptance markets showed for these products.

As regards markets, we are very interested also in understanding how these products innovation involves agricultural production. We intended questions on pulses' origin and their selection's criteria, on the presence of supply contracts that require cultural rotation with legumes and on their eventual ambition to boost legumes cultivation in Europe. We also scheduled some questions concerning their perceptions about lock-in factors that curb pulses utilization and if they had suggestions for researchers about particular issues.

(e) *Policy-Institutions*

As Institutions and legislation are crucial to innovations emersion, we wanted to investigate whether a political decision like a nutritional recommendation had been relevant to the choice of developing the product or affected its diffusion; we also wondered if the firm was engaged in collaborations with institutions and how the position of pulses on different national Food Pyramids could influence their consumption. Particularly speaking of pasta, we intended to ask if the legislation about product's classification could be a relevant limit or not.

(f) *Technology*

Product innovation may require new technological processes to transform ingredients, to adapt the production chain. Do firms have the resources to conduct those technological changes or do they develop new relations interfirms with subcontracts to accomplish a part or the totality of the new product. R&D's work also involves the research of a certain taste, color and texture that are crucial for consumers' acceptance: how this factor influence technological research ? We also investigated if the enterprise decided to patent the technology used.

(g) *Infrastructures*

The focus was on the influence of the *infrastructure regime*, and particularly how different infrastructures and distribution chains affect the choice to develop and commercialize the product on a market rather than on others.

2.3 Case studies' selection

Our study is limited to some Italian and French companies whose products are representative of Mediterranean diets where pulses are broadly embedded. This choice was also made because our main interest is the development of European pulses production and consumption. One exception was made in the case of multigrain pasta which is sold by an Italian company (Barilla) but only on North-American market (for the moment), but useful for comparison.

Regarding to company's size characteristics selected products are offered by a variety of enterprises, enabling to look for insights on how innovation and research and development process are structured and took place in different organizations. Furthermore, in innovation systems' literature incumbent firms are in general more reluctant to radical innovations: we wanted to understand if in our cases this dynamic is confirmed or not.

Two types of products currently developed were identified: pastas made with pulses' flour⁶ and precooked mixes of pulses and cereal grains. The majority of them have been launched over the market during the last two years, so we can actually talk about innovation food products.

⁶ Both as primary or secondary ingredient

Fig. 1.1 Case studies' presentation

Product	Typology and grain-legumes used	Product's launch	Distribution's Channels	Company (and date of foundation)	Company size
<i>PastaPlus</i>	Multigrain Pasta Chickpea, lentil	2005 – Usa 2014 - Canada	Large-Scale Retail Trade, FoodService	Barilla (1877)	Large multinational
<i>Pasta Orizzonti</i>	Spelt-lentils Pasta	2006 - Italy	Large-Scale Retail Trade	Barilla (1877)	Large multinational
<i>Lentille Faciles</i>	Cereal-Legumes precooked mix lentils	2016 – France	Large-Scale Retail Trade	Panzani- Lustucru (1950)	Large, owned by a Spanish Group
<i>Pasta Wellness</i>	Durum wheat- Chickpeas Pasta	2016 –Italy, Northern Europe, Northern America	Large-Scale Retail Trade, Specialized Shops, FoodService	Delverde (1967)	Small, Owned by an Argentinian Group
<i>100%Legumi</i>	100% Legumes Organic Pasta (green lentils, coral lentils, mixed lentils, chickpeas, green soy, pea)	2014 - Italy	Organic Retailers, Pharmacies and Para- Pharmacies, Herbalist's shops	Fior di Loto (1972)	Small
<i>Mélange gourmands céréales-légumes secs</i>	Cereal-Legumes precooked mix (Blond, green and coral lentils)	2015 - France	Large-Scale Retail Trade, FoodService	Sabarot (1819)	Small
<i>Mélange céréales-légumes secs</i>	Cereal-Legumes precooked mix (lentils, pea, lupins)	2013 - France	Large-Scale Retail Trade	Tipiak (1967)	Medium

The Figure 2.1 presents those case studies. In three cases innovation are provided by large companies and other cases, by SME⁷. Those companies experiment various degrees of export's vocation, no matter companies' size. Regarding to distribution channels, the vast majority of companies commercialize their products through Large-Scale Retail Trade, with their own brand and/or for other private company. One case we found that the main distribution is via Organic Shops, pharmacies and para-pharmacies.

