Innovation capacity of the agricultural sector: network of productive interactions, knowledge transfer and differentiation mechanisms

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To my parents, my sister, my brother, my life partner and my son

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Abstract

Economic growth is increasingly explained and driven by knowledge acquisition and firms' capabilities to adapt to new evolving situations to fit economic, societal and environmental frames. Strategic behaviour of private companies in differentiating and promoting their products and services is crucial for their competitiveness. In parallel, public research performed at different territorial levels and by a high diversity of actors is a strategic source of key assets adding value to the firms. External actors operate in a non-linear structure allowing frequent feedback and interactive loops in order to optimise the replies to substantial problems and constantly valorise their resources. These features are explored in the thesis through different projects. This dissertation is motivated by international negotiations in the frame of the GATT agreements and bilaterally between the European Union and Switzerland that are going towards the breakdown of borders, threatening the competitiveness of the Swiss agriculture. Negative externalities will affect small firms composing this agricultural network. Thus, the dissertation is focusing on innovation as a strategic asset to maintain the competitiveness and differentiate the domestic agricultural products.

The first research project concentrates on interactions occurring in the Swiss apricot network. We investigate the types of interactions producing innovations that come from different sources that are internal or external to the agricultural production supply chain. We use network theory to model the structure of the domain and understand what is inherent to innovation production thanks to collaborations through an empirical work.

In the second research project, we examine whether there is a connection between the issues faced by small companies producing food and the innovative solutions and knowledge generated by research institutions. The importance of solutions to daily activities conducted by companies depends on the nature of the sector. Thus, research projects providing outputs like publications might not specifically target these issues. Moreover, access, awareness and affordability of innovations can be hindering factors for small firms composing a low-technology intensive sector. Gaps of knowledge transfer, innovation and implementation are identified in this setting.

In the last research project, we address market failures hampering economic and strategic management decisions encountered in the agricultural sector. We empirically construct two case studies highlighting the necessity of intellectual appropriation mechanisms. We explore the use of patents and regional trademark to add value to the emblematic product of a small region. Organisational and marketing innovations have to be supported and diffused by key stakeholders, aiming a good communication based on criteria that take into account diverse interests of those stakeholders; consumers have to be involved in the innovation process.

Furthermore, knowledge transfer, innovation generation, diffusion and implementation rely upon the will of stakeholders to take part in an efficient process of interactions and communication in

order to produce and perform useful products and services. Practical implications are levered in the projects presented.

Finally, digital technologies are efficient for information exchange and can decrease time and transaction costs. These technologies are explored as part of the solution to small firms' challenges. Some examples related to the three research project realized are given.

Keywords

Innovation, small and medium-sized enterprises, traditional food production, knowledge transfer, network, informal collaborations, intellectual property rights, basic research, applied research, digitalization

Résumé

La croissance économique est de plus en plus expliquée et axée sur l'acquisition de connaissances et la capacité des entreprises à s'adapter à de nouvelles situations évoluant rapidement pour correspondre aux cadres économiques, sociétaux et environnementaux. Le comportement stratégique des firmes privées pour différencier et promouvoir leurs produits et services est crucial pour leur compétitivité. Parallèlement, la recherche publique réalisée à différents niveaux territoriaux et par une grande diversité d'acteurs est une source stratégique de ressources et biens clés ajoutant de la valeur à ces firmes. Les acteurs externes opèrent et interagissent selon un schéma non linéaire permettant la réalisation fréquente de boucles interactives de façon à optimiser les réponses aux problèmes substantiels et valoriser les ressources de manière constante. Ces éléments sont explorés dans la thèse à travers différents projets. Cette thèse est motivée par les négociations internationales qui ont lieu dans le cadre du GATT et bilatéralement entre l'Union Européenne et la Suisse, qui tendent vers une réduction des mesures mises en place aux frontières, menaçant la compétitivité de l'agriculture suisse. Des externalités négatives auront un impact sur les petites et moyennes entreprises composant le réseau agricole. Ainsi, la thèse se concentre sur l'innovation comme un actif stratégique pour maintenir la compétitivité et différencier les produits agricoles domestiques.

Le premier projet de recherche se concentre sur les interactions existantes dans le secteur arboricole suisse et plus particulièrement la production de l'abricot. Nous étudions les types d'interactions produisant des innovations qui proviennent de diverses sources internes et externes à la chaine de valeur agricole. Nous utilisons la théorie des réseaux sociaux pour modéliser la structure du domaine et comprendre ce qui est inhérent à la production d'innovation passant par les collaborations à travers un travail empirique.

Dans le deuxième projet de recherche, nous examinons s'il existe une connexion entre les problèmes rencontrés par les petites et moyennes entreprises opérant dans la production d'abricot et les solutions d'innovations et connaissances générées par la recherche. L'importance des solutions pour les activités quotidiennes conduites par les entreprises dépend de la nature du secteur. Les projets de recherche fournissant des résultats comme des publications peuvent ne pas cibler spécifiquement les problèmes des entreprises. De plus, l'accès, la prise de conscience et l'accessibilité des innovations peuvent être des facteurs d'empêchement pour les petites entreprises d'un secteur basé sur une faible intensité technologique.

Des manques dans le transfert de connaissances et d'innovation et de mise en place de ces solutions sont identifiés dans ce cadre.

Dans le dernier projet de recherche, nous abordons le thème des défaillances du marché en étudiant empiriquement le secteur grâce à deux études de cas, mettant en exergue la nécessité de

l’utilisation de moyens de propriété intellectuel pour faciliter le dépassement de ces défaillances qui entravent les décisions économiques et de gestion de la production. Nous analysons l’utilisation de brevets et d’une marque régionale pour l’ajout de valeur à un produit emblématique d’un territoire local. Des innovations marketing et organisationnelles doivent être soutenues et diffusées par les acteurs et parties prenantes pour optimiser la communication basée sur des critères prenant en compte la diversité des intérêts de ces acteurs ; les consommateurs devraient être inclus dans ce procédé.

Par ailleurs, le transfert de connaissances, la génération d’innovation, la diffusion et la mise en place reposent sur la volonté des acteurs à prendre part à des processus efficients basés sur des interactions et de communication pour produire des produits et services effectifs et utiles. Des politiques à mettre en place et des implications pratiques sont décrites à différents niveaux dans les projets présentés.

Finalement, les technologies numériques ou digitales sont efficientes dans l'échange d'informations et peuvent réduire les coûts de transaction. Ces technologies sont explorées en tant que solutions aux problèmes rencontrés par les petites entreprises. Quelques exemples liés aux trois projets de recherche réalisés sont donnés.

Mots-clés

Innovation, petites et moyennes entreprises, production traditionnelle agricole, transfert de connaissances, réseau, collaborations informelles, droits de propriété intellectuelle, recherche fondamentale, recherché appliquée, digitalisation

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Chapter 1 Introduction

Agriculture represents an important sector of the global economy, employing a large part of the population all around the world. Nevertheless, in the most developed countries the labour force share dwindled after the war periods. Therefore, the share of agriculture in Gross Domestic Product dropped sharply in these regions. Moreover, farm households need to maintain their competitiveness in a more globalized society in which economic growth is increasingly based on knowledge. Capabilities of firms to adapt to new political, economic, environmental and social frameworks are crucial and relate to their innovation capacity. Building up skills and knowledge in a constant changing environment is part of management strategies defined by numerous firms in order to be competitive on different levels (e.g. regional, national and international markets). To do so, small and big private firms need to use a bunch of resources inside and outside their boundaries. Financial resources, human capital investment, research and development programs and immaterial assets are further factors that are used by these companies to innovate. A trade-off between internal and external resources has to be made in order to ensure valorisation of internal resources and efficient and sustainable exploitation and exploration of external sources. Established interactions are promoting the existence of diverse flows of information, materials, knowledge and innovations, enriched by feedback loops between all stakeholders involved. These actors can play multiple roles like political and legal support, financial support, intermediaries to transfer different assets, promotion activities and dissemination of knowledge to the wider society for example. Collaborating with diverse types of actors implies the use of formal and informal channels. In small network and in industries not highly intensive in technology, informal interactions can prevail relying on tacit connections. This tacitness is more and more studied in the literature and has a lot to do with relationships between partners. Scientific content, methods and protocols are transferred through codified tools. However, social structures and information on organizational patterns can only be transmitted via tacit interactions. Thus, contextualizing appears to be essential in order to include all pieces of information when collaborating or transferring diverse elements. Finally, agriculture is context-dependent and highly shaped by external stimuli that are climatic conditions. Territory is a level of analysis that should be taken into account when studying firms' capabilities to innovate. In this dissertation, the focus has been put on a specific setting.

Figure 1-1 exposes the relations between the three research projects.