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⁷ Small and Medium Entreprises

2.4 Case studies' presentation

The first case study is the multigrain *PastaPlus* that Barilla commercializes within the US since 2005, and the second is pasta *Orizzonti* from the same firm. Barilla is an Italian based multinational enterprise, family owned, that has more than 8000 employees and a turnover of 3,254 billions Euro⁸. The enterprise commercializes pastas, pasta sauces and ready meals, as well as bakery product. Its presence in the USA dates the first '90s and US' market is only second of importance after the Italian one. We interviewed the actual Global Ready Meals Director chez Barilla, responsible de R&D Barilla America when *PastaPlus* was developed, and an agronomist that worked for Barilla in that period.

Lentilles Faciles is a precooked cereals-pulses mix sold in the French market by Lustucru, a subsidiary of Panzani. The latter is the first French pasta maker, employs more than 1180 workers, its turnover in 2011 was around 565 millions Euro and it's owned by the Spanish Group EBRO. *Lentilles Faciles* line has been launched on the market in 2016, composed by 2 cereal-pulses mix (Coral lentils, rice and quinoa; yellow lentils, blond lentils and rice), a mix of green and blond lentils and green lentils only. All products are packaged in cooking bags and precooked, requiring only 5-8 minutes of extra cooking time. The interview was carried out with one of the directors of R&D at Panzani.

The fourth selected case study is Chickpeas pasta "Wellness" from Delverde, a small scale Italian pasta owned by an Argentinian group⁹ which has a strong export vocation, selling toward more than 70 countries. The new pasta is made of durum wheat and 30% of chickpeas flour, and requires 8-9 minutes to be ready. The product has been launched in the first months of 2016 on the Italian, Northern Europe and Northern America markets, via Large-Scale Retail Trade, Specialized Shops and FoodService. We interviewed the Delverde Brand Manager.

100% *legumi* organic pasta is proposed by Fior di Loto, a small Italian company specialized in organic food that develops and commercializes products manufactured by contractors. Fior di Loto has 30 employees with a turnover of 22 million Euro in 2015. The company has a strong vocation to food products innovation and proposes a large offer of pulses-based products. This product line is made of 100% legumes flour and comprehends many types of pasta: green lentils, coral lentils, mixed lentils, chickpeas, green soy, pea. On the market since 2014, some of them present the coeliac labelling. They are marketed via Organic Retailers, Pharmacies and Para-Pharmacies, Herbalist's shops and coeliac shops, Large-Scale Retail Trade. A responsible from Marketing and Communication participate to our study.

Sabarot, a French enterprise, markets this pre-cooked cereal-pulses mix since the beginning of 2016. *Mélange gourmands céréales-légumes secs* line presents seven references: Riz des 2 mondes (basmati rice, white and red quinoa), Céréales et lentilles (boulgour, wheat, green lentils, coral lentils), Trio de quinoa (white, red and black quinoa), Mélange 4 céréales (couscous, soy, oat, barley), Quinoa et boulgour, Mélanges 5 graines (wheat, rice, lentils, flaxseeds), basmati rice and pulses (Basmati rice, coral and blond lentils, pea). It requires 9-10 minutes of cooking time. We interviewed M. Antoine Wassner, CEO at Sabarot.

⁸ 2014 data

⁹ *Molinos Río de la Plata s.a.* is the Argentina's largest branded food products, a multinational that controls Delverde since 2009.

3. Results

3.1 Consumer's preferences

As confirmed by interviews, in last years the Agro-food industry has been increasingly involved in the proposition of new plant-based food, among which legumes-based products. All the analyzed products are part of this phenomenon that originates as a response to a general societal demanding of new vegetable protein products, of functional¹⁰ and healthy products as well as vegetarian/flexitarian instances¹¹. Surveys commissioned by enterprises show that this range of products has a great potential of growth¹² and assures higher economic margins than classical products. These first considerations give us some insights of the increasing interest from agro-food industry to the sector of new pulses-based products.