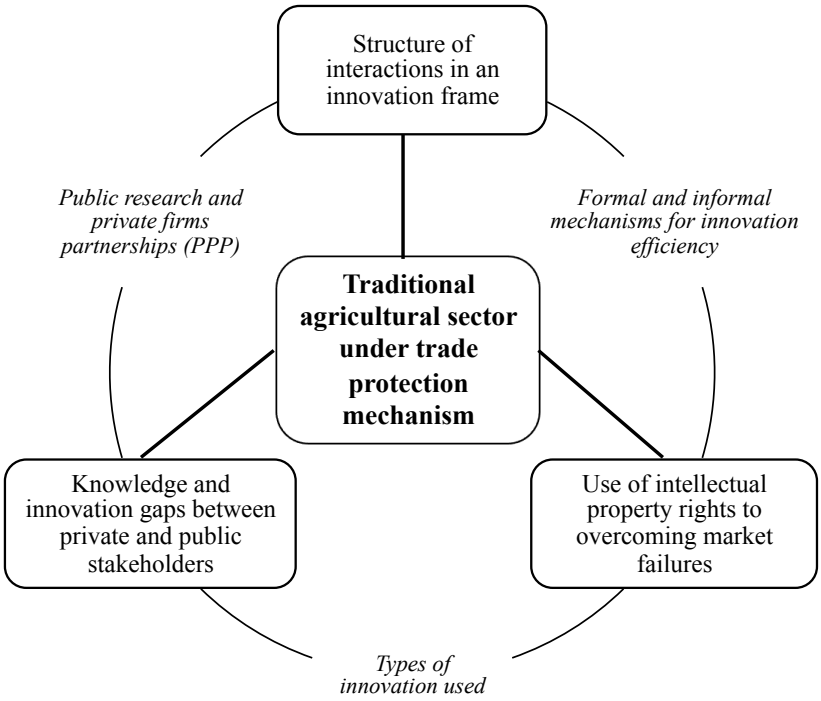

Figure 1-1: Three essays on innovation in agricultural domain

The primary purpose of this thesis is three-fold. We first deepen the understanding of the structure of a traditional agricultural sector located in a small European protectionist country. Second, we investigate the innovations developed in the sector via collaborations using different approaches to identify the knowledge and innovation gaps standing between two parts of the scientific community. We shed light on gaps related to knowledge transfer, innovation transfer and innovation implementation occurring in the selected sector. Political implications are then drawn from these works. Finally, we aim to determine whether the use of intellectual property rights in a traditional agricultural sector facilitates overcoming market failures faced by small firms in the domain.

The thesis is divided into four main chapters. The dissertation deals with the Swiss apricot sector that is a peripheral sector in the country and at the international level in terms of production volumes. This section presents the thesis overview and its contribution.

In Chapter 2, an overview of the agricultural sector, its evolution, the importance of technical change and innovation occurring in this domain are presented. This chapter enables to highlight the main elements of economic theory through formal mechanisms of innovation measurement. Induced technical change theory, mechanisation of agriculture, human capital investment and intellectual property rights are exposed. Then, innovation sources through Research and Development, capital goods, informal knowledge and open innovation are described. The role of public and private stakeholders of different areas like research centres, universities, extension services, associations and firms is briefly explained. Agricultural framework is finally described in

terms of agricultural policy structure and farms situation with information on structural change in the targeted sector, enabling the introduction to three research projects that are presented in chapters 3 to 5.

In Chapter 3, we present the results of the research project entitled *Productive interactions in a low-technology-intensive sector: Insights from the Swiss fruit sector*. In this chapter, we address the organization of interactions existing in specific setting to track innovations. Interactions between actors composing a network are required to transfer knowledge. However, only few of these interactions can become productive given the structural conditions of the domain in which they take place. An approach used in a previous research paper is one of the bases of this chapter. In the Social Impact Assessment Methods through Productive Interactions (SIAMPI) project, productive interactions were defined as "exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant […] through various "tracks", for instance, a research publication, an exhibition, a design, people or financial support. An interaction is productive when it leads to efforts by stakeholders to somehow use or apply research results or practical information or experiences" (Molas-Gallart & Tang, 2011; Spaapen & van Drooge, 2011). Few studies have investigated this type of interactions in a minor crop frame. This chapter is motivated by the idea that innovations can be provided by different types of actors and can flow between them based on diverse interactions that can be productive. The research project addresses this gap in the literature with an emphasis on informal collaborations between farmers involved in the Swiss stone fruit production and external partners of this production value chain like research organizations, regional extension services, associations of the sector, Higher Education Institutions and other actors. An analysis of the collaborations occurring in the network is conducted thanks to different structured interviews with researchers of the national research centre located in the same place than the stakeholders of the fruit production chain and with these stakeholders. Market structure elements are provided to support the analyses and understand the mechanism of interactions observed. Innovations developed and adopted by the practitioners are identified in order to track their process of creation. Social Network Analysis is used to measure how the agricultural network is socially structured in terms of density and connectivity.

The main outcome of this project is that farmers do not rely at all on formal collaborations to transfer information and knowledge. The sector is rather and sufficiently small to ensure good connections between actors. Furthermore, local and regional centres of fundamental and applied research and extension services are more connected with practitioners of the production chain than universities or Universities of Applied Sciences. This is related to the nature of the sector that is more upstream oriented and needs fundamental knowledge.

To conclude this chapter, the difficulty in domains in which Research and Development is not central and informal interactions dominate is to observe and measure innovations. Market and structural contexts are determinant factors as to whether an interaction becomes productive. Public policies should foster innovation based on these factors and endorse measures to support extended collaborations.

Chapter 4 presents a research project entitled *Are innovation needs of low-technological Small and Medium-sized Enterprises in line with knowledge production by research institutions?*

The linear innovation model has long been criticized in the literature and replaced to some extent by other approaches that include multiple stakeholders involved at different stages and levels to flow information, knowledge and diverse assets needed to produce innovations. Feedback loops between research, production and consumers are essential to create suitable innovations that will be used and improve economic, environmental, social, or organisational situations. Few studies have investigated the links between what the scientific community (e.g. international or national research centres, universities or other fundamental knowledge production entities) is providing and what the practical side needs to be competitive and sustainable on the long run. We based our research project on the assumptions that innovation is required and desired to maintain firms' competitiveness. Furthermore, the sector that is the focus of this dissertation has received little attention in terms of production and use of knowledge and innovation. Therefore, we address these gaps by investigating the links or matches potentially existing between two parts of the innovation chain; public research and private firms. Hence, we analyse knowledge and innovation transfer between researchers and practitioners and to understand to what extent the needs of the sector match what the scientific community has been provided until now. The study is customer-oriented; the starting point of the study is the firm and the needs in terms of innovations along the value chain.

Our results reveal important innovation improvements needed in traditional agricultural sector. The main topic discussed was related to varietal innovations regarding quality and productivity. Coping with climate change impacts, pressures of diseases and pests, consumers' expectations, logistics and distribution requirements and new management system, legal and marketing matters are topics that have their importance at different level in the value chain. Methodological implications are drawn from this research project as well as strategic management decisions for the sector. Gaps are identified between what research does provide and what private firms are asking for. Generic knowledge and specific knowledge production, innovation transfer and implementation have to be better understood at the beginning of any innovation process and project to ensure an efficient connection between the two communities. These research outputs could help designing a process to better fill the gaps of knowledge and innovation thanks to adequate research programs. Extending and promoting interactions between actors would improve communication and foster knowledge transfer and innovation production. The open innovation schema that has been promoted by numerous authors is not sufficient. Management skills, firms' capacities and stakeholders' willingness to participate have to be included and proactively deepen. Every link in the supply chain is important and should express and efficiently communicate priorities and targets in innovation and management based on their resources.

In Chapter 5, the research project *Investigation of market failures in agriculture: case studies on intellectual property rights* investigates market failures like information asymmetry and ill-defined property rights that agricultural firms have to cope with. Market-based instruments, government

intervention and policies can be applied to reduce these failures. Furthermore, intensive competition at different levels prevents companies to efficiently be competitive. Hence, use of intellectual property rights is analysed in this chapter as a mean to cope with important failures. Trademarks and patents can be complementary or substitute formal appropriation mechanisms used by firms. The research project addresses this thanks to an identification of innovation needs of small firms in stone fruit production in Switzerland by using two case studies based on intellectual property rights (IPR) mechanisms; patents and regional or umbrella trademark. Characteristics and evolution of the brand are explored to analyse whether the introduction of the regional umbrella brand in the apricot sector was an efficient solution to overcome the market failures.

The findings indicate a poor use of patents in the sector with different European inventors and applicants. In addition, the regional trademark is highly recognized by consumers through origin criteria but not quality differentiation. Consumers' trust, competition through imports, products and labels and political load are substantial hindering factors. Finally, cross-sectoral brands imply difficulty for the creation of tailor-mades solutions because of products' diversity and firms' profile in the frame of limited financial resources.

To conclude, knowledge stock is contained in formal intellectual property rights through trademarks and patents and informal appropriation tools like producers' trademark. Food traditional production is not the intended sector for patents' use but extended potentialities exist in new process technologies, logistics, value chain organization and distribution systems. To foster trademark position, diverse strategies should be designed to engage consumers' loyalty to avoid competing firms creating individual trademarks. The marketing mix should be revised (e.g. trademark's requirements, distribution places) and segmentation adapted to compete with European imports and retailers' trademarks. This study highlights marketing and management strategies to be pursued. All value chain actors would benefit from it. Cross-sectoral synergies have to be investigated to create positive spillover for all the products, producers and consumers related to the trademark.