Enterprises individuate the *targeted consumer* as a medium-upper class's person that wishes to eat more naturally and healthy, with a relatively high purchasing power and little time to cook. Pasta products took in consideration consumers' preferences for whole grain pasta as well as for pulses in terms of taste, nutritional richness and symbolic meanings as part of food tradition. The idea is to provide a "non-punitive" wellness food that combines taste to health. Cereals-legumes mix products were developed not only around taste preferences but also in reference to visual preferences, using grains and combining different colors. The "*gourmand*" and visual aspects play a major role in purchase's determinants, as well as practicality (short time cooking, single-portion bags). Texture and other sensorial aspects are in general taken in account by all firms. Excepting for the organic 100% legumes pasta, studied products are mainly directed to the great audience of Large-Scale Retail Trade consumers and in some cases to foodservice.

Only Fior di Loto and Barilla were more influenced by particular diet trends. Fior di Loto takes more in consideration vegetarians and the recent *free from* trend, as they expressively developed their pasta to enlarge their gluten-free offer, a sector where they're specialized. The firm consider their pasta as more targeted at people looking to reduce allergens, to vegans/vegetarians, and to athletes looking for plant proteins source. *Diet trends* had a marked decisive influence in Barilla PastaPlus case. At the turn of the century Barilla was involved in a global project of product innovation in order to match the rising demand for functional food. They started to work on pasta enrichment using natural ingredients. This process was accelerated by the *low carb diet*¹³ diffusion that strongly affected pasta sales, convincing Barilla to accelerate the launch on the US market PastaPlus at the end of 2004. In response to low carb diets, their idea was not to offer a no carb product but a well-balanced pasta made of natural ingredients, the ideal product for the mother willing to offer a complete meal to their children. Pasta Orizzonti was developed in the same project and commercialized in Italy since 2006.

One determinant *purchasing factor* is easiness and quickness to prepare, in compatibility with modern way of life. People are more aware of pulses benefits, but have little time to cook them. The

¹⁰A **functional** food is a food given an additional **function** by adding new ingredients or more of existing ingredients

¹¹ Which aim is the reduction of meat consumption

¹²This trend is referred to France and Italy, and more in general to Europe

¹³ Like Atkins diet.

empirical study confirmed that long time required for pulses preparation is a crucial lock-in to overcome in order to re-launch their consumption.

Analyzed enterprises are well aware of legumes *benefits* both at nutritional and environmental level, but the two issues aren't particularly taken into account in product's development and commercialization. Mostly of the products are developed to answer to the ongoing consumers' request for new healthy, natural and vegetal food, whether instances for a more environmentally sound alimentation seem to be less important. Advertisements on packaging, which are rarely focused on foods' nutritional benefits, not even pay a word for the environmental aspects, not perceived as determinants for purchasing¹⁴.

Only in one case a firm admitted that they took inspiration from another product already marketed by competitors, but it was not the case of a niche novelty. In none of the cases the intention to directly propose an alternative to meat was founded, products' development has not been guided by that aim and they all lack in amino acids. Firms consider that this issue has a big potential for future development, but for the moment they remain prudent¹⁵. This is particularly true for French enterprises, who see the potential growth of plant-based food but consider French strong "meat culture" as an obstacle that doesn't allow their diffusion at the level of other countries. On this point Sabarot's case is interesting as it shows an engagement in the issue of plant/animal protein rebalancing. In a co-evolutionary dynamics, starting from surveys that show consumer's interest in it, they're engaged in supporting support vegetarian and flexitarians tendencies by advertising on packaging and by the creation of a website, <https://www.lundi-veggie.fr/>, in which they wish to involve other enterprises. This website provides vegetarian-recipes and aims to propose a free-meat Monday every week. Firms also remarked that the International Year Of Pulses influenced the increase in consumer's attentions on these products; this landscape factor favored the extension of the segment and the enlargement of product lines.