Finally, Chapter 6 closes this dissertation with conclusions and contributions of the research projects presented. Table 1-1 presents the overview of the dissertation.

	Research project 1 - Chapter 3	**Research project 2 - Chapter 4**	**Research project 3 - Chapter 5**
Title	Productive interactions in a low-technology-intensive sector: Insights from the Swiss fruit sector	Are innovation needs of low-technological Small and Medium-sized Enterprises in line with knowledge production by research institutions?	Investigation of market failures in agriculture: case studies on intellectual property rights
General topic	Structure of interactions in network of agricultural actors to track innovations	Links between what the scientific community is providing and what the practitioners need to remain competitive	Intellectual property rights mechanisms required as efficient solutions to overcome market failures
Motivations	Innovations are provided by different actors and flow between them based on diverse interactions that can be productive	Transfer and implementation of knowledge and innovation are crucial between scientific research outcomes and challenges of companies	Appropriation mechanisms can be solutions to improve competitiveness of companies.
Main research questions	- What is the underlying structure of interactions in a low technology intensive sector? - Are the innovations diffused via productive interactions?	- To what extent the scientific research outcomes are related to small firms' needs? - What are the gaps between stakeholders that can be prevented?	- Do formal intellectual property rights allow the overcome of market failures? - Do trademarks and patents can be substitute or complementary as appropriation tools for agricultural firms?
Methods	Semi-structured interviews Social Network Analysis Secondary data	Semi-structured interviews Bibliometric analysis	Semi-structured interviews Secondary data
Outcomes	- Farmers use informal collaborations to transfer information and knowledge. - Local and regional centres of fundamental and applied research and extension services are more connected with practitioners of the production chain than Universities of Applied Sciences. - Market and structural contexts are determinant factors for making an interaction productive.	- Important innovation improvements needs, especially in varietal innovations. - Methodological implications and strategic management decisions for the sector. - Existing important gaps are identified between what research provides and what private firms are asking for.	- Patents are poorly used in the Swiss stone fruit production chain - The regional trademark is highly recognized by consumers through origin criteria but not quality differentiation. - Hindering factors are identified (e.g. consumers' trust, competition through imports, products and political load). - Management and marketing strategies can be designed to foster trademark position, to engage consumers' loyalty and to efficiently increase trademark awareness

Table 1-1. Overview of the thesis

Chapter 2 Agricultural sector, technical change and innovation

2.1 Introduction

Technological innovation impacts firms' strategic decisions related to, inter alia, marketing, competitive and market intelligence, innovation adoption, intellectual property use and financial investments (Shane, 2008). Therefore, innovation management represent a substantial part of what companies can undertake to remain competitive and sustainable. Agriculture evolved partially through innovation use, coming from Research and Development (R&D). Agricultural research and development is unevenly distributed around the globe. Since the middle of the 21st century, low and middle-income countries invested more in R&D than high-income countries. Furthermore, there is a discrepancy between private and public sector. The former increases its investments to roughly reach with the latter (Pardey et al., 2016). These facts are impacting current and future food and agricultural production and supplies, population employment, structural changes and orientation of the sector towards specific patterns. Hence, innovation choices play a substantial role, especially with the changeover from an agricultural production system that is natural resource-based to a system that is science-based, to satisfy the growth of world population and income. From 2.5 billion inhabitants in 1950 to 6 billion inhabitants in 2000 and 9 billion inhabitants expected in 2050, agricultural sector must develop or adapt to a new paradigm to ensure these tremendous changes (Ruttan, 2005).

Economists have studied economic growth that could potentially explain agricultural evolution. Theory of induced technical change, agricultural mechanisation, human capital investment and different crucial elements are exposed in this chapter. Innovation sources and roles of different stakeholders are investigated. By formal and informal channels, knowledge and innovation can flow between different actors and economic agents in a specific ecosystem. In the next sections, innovation in agriculture is defined and processes of adoption and diffusion are explained. Formal channels are presented through induced technical change. The informal transfer mode exposes the importance of tacit knowledge and interactions with the environment to maximize innovation opportunities The Swiss context is finally displayed.

2.2 Innovation framework

2.2.1 Innovation definition

According to Rogers (1983), an innovation is

> "an idea, practice, or object that is perceived as new by an individual or other unit of adoption. It matters little, so far as human behaviour is concerned, whether or not an idea is "objectively" new as measured by the lapse of time since its first use or discovery. The perceived newness of the idea for the individual determines his or her reaction to it. If the idea seems new to the individual, it is an innovation."

Invention, innovation and diffusion share blurred boundaries. Schumpeter considered invention as "the original development of some novel would-be process of production or product". Innovation represents the introduction of the invention with economic use and diffusion introduces buyers and competitors (Dosi & Nelson, 2010). Innovation was defined as endogenous by Audretsch (2008). Efforts of firms to generate new knowledge and ideas are the outcome of innovative opportunities. The firms will appropriate the investment returns through commercialization of these investments. Schumpeter's creative destruction is a driver of technical change. Hence, this process should work properly in innovation settings (Guellec, 2001).

Agricultural innovations introduced in the 1960s integrated different characteristics and goals (e.g. high-yielding varieties and chemicals, fertilizer and herbicides) driven by food shortages or high prices of agricultural commodities (Feder & Umali, 1993). Moreover, consumers' expectations were one motor for improved product quality, cost-reducing innovations and innovations for health and environment preservation (Hayami & Ruttan, 1985; Sunding & Zilberman, 2001). Finally, one of the key challenges for firms is to trade-off the need to satisfy consumers' expectations, especially due to the quality image provided by trademarks and brands, and to offer significantly new products to attract consumers. Path dependency may create disincentives to innovation (Davis, 2010).

2.2.2 Innovation sources

Our economy is mainly based on two sources of innovations in the private sector: big firms and start-ups. Therefore, institutional adjustment is required to match new structures and organisation of innovation activities in the emerging domains (Dominique Foray, 2009). The other main sources of innovation are R&D, human capital, skilled labor and educational levels (Audretsch, 2008). Origin of innovations has evolved. Innovations were more produced by practitioners in the past, while they are more generated by firms and universities nowadays (Hayami & Ruttan, 1985). Besides, innovations are disclosed to answer economic opportunities and fill in scarcity of resources or institutional and policy constraints (e.g. environmental-friendly products emerged together with new environmental regulations (Sunding & Zilberman, 2001). According to Biggs and Clay (1981), local knowledge can be seen as informal experimentation that has to be combined with purposive

selection and with natural selection (i.e. environmental stress leading to mutation) to be a source of innovation. Therefore, farmers continue to innovate to maintain the dynamic equilibrium engaged by the process of natural selection. Furthermore, trade and human migration are also sources of innovation. New crops, similar environmental varieties and exotic varieties travelled and were incorporated in different environments following "European voyages of discovery".

Many policies not targeting agriculture display externalities on the costs of agricultural production like labour, immigration or water policies. These policies are a stimulus for innovation through the constraints they entail. Farmers and other stakeholders of agricultural domain adopt new technologies to comply with the new regulations for example (Bowman & Zilberman, 2013).

It should be noticed that different models of innovation process have been defined in the literature. The linear model was first acknowledged to explain how innovations flow from scientific research to practitioners and firms. This model has been criticized and the non-linear model with different sources for innovation stated the use of different agents included in iterative loops of feedback to constantly innovate (Biggs, 1990). As a matter of fact, users are an important source of innovation according to Von Hippel (1988a). Furthermore, the traditional models of "technology-push" versus "demand-pull" did not make consensus (Gibbons et al., 1994; B.-Å. Lundvall, 2005). International and national research centres, farmers, extension services, non-governmental organisations represent important sources of innovation that collaborate for knowledge production and transfer through formal and informal research activities. Formal and informal research is conducted through the network.

Finally, Aghion (2006) stated four ways of fostering innovation and growth: (i) competition and market entry costs for industries close to the technological frontier; (ii) investment in higher (tertiary) education to increase the innovative potential; (iii) reforming credit market and labour market; (iv) managing the economic cycle to profit from a reactive macroeconomic policy to reduce the growth deficit. Some of these ways are underlined in the following sections.

Research and Development

Research and Development (R&D) is required to move from traditional-based sector to knowledge-based sector (Dominique Foray, 2009). Innovation fostering can be done through R&D investment. R&D generates information and enhance firms' absorptive capacity (Cohen & Levinthal, 1990). Assimilation and exploitation of information are easily realized (Cohen & Levinthal, 1989). R&D can be performed internally to the firm, subcontracted or performed in collaboration like R&D venture (Rothwell & Dodgson, 1991). Firms' motivations for subcontracting R&D include technology access that is new to the firm, shortening lead times and filling lacks of skills. Furthermore, accumulated knowledge is crucial for technical innovation and used at different stages of the innovation chain (Kline & Rosenberg, 1986).

Nonetheless, R&D subsidies and patents cannot enhance innovation and productivity growth (Aghion, 2006). Research and Development is not mandatory at every stage of the chain and differs across sectors. Pavitt (1984) determines four categories of industries that do not use R&D with the

same intensity. Science-based firms use a lot of R&D, while supplier-dominated firms rely more on inputs investments like machinery and production-intensive firms spend a significant proportion of their R&D expenditures on non-R&D activities.