3.2 Scientific and technical knowledge in product development and production

Development processes followed different paths, with a various degree of R&D internalization depending on firms' structuration and availability of knowledge. Barilla carried out a totally internal development process. They implemented a screening of all legumes' nutritional, technical and functional properties in order to find the proper combination of ingredients. The aim was to create a balanced product under all nutritional components, of which amino-acids balance. Barilla buys already mixed flour by exclusive contractor, and then processes it internally. Pulses flour is difficult to be treated, because of the absence of gluten, and need a thermic process before dough formation. The production chain required many investments for adaptation, notably in the first parts where ingredients are mixed and dough created. R&D took place in Italy, as well as the production for the first two years of PPLus; after, the pasta is produced in the USA. On the contrary, as Fior di Loto is a small-medium enterprise(SME) that doesn't produce directly its

¹⁴ As suggested by one interviewee, Italian and French consumers are more interested in organic and vegetal products for their taste and quality and nutritional aspects; instead, in northern Europe, environmental sensibility on food issue is more developed.

aliments, once they had the idea of *100% pulses pasta* they started to search a pasta fabricant to develop it. As they didn't find necessary technical knowledge in Italy, they established collaboration with a French contractor who had already produced pulses pasta, convincing him to continue its development; the process took the form of a *co-evolution*, with many trials to prove performances of different formulations and shapes, and also took advantage of some chefs' advices. They encountered many difficulties in cooking resistance, as many legumes cook too quickly. The development process conducted to one only shape in many formulation. Raw legumes flours are difficult to manipulate, they're working with an Italian producer that uses pre-gelatinized in order to facilitate the process.

Delverde also mobilized external knowledge resources in order to develop their pasta. They conducted both internal and external tests, and after a year they set up the final recipe and the supplier. First tests were made in external production site, once developed the product is internally processed in *ad hoc* production chain. Panzani developed the conception of *Lentilles faciles* but knowledge about legumes precooking wasn't available internally, so the firm has to resort to a third part supplier. They found a contractor specialized in thermic treatment in Italy, the enterprise Pedon which is European leader in the sector. Panzani buys lentils in France, which are precooked by Pedon and then packaged in France. In developing their product they didn't particularly take in consideration the nutritional side as not perceived prior in users preferences. Sabarot and Tipiak too followed the similar path development of Panzani, establishing supply connections with Pedon for the same reasons. Moreover, most of producers declare that anti-nutritional factors have been generally resolved by thermic processes, as well as legumes problems related to digestibility and flatulencies.

Thus, excepting technical and nutritional aspects, ingredients' formulation has been guided by considerations on consumers' preferences¹⁶, market availability and allergenic risks. As resulted by interviews, none of the firms decided to patent their products and preferred to remain in the industrial secret. They justify this choice because of the relative simplicity of products or because are processed by contractors.

3.3 Market positioning and acceptance

Products are positioned at a premium price. They're mainly sold in big commercial surfaces¹⁷, well interested because of bigger margins of gains than classical products, where they're placed in pasta's section or in pulses grains' section in the case of *mélanges*. In only one case they're also sold under private label (Sabarot). Foodservice is a sales channel that firms try to experiment but remains less developed, a sector that shows interest but mainly because of price reasons sales remain low. Barilla PastaPlus reached an important goal in receiving, after extensive review by the USDA, the possibility to be served in US school's canteens, proposed both as a meat and a bread alternate¹⁸.

¹⁶ This included also visual criteria, which lead to the use of blond lentils, and other considerations like the idea that beans generate flatulencies, that lead to their exclusion.

¹⁷ Excepting Fior di Loto's pasta, see paragraph 4.1

¹⁸ Because of the unique formulation, which includes a high-quality protein-rich mixture of lentils, chick peas and egg whites, USDA approved the pasta to contribute 1 ounce of meat alternate and 2 servings of bread alternate in the federally-reimbursed foodservice programs. Barilla PLUS is the

Delverde is the only that sold in other markets, in countries where wellness pastas are already developed (Northern Europe, Germany, USA, Canada). Registering interest from France too, they forecast an expansion in all Europe. Products received a general good acceptance from consumers, with constant sales' augmentation. I.e., even if commercialized since few months, Delverde registers good results (+5% of sales per month, and increasing demands from retailers) and Fior di Loto sold around 18000-20000 units/6 months.