Innovation through capital goods

Capital goods sector represents the supply of important new technologies that diffuse innovations to other sectors like services sector and consumers sector (Barras, 1986; Parisi, Schiantarelli, & Sembenelli, 2006; Rosenberg, 1963). New machines highly specified that correspond to firms' specialisation on narrow activities are provided by the capital goods sector. Diffusion of those technologies is often performed with a relative lag. This lag can be comprised of two components; on the one hand the delay of awareness and availability of the new technologies to end users and on the other hand the completion of capabilities to use the innovations at their full capacity (Barras, 1986). Furthermore, adoption of capital goods innovation tends to be higher for large firms and can be explained by the likelihood of old technologies replacement need, greater financial resources to afford new technologies and efficient network through which useful information can flow (Benvignati, 1982).

Agricultural inputs supply is partially provided by these capital goods. Thus, innovation can come from this sector like mechanisation that improve labour and land productivity, process machines to improve the transformation of raw materials, to enhance quality analysis at the field, logistics and distribution.

2.2.3 Innovation adoption and diffusion

Innovation adoption has long been studied in the literature. Adoption is represented by a S-shape curve or normal curve, where different categories of adopters are following one another; early adopters constitute a small percentage, early and late majority are the main group and late adopters or laggards constitute a small percentage of the adoption rate (Bowman & Zilberman, 2013; Hayami & Ruttan, 1985; Rogers, 1983; Shankar, 2008; Straub, 2009). Experience of adopters decreases the uncertainty initially perceived before the adoption stage (Bowman & Zilberman, 2013; Feder & Umali, 1993; Sunding & Zilberman, 2001). The factors of adoption are diverse. The innovation stage is important to identify the relevant factors of adoption or non-adoption, nature of the sector (time delay from invention to commercialization – e.g. high-technology sector versus plant breeding) (Cohen & Levinthal, 1989; Niosi & Banik, 2005; Teece, 1986). Ease of use, perceived usefulness, firm size and firm reputation (Shankar, 2008), adopters' features like location, age, education, income, gender (Bowman & Zilberman, 2013; Hayami & Ruttan, 1970b; Shankar, 2008) are all factors that impact innovation process. Environment of the firm has an importance on the adoption behaviour and the innovation diffusion through the facilitation of links between firms, technology suppliers and other actors involved in the knowledge creation process (Galliano & Roux, 2003). Lack of information about the costs and benefits of adopting new technologies and lack of knowledge about how to implement such technologies or practices affect farmers'

propensity to adopt innovations (Bowman & Zilberman, 2013). Uncertainty and risks associated with adoption of new technology like factors of production and new knowledge to learning how to use these new factors can be a limiting adoption determinant. Farmers that stay in traditional agriculture are more secure than those going towards modernized agriculture (Schultz, 1964). Furthermore, economic infrastructures play a role for innovation adoption (Shankar, 2008), lack of credit and access to extension services, inputs and information and output market conditions (e.g. price variability, transportation costs, supply chain transactions costs) (Bowman & Zilberman, 2013; Feder & Umali, 1993; Sunding & Zilberman, 2001). Straub (2009) talked about adoption as a behaviour change that can be predicted by cognitive, contextual and affective factors. Adoption behaviour can be represented by a discrete choice (i.e. using an innovation or not using an innovation) and a continuous variable (i.e. intensity of innovation use like the percentage of harvested surface with the new crop variety) (Hayami & Ruttan, 1985). Ability to adopt technologies depends also on specificities regarding locations. Technology is location-specific in agriculture (Pardey, Alston, & Ruttan, 2010; Ruttan, 2005). There are differences between countries, between regions in a country and even between sub-regions in a region (Hayami & Ruttan, 1970a). Investment in education and research at once could lead to raising adoption of technology impacting productivity thanks to innovation embodied in modern inputs (Hayami & Ruttan, 1970a).

Diffusion process is a result of technology-push factors (price-performance characteristics, performance uncertainty, usability) and demand-pull factors (market structure, opportunities in applying the technology, adaptability of end users) (Barras, 1986). Diffusion of new technology can be slowed down because of imperfect information (Jaffee et al., 2005; Suriñach et al., 2009). Every new technology consists of the technology embodied in the product, service or process, and the knowledge needed to use the technology. The latter can be translated formally or with tacit means. Therefore, diffusion needs interactions between users and suppliers. Consequently, all the potential adopters may be aware of the availability of the new technology but are not keen to adopt it because of information or knowledge gap.

In 1958, Cochrane introduced the “treadmill effect” by explaining the output prices impact of technology adoption according to users’ profile (i.e. early adopters, followers and laggards). Only early adopters would gain from innovation adoption in the agricultural sector. Because of great evolution of technical progress, farmers that are followers or laggards may undergo declining profits (Chavas, 2001; Sunding & Zilberman, 2001). Technology adoption can affect the sector, leading to structural changes. However, it also can worsen the situation of main farms (Hayami & Ruttan, 1985).

Diffusion represents the spread of an innovation into a population (Straub, 2009) or an “aggregate adoption” (Hayami & Ruttan, 1985; Sunding & Zilberman, 2001) with communication channels over time, and explained by three main sources: adopters’ characteristics, innovation improvement and knowledge and information diffusion that is unequal (Griliches, 1957). Diffusion is time-consuming, is heterogeneous across regions and technologies and follows a S-shaped curve for successful innovations (Bowman & Zilberman, 2013; Dosi, 1993; Hayami & Ruttan, 1985; Rogers, 1983). Diffusion can be uneven between regions or countries through differential in technical capacity to develop innovations adapted to local resource endowments and prices (Hayami & Ruttan, 1970a). Suriñach et al. (2009) found three determinants of innovation diffusion;

technology awareness, ability to adapt to the new technology and profitability of this technology. Availability and price of the agricultural factors are crucial for the adoption and so economic growth in poor countries. Suppliers distributing new factors of production are firms for profit and non-for-profit agencies. Their supply depends upon the costs of entry and market size. The latter is generally small and can explain the different dates at which different private firms entered the market. Nevertheless, costs of entry can be reduced thanks to non-profit agencies by providing farmers with information at the technical and economic levels. Entry costs are represented by how much has to be spent to adapt the new factor to the community necessities, information that farmers will need and other costs (Schultz, 1964). Moreover, the skills that adopters must acquire to use the new technology are costly, especially for the adaptation of this new technology to the new environment (Jaffee et al., 2005). Investment in human capital can be a lever for the awareness and the ability of adaptation. R&D helps in the absorptive capacity process, hence in the adaptation of the new technology (Suriñach et al., 2009).

Information about innovation flows between adopters and non-adopters using communication channels. These channels can be direct, observations or mass influence. For direct communication, interpersonal contacts comprise subjective assessment transmitted by “near-peers”. Hence, diffusion process begins with the spread of objective and subjective information from individuals to individuals constituting a population where new adopters imitate network peers (Straub, 2009). Exogenous and endogenous information impact innovators and imitators respectively (Feder & Umali, 1993).

Taxonomy of sectors

There are differences in the knowledge production across sectors. In the supplier-dominated sectors (e.g. farming, cleaning services and transport) firms are developing innovations mainly thanks to other firms like suppliers, large customers or research services. The scale-intensive sector (e.g. paper mills, telecoms) is characterized by a focus on process development via internal production or suppliers of capital goods. The specialized suppliers (e.g. software, professional services) develop new products in cooperation with customers. Lastly, science-based producers (e.g. pharmaceuticals or biotechnology) collaborate more with universities to develop new products and processes (B.-Å. Lundvall, 2008; Pavitt, 1984). All these sectors do not tackle innovation with the same strategies and do not rely on the same resources.

2.2.4 Innovation transfer

2.2.4.1 Economic theory through formal mechanisms of innovation

This section presents the evolution of the agricultural sector using formal channels to innovating.

Induced technical change theory

Schultz (1964) defined technological change as "an unexplained residual which conceals most of the important sources of the relatively low-priced permanent income streams that induce the savings and investment related to growth". Technological change is finally the use of new production factors. The induced innovation hypothesis of Hayami and Ruttan (1985) states that "relative resource scarcity tends to guide technological change toward using additional inputs that are plentiful and inexpensive, while saving on care and expensive inputs" (Chavas, 2001). According to Pardey et al. (2010), "technological change is exogenous to agriculture" while technical change was the motor of mechanization and manufacturing (Pardey et al., 2010).

Technological change in agriculture has greatly evolved. In the post World War II period, the main goal was productivity increase to satisfy growing population needs (Ruttan, 1997; Wright, 2012). Therefore, biological technology and machinery targeted land productivity and labour productivity respectively (Ruttan, 2005), depending on the characteristics of the countries, demographic pressure, soil and climate features and capacities to adopt technology (Giampietro et al., 1999; Hayami and Ruttan, 1970a; Ruttan, 1997; Wright, 2012). As agricultural technological change is endogenous, the choice of resources to increase productivity on either the land or labour level will be made in favour of scarce resources in order to sustain them. Productivity growth can be explained by factors like endowment of resources, technological capital, human capital and investment in private and public research (Hayami and Ruttan, 1970a; Ruttan, 2002a).

By the middle of the 20th century, economists focused on technical change by measuring its contribution to economic growth (Fan & Ruttan, 1992). Direction and rate of technical change was the study objective of economists in 1960s. Griliches (1957) stated that "the rate of technical change was induced by growth in demand".

Importance of factor prices

The role of changes in relative factor endowments on the direction of technical change has been studied in agricultural and resource economics (Ruttan, 1996). Assumptions' origin about the direction of technical change came from Hicks. He argued that

> "A change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind – directed to economising the use of a factor which has become relatively expensive." (Brugger & Gehrke, 2016)

A change in production factor prices has an effect on the direction of invention or innovation (Hayami and Ruttan, 1970a). Moreover, the research allocation can respond to differences in resource endowments and economic environment (Fan & Ruttan, 1992; Ruttan, 1977). Resource endowment is the major factor accounting for differences in labor productivity between the developed countries of recent settlement and the older developed countries (Australia, Canada, New Zealand, and the United States) (Hayami & Ruttan, 1970a).

The aim of mechanical technology is to substitute power and machinery for labor. It is labor saving. Biological and chemical technology substitute labour-intensive practices and industrial inputs for land. It is land saving (Ruttan, 2005). Biological innovations were represented by yield-increasing varieties. These varieties were complementary to fertilizer use both in Japan for rice-improved varieties and in the U.S. for hybrid corn. Factor-price ratios also evolved. Hayami and Ruttan (1970b) studied the U.S. and Japan models of agricultural systems, which are different in terms of relative land and labor endowments They examined the adaptation of agricultural technology to different localities and hypothesized that it was successful thanks to induced innovations like technologies saving limiting factors. In Japan there were chemical and biological innovations for yield growth while in the U.S there were mechanical innovations of a labour-saving type. The differences increased between 1880 and 1960. The total agricultural land area per male worker and the arable land area per male worker were sharply larger in the United States than in Japan. Prices of land and labor were higher in Japan at that time than in the U.S. land area per worker increased more rapidly in the U.S. while land productivity increased more rapidly in Japan. Moreover, machinery price decreased relative to the wage rate and fertilizer price decreased relative to land price. Factor prices changes allowed factor substitution. A substitution of land and power for labor in the United States arise with decrease of prices. This affected the innovations adopted; the U.S chose mechanical innovations, Japan preferred biological innovations (Hayami & Ruttan, 1970a).

Technology advances are induced by the "demand-pull" model. This model has highlighted the importance of market demand on knowledge supply. The demand-induced model indicated that aggregate demand growth is related to technical change. Therefore, supply and demand factors represent crucial elements for innovation activities, evolving with product life cycle (Ruttan, 1996).

The process of technological change which is endogenously driven by price changes in the market can be characterized as price-induced innovation (Celikkol & Stefanou, 1999). When a factor is scarce or abundant, farmers seek innovation to save the scarce factor and use the abundant one. As factor-ratio changes, technical change is biased toward them (Fan & Ruttan, 1992).

Human capital investment

Knowledge is considered a public good by some authors (Arrow, 1962; Jaffee, 1986) whereas others qualify it as not exclusively private or exclusively public. Knowledge as a public good can be used by anyone anywhere. However, there are poor incentives to invest in its production. Knowledge as a private good would be difficult to transfer and investments should be made by individual agents (Cowan, David, & Foray, 1999; B.-Å. Lundvall, 2008). Knowledge partly relies on skills and competencies. New knowledge and new skills are highly intertwined and can be seen as indivisibilities and involved in human capital. Human capital investment is necessary for firms' competitiveness as stated in the Resource-Based View theory (Eisenhardt & Martin, 2000). Firms' resources represent a substantial competitive advantage like physical, human and organizational

resources including abilities driving to competitive advantage in a certain domain. Different modes of human capital investment can be conducted. Trial and error learning is one way to acquire skills and knowledge but is very time-consuming and costly. On-the-job-training consist of discussions, short courses and demonstrations provided by the firms selling the new factors or external actors like public agencies. For farmers, extension programs, short courses off-seasons are necessary to provide skills, demonstrations teaching new farm skills and meetings for farm people instruction. Furthermore, human capital investment through schooling provides the foundations for knowledge and skills. The elementary, secondary and higher levels of schooling are fundamental for investing in farm people. Lastly, migration is a source of investment in people can enhance human capital (Schultz, 1964). Investment in higher education is more beneficial for countries close to the technological frontier. They do not use imitation but innovation as engine of growth (Dominique Foray, 2009).

Intellectual property rights

Innovations can be protected by various means. Patents remains a good indicator to identify the differences of knowledge advances between firms (Pakes & Griliches, 1980). Patent is a proxy for innovation activity, despite the fact it encompassed non-negligible flaws. Although, there is a risk to analyse innovations through the lens of patents amongst other protection mechanisms, because every invention is patentable. Hence it may overlook the innovations not patented (B. H. Hall, Jaffe, & Trajtenberg, 2005; Pakes & Griliches, 1980). Secrecy is widely spread in industrial sectors such as agriculture and food, instead of patenting which is less significant (Biggs & Clay, 1981). Intellectual Property Rights (IPR) and plant breeders' rights are the most expensive protection available nowadays. Likewise, a strong bias exist towards plant variety rights for rich country jurisdictions and high value-added sectors like fruits, vegetables, and ornamentals (Pardey et al., 2010).

Knowledge spills over among firms, impacting economic long-run growth depending on the mechanisms of knowledge flow (Romer, 1993). Patent application and disclosure tends to favour knowledge flows between firms while secrecy tends to hinder it (B. Hall, Helmers, Rogers, & Sena, 2014). The Community Innovation Survey (CIS) results about the Yale I and Swiss surveys found that patents are considered ineffective as protection tools against imitators by half of innovating firms. Nevertheless, secrecy, lead-time and highly qualified people tend to be more efficient. These results are sector-dependent (e.g. patents are used mainly in pharmaceuticals and chemical companies) (B. Hall et al., 2014).

2.2.4.2 Use of informal processes for innovation

Transfer of knowledge and technology through informal and tacit bonds

Knowledge is not a traditional production factor like agricultural factors of production (e.g. land, labor and capital) (Arrow, 1962). Because of uncertainty and asymmetric nature of knowledge, transaction costs can be very high (Gilbert, Audretsch, & McDougall, 2004). Knowledge and information transfer is costly and depends on knowledge patterns like codification degree (codified versus tacit) and technology embeddedness (Schartinger, Rammer, Fischer, & Fröhlich, 2002). Informal interactions can transfer tacit knowledge (EU SCAR, 2012). Tacit knowledge is a non-rival good; it can spill over to other firms (Gilbert et al., 2004). The tacitness feature of knowledge is "a powerful exclusionary means" (Foray and Lissoni, 2010). Scientific knowledge defined as "universal, objective and decontextualized" by Ingram (2008) should be coupled with tacit knowledge ("implicit, indigenous and context-dependent") in order to provide farmers with enough capabilities to implement new technologies and management practices.

Tacit knowledge is important for the use of new technology (Dosi & Nelson, 2010). It is embedded in organizational routines, transmitted via 'social processes' because rooted within a social framework (Ingram, 1985), hindering knowledge transfer to other settings (Ruttan, 2002b) and prevails in daily collaboration tasks (Lawson & Lorenz, 1999).

Cowan (1999) and Von Hippel (1994) talked about stickiness of information and knowledge, being an indicator of difficulty to transfer it into different environments. Thus, informal interactions are a good channel through which knowledge can be diffused (Dahl & Pedersen, 2004). Pardey et al. (2010) argued that the process of using animals and plants to produce food and fibber was done gradually, informally and sometimes un-intentionally. Results' communication by word-of-mouth was crucial. Unorganized agricultural activities and unsystematic technology transfer were prevailing in old agricultural communities when formal R&D has not been yet developed. Hence, informal processes were successful (Biggs & Clay, 1981). Moreover, innovation opportunity increase relates to an efficient knowledge distribution (D. Foray & Lundvall, 1994).

Finally, in the literature on university-industry collaborations, formal technology transfers have been mainly studied using codified indicators like patents, licenses, royalty agreements (Grimpe & Hussinger, 2013). Nevertheless, informal R&D contributed in the past and nowadays to technological change (Biggs & Clay, 1981). Informal R&D processes rely on technology users because they need to solve their issues by using their knowledge on the local environment and exploit the natural selection opportunities (Biggs & Clay, 1981). Informal interactions are suitable to maintain established relationships between academic and non-academic partners (Norn, Wohlert, & Anthonsen, 2014). Informal transfer channels generally involve interpersonal contacts created during events like conferences, seminars, other informal contacts like meetings, talks, phone calls or emails exchanged. Experiences, physical and personal transfer of know-how between partners with informal means are crucial to knowledge transfer (Goffin, Baxter, Szwejczewski, Cousens, & van der Hoven, 2011; Teece, 1986). This type of links is assumed to potentially precede formal relationships (Bercovitz & Feldmann, 2006). Hence, both formal and informal interactions are commonly used in diverse sectors (Grimpe & Hussinger, 2013) and their combination would ensure efficiency for knowledge transfer and innovation adoption (Morgan & Murdoch, 2000). Experiences and know-how can be included in collaborations formalized between stakeholders

(Almeida & Kogut, 1999; Russell, Greenhalgh, Boynton, & Rigby, 2004).