Barilla's case merits deepening, because of its two products are sold from more time and because, whether inscribed in the same development process, their destinies follow divergent paths. PastaPlus is already sold in US since 2004¹⁹; American market showed a good acceptance of the product with increasing sales until 2008-2009 and than stabilization. After 10 years PastaPlus continues to sell millions of units per year, confirming that it was the good response to a consumer demand for more rich foods. In 2015 Barilla changed the name in ProteinPlus in order to re-launch it. Many enterprises tried to copy Barilla PastaPlus but didn't remain in the market. On the contrary, Orizzonti pasta registered success at the beginning (2006) but remained on the market only few years because of external factors (economic crisis) as well as Barilla's strategic errors (contemporary launch of whole grain pasta, lack in communication..), but also for cultural factors and tradition.

3.4 Agricultural production

Regarding to pulses' origins, different tendencies were registered. Big enterprises that require big volumes privilege price competitiveness: Barilla uses pulses from Canada for PastaPlus and from Turkey for Orizzonti because of price, availability of needed varieties and market nearness. Panzani uses French lentils while Sabarot uses them only partially. Delverde and Fior di Loto utilize European raw material, the second due to too high prices of Italian organic chickpeas.

None of the enterprises declare to have direct contact with agricultural producers, as they buy flour or grains from a distributor. Questioning about crop rotation of wheat-pulses, no supply contract that requires it has been established. Only Barilla has knowledge that their wheat suppliers in Europe practice crop rotation with pulses; but those cultivated pulses aren't used, because they don't have legumes-based outlets and because of price reasons. For Barilla interviewee, France and Spain could be competitive on European pulses market because of their vast agricultural surfaces, on the contrary Italy could re-launch pulses' production only by local specialties valorization and by organic cultivation. Other interviewees pointed out bad seeds qualities, low yields and plants fragility and vulnerability to illnesses as the crucial issues that require improvements in order to foster European and French production.

first pasta to contribute both meat alternate and bread alternate to USDA's menu planning requirements. Barilla PLUS packages carry a USDA Child Nutrition Label

<http://www.schoolbuyersonline.com/doc/barilla-plus-pasta-offers-schools-a-healthy-m-0001>

Food Buying Guide for Child Nutrition Programs :

http://www.fns.usda.gov/sites/default/files/FBG_Section_1-MeatAlternates.pdf

¹⁹and since 2014 in Canada too. Barilla also tried to launch PPlus in Sweden, where consumers' characteristics are more similar to those of anglo-saxons, but it lasts only a year.

Finally, an effect of International Year of Pulses has been remarked by one interviewee, resulting in the augmentation of their French supply of grains. Another interviewee noticed that caused also an augmentation in pulses' flour requests from food industry that wasn't especially expected by suppliers, resulting in lack of raw material.

3.5 Policy-Institutions

Firms didn't perceive the issue of denomination's rules regarding pasta products as a particular constraint. For some, legislation consents to denominate as "pasta" products with other ingredients than durum wheat within certain limits. Others avoid the problem by calling their products "specialties" or without calling it pasta but directly using shape's name: "fusilli", "penne" etc. In any case, enterprises don't consider this as a critical issue and doesn't claim for a regulatory reform. Anyway, this aspect deserves more deepening. Therefore Fior di Loto found that legislative uncertainty about taxation of legumes obliged them to apply a 10% tax ratio instead of the 4% ratio of traditional pasta. But, after consulting Italian Borders' Authority, they were able to apply the 4% ratio with favorable impact on final price.

Barilla remarked that comparatively to Europe they are able to establish better relations with institution in USA, where is more easy to individuate the competent authority on a determinate issue. It is thanks to these good relations Barilla PastaPlus obtained the possibility to be served in schools. Sabarot tried to establish a dialogue with French authorities in order to influence pulses reclassification as protein source in French National Food Pyramid. This measure permitted to foster legumes' consumption in countries where it was adopted, but for the moment the enterprise request doesn't got an answer.

3.6 Infrastructures

Regime's infrastructures doesn't particularly account for product development and commercialization.

4. Discussion and conclusion

We first propose a discussion on the operationalization of the MLP framework used.