Open innovation: combining internal and external sources for maximizing innovation opportunities

Firms' capacity to innovate depends on both internal resources (e.g. R&D structure, skilled labor, openness towards new ideas, financial resources, size, experience of the manager) and external resources (e.g. strategic environment, available infrastructure for collaboration and networking, potential of business-to-business relationships, access to support from providers and government) (Cassiman & Veugelers, 2006; H. W. Chesbrough & Appleyard, 2007; Gellynck & Kühne, 2010). Internal R&D is useful to identify features of the new capital goods at the technological frontier purchased by the firm. Hence, new technology absorption is facilitated (Parisi et al., 2006). Studies have shown that internal and external firm sources can be complementary. Relying on different knowledge sources can pull up R&D possibilities and thus innovation creation and diffusion (S. Freeman, Edwards, & Schroder, 2006). The open innovation concept developed by Chesbrough relates knowledge inflows and outflows in order to improve internal innovation (H. W. Chesbrough & Appleyard, 2007; Vrande, Jong, Vanhaverbeke, & Rochemont, 2009). Innovation cooperation through the use of external partners to complement internal resources takes a substantial part of the open innovation model (Gallaud & Nayaradou, 2012). Innovation process can be based on feedback from users, experiences from their side is therefore useful. However, the « functional fixedness » of Von Hippel (1988b) fosters incremental innovation opposed to disruptive innovations. Therefore, including external partners in order to get a general overview is needed (Enkel, Kausch, & Gassmann, 2005).

In the agricultural sector, mechanical innovations tend to be developed by the private sector while biological innovations tend to be primarily developed by the public sector (Sunding & Zilberman, 2001). Moreover, vertical coordination depends on contracts, especially in fresh products sector like vegetable and fruit because of the product quality, which is timely bounded to economic decisions (Chavas, 2001).

Collaboration with external partners like universities enhance the capability of firms to introduce more advanced innovations by extending the knowledge base (Tödtling, Lehner, & Kaufmann, 2009). However, for incremental innovations, links with service firms appear to help undertaking innovations. Practical knowledge is more valuable in this setting than scientific knowledge, commonly found in universities. University research and industrial research are complementary. The former produces knowledge mandatory to create inventions that could turn into innovations. The latter provide efficient and useful innovative tools (Dominique Foray, 2009). Moreover, open science fosters knowledge cumulativity, progressivity, inventiveness, quality control and capital investment enrichment contribution (Encaoua, Foray, Hatchuel, & Mairesse, 2004).

2.3 Agricultural innovation

2.3.1 Historical background

Schultz (1964) defined traditional agriculture as an equilibrium in which no new factors are introduced. Risk and uncertainty are not included in this definition. He stated that traditional agriculture is dependent on factors of production characterizing a slow growth. Farmers cannot contribute to economic growth beyond a certain point where factors allocation is no longer efficient and the rate of return to investment at the margin is low. In order to accelerate this growth, innovative production factors must be adopted by farmers, along with skills needed to effectively use the new production factors.

During the nineteenth and twentieth centuries, industrial sectors had changed worldwide. Agriculture benefitted from a higher productivity growth than other sectors (Chavas, 2001). However, this sector accounted for a small share of the global economy and represented 2.8 percent of overall income in developed countries (Alston & Pardey, 2014). In the last centuries, this sector was dedicated to feed the growing population (Chavas, 2001). In the first half of the twentieth century, smaller farms disappeared due to the decrease in family labor (Chavas, 2001; Pardey et al., 2010). Even with the introduction of modern technologies in agriculture, the dominant farm size at that time was still small. Innovations introduced allowed higher crop production per acre; decreasing the rate of labor. This labor has also the tendency to migrate to urban areas when agricultural wages are decreasing. Furthermore, food prices have decreased over the last decades mainly thanks to an increased productivity (Chavas, 2001). Innovations were mechanical technologies, chemical technologies and information technologies (Pardey et al., 2010). Nowadays, agriculture has an atomistic structure, is small-scale and competitive (Pardey et al., 2010). There is a high heterogeneity in the structure of the sector all around the world. Most of the farmers work in small subsistence farms that represent a high share of the population employed in developing countries (Alston & Pardey, 2014; Chavas, 2001). In the richest countries, farms are large-scale and a small proportion of the population is involved in farming like in the United States with less than 1%. However, in the poorest countries of the world, farms are small. In 2010, about 2.6 billion people conducted agriculture for their livelihood (Alston & Pardey, 2014).

Agricultural sector displays specific characteristics that differ from industries. Environment is a major factor with which producers have to deal with every day. As environment takes a major role in crop management, farmers have to adapt and take decisions with non-negligible flexibility. Their capacity to exploit the opportunities rely upon their knowledge of the production potentialities (Biggs & Clay, 1981).

2.3.2 Mechanisation of agriculture

According to Pardey et al. (2010), thanks to investments in agricultural R&D, the Malthusian theory was not realized. Hence, agricultural productivity increased more than the increase of population in the last 60 years.

Technical progress: labour-saving and land-saving technologies

Two types of technology were diffused in the nineteenth century: labour-saving and land-saving technologies. The first substitutes machinery and power for labour. The latter substitutes labour-intensive and industrial inputs and practices (e.g. fertilizer and plant animal protection chemicals) for land (Ruttan, 2005). Specialization of farms and increased size were a consequence of labour-saving innovations adoption, with impact as services and infrastructures demand for rural areas (Pardey et al., 2010). Nevertheless, mechanical innovations can also be land saving, and biological innovations can be labour saving. It depends on the constraints existing like factor supply, factor prices, scientific and technical (Pardey et al., 2010).

In the late nineteenth century, food production increased via the increases in the area cultivated. At the end of the twentieth century, crop and animal productions continued to increase thanks to the increase in output per hectare (i.e. land productivity) (Alston & Pardey, 2017; Ruttan, 2005). Land productivity increase was done through use of innovation like machinery (e.g. steel plow, the thrasher), irrigation and fertilizers, improved production methods and genetic materials (Alston & Pardey, 2017). After the World War II, agricultural production growth was substantial for the global economy growth (Ruttan, 2005). Mechanization partially explains this productivity growth. In the first half of the nineteenth century, mechanization in the United States targeted higher labor productivity and greater capital-intensive (David, 1971). It consisted of introducing new devices (e.g. reapers, plows, mowers, threshers, seed drills, grain separators) (David, 1971; Rasmussen, 1982); improving plants, using products for management improvement (pesticides, fertilizers), irrigation works, logistics with improved transportation for distribution and electric power diffusion to rural areas. However, these trends have changed. The non-farm sector benefitted rapid growth in developed countries in the twentieth century (Chavas, 2001). Total productivity growth was due to land productivity growth in Germany and Japan for example (Ruttan, 1977).

Technical progress induced greater land productivity and lower farm labour. An economic rationale for farmers was to invest in low prices of inputs like fertilizers in order to saving other high costs like farm labour. Furthermore, non-farm sector benefitted from higher wages due to economic growth; consequently employment mobility was higher from the farm sector to the non-farm sector (Rasmussen, 1982).

Agricultural technological change is a consequence of manufacturing technical change through labor mobility that increased rates of wages. Hence, labor-saving innovations were sought (Pardey et al., 2010).

Evolution of agricultural innovations: some examples

In the U.S., mechanical innovations prevailed in the late nineteenth and early twentieth centuries, using animal and then tractor motive power. The area per worker increased thanks to these innovations introduced because of labor availability constraints. In Japan, biological and chemical innovations were mostly adopted to increase yield with higher use of fertilisers because of land availability constraints (Ruttan, 1977; Sunding & Zilberman, 2001). Chemical and biological innovations were important after the Second World War. Sunding and Zilberman (2001) argued that biotechnological and informational innovations would be dominant in the future. Nowadays, fertilizer use increased by 94.5 percent in the high-income countries (Alston & Pardey, 2017).

The GxE (i.e. gene by environment) concept was applied to grow crops adapted to their environment and was an inherent agricultural pattern feature. Research activities are now directed to find adaptive innovations for specific local environments (Alston & Pardey, 2017; Sunding & Zilberman, 2001). With human activity, migration and environmental evolution, need of breeding appeared at the beginning of the twentieth century, supported by Mendel's law of heredity and Darwin theory of evolution. Together with other important biological and medicinal discoveries like the germ theory of disease by Pasteur, a great leap forward was done in agricultural sciences, helping crop management (Pardey et al., 2010).

David (1971) defined the threshold size as the level of acreage to be harvested in order for the mechanical technology adoption (reaper) to be profitable towards hand methods, given the fixed costs of the reaping process. Approximately two decades passed by between the availability of the mechanical innovation (reaper) in 1830s and its adoption by farmers in 1850s. The lag between research and effects on agricultural sector varies from ten to thirty years (Chavas, 2001; Pardey et al., 2010). Ruttan (2002) found that for U.S. agricultural research the research lag can be comprised between at least 35 years and up to 50 years with a peak in year 24. The reaper invention was highly important as harvesting was an essential task in agriculture (Rasmussen, 1982). Different factors were in cause like the competitive demands for labour (e.g. railroad construction) or exogenous shocks (e.g. Crimean War). The exogenous shock (Civil War) was an impetus for farmers to adopt new technologies marketed years ago. The switching from hand-power to horsepower was then a substantial change in the U.S agricultural sector. The rate of farm workers decreased from 64% (1850) to 49% (1880) (Rasmussen, 1982). In David's paper (The Mechanisation of Reaping in Ante-Bellum Midwest), the reapers were indivisible fixed capital so that farmers could not share or divide the innovation between them (Lissoni, 2005; Olmstead, 1975). The author stated that the decision about the quantity of acres that would be planted with the technology was independent of the technology (Olmstead, 1975). The technology has been shared through contracting and diffusion was due to the change of contracting features (Olmstead, 1975).

Finally, the weak elasticity of labor supply evolved towards greater elasticity because of new harvesting method availability (David, 1971). Social effects have been found; it was harder for new entrants in agriculture to acquire a farm because the capital needed highly increased. A lot of small

farms disappeared, the remaining ones increased in size. This is a consequence of the hidden costs of mechanization of farms (Rasmussen, 1982).

The case of hybrid corn

The work by Griliches (1957) was a study of the spatial diffusion of an agricultural innovation, to understand the propagation of technological change in U.S. agriculture. Hybrid corn was a breeding method aiming at producing corn for specific areas. The product rapidly spread through the Corn Belt in the Midwest and more slowly across other regions of the country. Two major problems came up; the "acceptance problem and the "availability problem". The former related to the adoption rate by farmers, which was not uniform across the states. The latter represents the specificities needed to develop the crop adaptable to diverse locations. Hence, hybrid corn was meant of several developments.

The role of demand was a determinant factor for invention timing and location (Ruttan, 1996). The development origin came from the shift of the supply side. However, the development rate was related to the acceptance of the product. The diffusion of hybrid corn took over 30 years across the states (Pardey et al., 2010). Rate of acceptance of the new variety was different among regions in the country, partly due to the profitability divergence of the transition from open pollinated to hybrid seeds. Besides, this rate was affected by the distribution and advertising activities of the private firms and extension agencies. In the Corn Belt, the product was sold by individual salesmen. In the South, it was done by stores where farmers had to go to provide themselves. Griliches explained the lateness of hybrid corn diffusion due to private seed companies' acquisition strategies of the inbred lines developed by the experiment stations (Schultz, 1964).

The Green Revolution

Combination of new crop varieties with high yield like corn, rice and wheat and low-cost fertilizer ended up in the acknowledged "Green Revolution" (Chavas, 2001). Much of the agricultural adoption literature was developed to explain adoption patterns of high-yield seed varieties (HYV), many of which were introduced as part of the "green revolution" in developing countries and the less advanced countries. Green revolution is considered as a radical innovation that substantially increased agricultural productivity of cereals thanks to technological capacity change (Parayil, 2003). However, HYV adoption is partial. Farmers divided the allocation of their land to traditional technologies and to HYV. Risk aversion was one motivation for diversification (Sunding & Zilberman, 2001). Furthermore, production of scientific and technological knowledge shifted radically at least in the most advanced countries in the frame of industrial capitalism. Clusters were created to develop technologies such as steam engine, chemicals, electronics or genetics (Parayil, 2003). The controversies stated that the introduction of high yielding modern varieties (MVs) was a source of inequality income distribution, especially in the rural areas, benefitting to larger farms and property owners. Ruttan (2002) criticized these controversies because labor hiring increased along with mechanization progress.

In "Transforming Traditional Agriculture", Theodore W. Schultz asserted that "in traditional agrarian societies, farmers were rational allocators of available resources and that they remained

poor because most poor countries provided them with only limited technical and economic opportunities to which they could respond" (Ruttan, 2005). Therefore, green revolution was to be paired with efficient, available, affordable and accessible technologies like mechanization.

2.4 Evolving role of public and private entities

2.4.1 Public and private R&D share for agriculture

Public and private research and development are needed to perform new technology adaptation to the particular circumstances of the country and the targeted adopters (Schultz, 1964). One gap existing between academic and industry sectors relies in the time horizon and the cognitive focus. On the academic side, researchers are looking for "hyper-innovative solutions". On the industry side, engineers focus more on the cost-effectiveness and reliability of the new products, processes or services. Hence, lacks between what the research and scientific community can look for and what private firms need are not connected to some extent (Foray and Lissoni, 2010).

Agriculture sector has changed all over the world with differences among countries in terms of land and labor productivity, Gross Domestic Product share dedicated to agriculture, public research investment and use of unconventional inputs like education, science and technology (Alston & Pardey, 2017). Agriculture transformation is mainly due to private and public sector science. Public actors have been acknowledged to be the source of innovative ideas by funding R&D in different sectors at the national and regional levels (Feldman & Kogler, 2008). Especially small farms might have difficulties to search for new factors of production, the rate of return will be too low (Schultz, 1964). Farm sector is instable because of climatic conditions that are challenging to manage and market conditions (e.g. low price elasticity of demand) (Chavas, 2001). Agricultural heterogeneity and environmental constraints (e.g. climatic events, pest infestation) was at the origin of creation of a network of research experimental stations (Sunding & Zilberman, 2001). Private and public R&D is combined to provide technical and technological solutions for agricultural sector.

Nonetheless, investments in public R&D are partly due to the public-good nature of science (Sunding & Zilberman, 2001). Agricultural disembodied innovations or embodied and non-shielded innovations came from public support to R&D activities (Sunding & Zilberman, 2001). However, public support sharply decreased, especially in countries that experienced high levels of productivity (Ruttan, 2005). In 2000, $33.7 billion were spent on public and private R&D for agriculture (pre-farm, on-farm, post-farm). 40% were done by private research and 60% by public agencies. The ratio of private versus public R&D share highly varies between countries, with the research in the United States conducted 55% by the private sector while only 35% in Australia and even lower in developing countries. The share of high-income countries decreased from 55.9 percent in 1960 to 47 percent in 2011 (Alston & Pardey, 2017). The rates of return to public investment in agricultural research and extension were above 20 percent, representing underinvestment in public research (Chavas, 2001; Sunding & Zilberman, 2001). In the late

nineteenth century, most of the advances in agriculture were made thanks to public R&D. The investment incentives were diverse like "IPR, tax concessions, fees for service and contract R&D, prize mechanisms, endowment funding (via foundations)". 4% of the total research expenditure in 2000 was dedicated to agriculture worldwide. In developing countries, the average share of public agricultural R&D relative to public science spending decreased from 22.5% in 1981 to 15.4% in 2000. The trend is the same for the three countries concentrating a large share of the R&D (China, India and Brazil) with a decrease from 20.3% to 8.6%. Research is invested in other areas but agriculture. Nowadays, much of the spending of high-income countries goes towards issues different from increasing agricultural productivity (Alston & Pardey, 2014). R&D is now directed towards food safety, environment, animal welfare and other topics (Pardey et al., 2010). The International Maize and Wheat Improvement Centre (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines are international agricultural research institutes targeting major crop foods around the world since 1960s. These non-for-profit organizations are strengthened by the Consultative Group for International Agricultural Research (CGIAR) (Biggs & Clay, 1981). The latter is an international organization, which manage agricultural research programs for poverty reduction and food safety improvement in developing countries. These institutions supported research from several decades and are major contributors in agricultural innovations for sustainability of rural communities.

Finally, small countries need to enhance the capacity of borrowing, adapting and diffusing technologies that were developed and used in similar climatic conditions (Ruttan, 2005). On international level, two main countries improved their agricultural performance through agricultural research and number of farmers. China and Brazil are investing more than richer countries in agriculture (Pardey et al., 2016).

2.4.2 Changing roles of market and government

The last decades have seen a privatization of agriculture, mainly due to higher investments in private research than in public research. These findings are valid for many countries in the world (Alston & Pardey, 2017). Under-investments in private and public agricultural R&D is due to market and government failures (Pardey et al., 2016). During the 1980s and 1990s, there was a shift from government to market support, related to increasing resource mobility like capital and finance (Chavas, 2001). In 2011, private firms realized around 52% of research on breeding, fertilizers, pesticides, food technologies and informatics in rich countries. The agricultural R&D public-sector spending in these countries declined from 56%in 1960 to 47% in 2011 (Pardey et al., 2016). Furthermore, regulatory barriers like those related to food safety, the time lag to obtain the approval of regulatory boundaries and other constraints biased the innovations path. Therefore, larger farms and prevailing crops are favoured and incentives to innovate towards other directions are low (Pardey et al., 2010).