Firstly as regards the co-evolution with landscape. Windows of opportunity for new legume-based food products are opened by societal evolutions towards more vegetable diets and supported by environmental, nutritional and economic landscape factors. Indeed the International Year of Pulses proclaimed by FAO in 2016 that promotes those key opportunities is such acknowledged by the interviewed firms of our study. But our study shows that those landscape factors are still little promoted by those firms. They use this opportunity of combined social tendencies towards new functional food requests, vegetarian/flexitarian movements, gluten-free habits and low carbs-diets, that contribute to changes users' practices and preferences; but they do not try to reinforce this tendency by promoting expressly this discourse through marketing strategies, except for one firm that launch its proper private "veggie" label. Indeed, to take advantage of these market opportunities they set up a differentiation strategy by using new raw materials, rather than pointing out legume's nutritional and environmental benefits. Development and marketing strategies were mainly oriented to offer new, attractive and practical foods. In product development, only some of them worked on the formulation looking for particular nutritional aims. Ingredients choice was

mainly influenced by technical factors as well as by visual, symbolic and tasting consumers' preferences as interpreted by firms. On the marketing side, legumes' nutritional benefits are scarcely advised and environmental properties are never mentioned. One firm tries to support and influence user's practices toward sustainability by providing a website and a private veggie label that promotes meatless choice in diets.

Secondly as regards the hypothesis that innovations are coming from niche actors. Contrary to MLP framework, innovative actors could be niche's actors looking for expansion (like Fior di Loto) or incumbent regime's actors looking to re-launch (like Barilla), all intentioned to play a role in the growing new plant-based food on the market.

Thirdly, as regards diffusion of innovation. Those food product innovations are linked to incremental technological innovation, as technological processes have been adapted from existing ones. At the scale of agro-food system, those new products are strongly innovative, related to capability to favour a greater insertion of legumes in everyday diets, influencing eating patterns and agricultural production. As our research pointed out, their contribution to such a transition is still "in the making". But none of the firms deposited a patent as they prefer secrecy. This could curb innovation's diffusion. On the other hand, due to a lack in technological knowledge about legumes processing, many firms were forced to search external partners. These collaborations with other actors in development and production processes as well in the supply of raw materials, permit to create a first specialized network that could contribute to diffuse technological innovations and to support further novelties based on legumes. How these innovations take place and diffuse in relation to firms' size and others characteristics merit further researches.

Moreover, these products generally registered good interest and sales between consumers. Large retailers show vivid interest for these products, as they permit higher economic margins than traditional products, and firms mostly tend to commercialize via this channel. Excepting the successful PastaPlus case of insertion in school canteen menus, Foodservice result less interested. This is mainly explicated for price reasons and because emersion of new tendencies is slower, especially in the catering sector. But, as we learned in another interview with one of the leaders in catering service, something is moving even in that sector, which for its characteristics could be key for the re-launch of pulses in current alimentation and certainly deserves further studies.

As regards institutions that play a major role in transition processes. Public institutions reveal a supporting role only in the mentioned case of PastaPlus (developed in America) for the diffusion of these products. Other case studies in France and Italia show that institutions weren't proactive and firms established relations connected to regulative issues only in two cases. One of them tries to influence the regulatory frame proposing the classification of legumes as protein source in nutritional recommendations.

On the supply side, firms in general are not engaged in direct relations with producers. Moreover, as they don't give particular importance to the environmental benefits of legumes, they don't show interest to establish contracts that involve cultural rotation with pulses with their suppliers of wheat. As in product's formulation the choice of legumes was not driven by environmental factors, so is the issue of their origins, poorly related to geographical origin or to sustainable cropping techniques. That means that an increasing consumption of legume-based food

could not necessarily result in an increased European legumes production: evaluating the co-evolution of food consumption and agricultural production is crucial to assess the sustainability of their contribution to agro-food transition.

To conclude, this study puts in lights the usefulness of MLP framework to analyse firms' innovation dynamics as a co-evolution process. But some of the hypotheses of MLP have to be moderated, such as the role of niche actors in promoting radical change. This transition "in the making" concerning grain-legumes in agro-food sector could be more considered as an accumulation of innovation products, coming from both incumbent and niche actors. One challenge now is to analyse how those changes can have impacts on agriculture in order to promote more grain-legumes cultivation in western countries.

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