Innovation obstacles are manifold; shortage of high-skilled workers, financing problems, partnership establishment difficulties and administrative difficulties (e.g. taxation, firms creation, etc.) (Encaoua et al., 2004). In traditional food networks, innovation barriers include lack of human resources, lack of financial resources, lack of knowledge of appropriate methods for innovation, conservative attitudes, conflict of interests among the chain partners, high lack of trust, lack of understanding the benefits of collaboration (Gellynck & Kühne, 2010).

Finally, matching needs of farmers with available technology is required first to facilitate the learning process. Networks of practice play an important role to support learning (Eastwood, Chapman, & Paine, 2012). Farmers' decision-making are heuristic-based (Eastwood et al., 2012). Means needed to accomplish transformation of traditional agricultural can follow two approaches: the command approach and the market approach. The former relates to political power deciding types and amount of crops to be produced. The latter lets the investments to the market. Thus, there are "economic incentives to guide farmers in making production decisions" (Schultz, 1964).

2.5 Swiss agricultural framework

In 2016, there were 8,419,600 inhabitants in Switzerland with a quarter permanent foreigners 3,577,000 households composed the country. There were 52,263 farms among 12% of them were organic farms. Structural change in the country is characterised by a decrease of 1.9% between 2015 and 2016, around a thousand farms disappeared along with an increase of harvested surface per farm. This change disturbed the diversified farms with a greater impact (Office Fédéral de la Statistique, 2017b). The Utilised Agricultural Land (UAL) was 1,049,072 hectares. The average per farm was 20.1 hectare with high disparities between farms in mountains, hills or plains. 25.9% was dedicated to open croplands and a total of 2.6% of the UAL was dedicated to grains, fruits and oleaginous. This UAL is small compared to European countries.

After the war period, barriers protection, high prices, support for production systems and technical progress allowed production increase and food independence. The following decades showed a tendency of low labour and capital productivity, explaining production factor migration of agricultural sector to other sectors (Lehmann & Stucki, 1997). The production value dropped by 13.4 billion Swiss Francs in 1985 to 10.3 billion Swiss Francs in 2017, mainly due to reduction of prices on a long-term basis. In parallel, agricultural services related to specialisation of activities increased (Office Fédéral de la Statistique, 2017b). The gross added value of the primary sector was divided by two in twenty years. It contributes to the Swiss economy by 0.7% in 2015 (4,301 million Swiss Francs in 2016). The tertiary sector is dominating with three quarters of the national firms included in this sector. In 2016, the labour force was 153,000 in agriculture (Office Fédéral de la Statistique, 2017b). In 2014, 63% of the domestic production satisfied the indigenous consumption in terms of food energy. Vegetables are the main imported products (Office Fédéral de la Statistique, 2017b).

2.5.1 Agricultural policy

Importance of direct payments

Direct payments are of several types: general direct payments (contribution to the surface, animal care and slopes), ecological (ecological compensation, extensive rapeseed and cereals, organic farming) and ethological (respectful housing) animals and regular outings in the open air) (Buchli, Flury, & GmbH, 2005). Direct payments aim to maintain agricultural surface. In specific conditions (i.e. mountains and hills), farmers are receiving contributions for sloping grounds. Granting all these direct payments is dependent on the furniture of proof of ecological performance (PEP). Other contributions are financial incentives to go further required PEP (e.g. ecological contribution, ethological contributions, contributions for water protection).

In 1992, the Swiss agricultural policy was reformed. Price and income policies were separated. The introduction of direct payments associated with environmental performances was a substantial change of the reform. They are remitted to farmers to the condition of compliance with proof for ecological performance. 95% of the land is cultivated according to the PEP conditions (Chappuis, Réviron, Barjolle, Damary, & Praz, 2006). Moreover, ecological direct payments (e.g. organic agriculture) can be provided to farmers through particular programs.

In the EU-28, 38.8% of agriculture is subsidized while in Switzerland it is 63.4% in 2016 (Lehmann & Stucki, 1997). Direct payments represent one of the main elements in the agricultural policy. There represent the lever of multifunctional agricultural promotion, crucial in the General Agreement on Tariffs and Trade (GATT) (Lehmann & Stucki, 1997). Introduction of agriculture in international market initiated essential reforms of agricultural policies. Financial subsidies coupled with product were replaced by subsidies coupled with crop surface (Kroll, Barjolle, & Jouen, 2010).

In 2013, direct payments accounted for 2.798 billion of Swiss francs – an average of 57,449 Swiss francs per farm. In 2017, the government spent 2,812 million of Swiss Francs for the direct payments as in the followings (in millions of Swiss Francs): 1,096 for contributions to the security of energy supply; 530 for the cultivated landscape, 464 for production system, 400 for biodiversity, 150 for landscape quality, 107 for transition and 65 for the efficient use of resources (Werder, 2017). Around half of the total was dedicated to mountain and hills regions (Office Fédéral de l'Agriculture, 2014).

A revision of the agricultural law in the frame of the Swiss agricultural policy of 2014-2017 fostered sectoral strategy based on quality to guarantee a safe and competitive production. Agricultural and food sectors are then driven by sustainability and quality goals. Sales promotion on export markets is enhanced by export supports initiatives (Office Fédéral de l'Agriculture, 2014).

European and Swiss agricultural policies

The policy aims to contribute to the conservation of natural resources, maintenance of the cultivated landscape, quality of life in rural areas and can be consumers and market-oriented. This agriculture aims to be competitive, sustainable and multifunctional, support targeted public interest services and foster innovation. Added-value, organic agriculture, technical know-how, labels like protected designation of origin, regional anchorage are elements substantial in the Swiss agriculture that is not oriented towards international markets.

The EU and Swiss agricultural policies have similar structure and budget. For the period 2014-2017, the Swiss parliament subsidised the policy with 13,830 millions of Swiss francs (around 11,750 million of Euros) with 84% for direct payments (OECD, 2017). The European Common Agricultural Policy for 2014-2020 period budget was 408.3 billion of Euros, with three quarters for direct payments and expenses related to market in the first pillar and one quarter for rural development measures in the second pillar (Commission Européenne, 2013).

The CAP distinguishes the support for productive activity (i.e. first pillar) from the support for rural development (i.e. second pillar). The Swiss agricultural policy distinguishes general direct payments related to the proof of ecological performance (equivalent to conditionality related to the support of the first pillar of CAP) and ecological payments related to specific and voluntary ecological services (beyond the required services) and specific payments for territories with difficult production conditions (e.g. mountains) (Kroll et al., 2010). Market support and direct payments are similar to measures of the first pillar in CAP. Structural modernization and ecological direct payments are similar to axes 1 and 2 of the second pillar (Kroll et al., 2010). Direct payments have been increased while market support has been sharply decreased. The latter aims to bring domestic prices close to international market prices (Kroll et al., 2010). Finally, support rate in small countries in Europe like Ireland and UK is similar to the one of Switzerland (between 15 to 20%). One of the main differences between the EU policy and the Swiss policy is the price applied (both at production and consumption levels). Even if the production prices dropped by 25% in Switzerland and 20% in EU-5 (representative countries), the gap remains very high (Kroll et al., 2010).

Expenditures in Swiss households

The average gross income was 9,604 Swiss Francs for the Swiss households in 2011, with 6,750 Swiss Francs as the average disposable income. More than 15% of the gross income was dedicated to housing and energy, 8% for transports, 6.75% for food and non-alcoholic beverages, 6.4% for leisure, 5.5% for catering and hosting services among the main expenditures categories.

The Swiss households (i.e. two parents and children) that spent 6.75% of the gross income for food products and non-alcoholic beverages was equal to an average of 648.54 CHF/month (Office Fédéral de la Statistique, 2013). In 2017, they spent 831 CHF/month, including meat (101 CHF), bread and grain products (101 CHF), eggs and dairy products (100 CHF), vegetables (72 CHF),

fruits (53 CHF), sweet products (39 CHF) and fish (20 CHF). The fruits and vegetables accounted for 20.3% of the total (Office Fédéral de la Statistique, 2017c). The Swiss households spent 53.36 CHF/month for 12.046 kg of fruits. Apples account for 6.94 CHF for 2.248 kg and 0.072% of gross income. Kernel fruits (e.g. apricots, cherries, plums, avocados, olives) account for 8.5 CHF for 1.831kg and 0.089% of gross income (Office Fédéral de la Statistique, 2013). There is a correlation between the age and the consumed quantity and the money spent. The greater the age the greater the fruits consumed and the money spent, independently of the household characteristics (e.g. number of persons, children or not) and on the fruit consumed (Office Fédéral de la Statistique, 2013). Different distribution channels are used for the fruits. In 2016, 80.9% of the fruits including the organic fruits were sold via the classic retailers' channels, 15.8% via the discounters and 3.3% via specialized shops and others (Office Fédéral de l'Agriculture, 2017).

Trade barriers

The European Free Trade Association (EFTA) aims to create a free trade area in Europe, since 1960. Norway, Island, Lichtenstein and Switzerland are belonging to this association nowadays. This association deleted custom duties for industrial products but not agriculture. Therefore, each country applies its own economic and border policy. 7% of the Swiss exports are going through these EFTA agreements. Similarly, production standards and requirements are different between the EU and Switzerland because of the different agricultural policies used. However, the standards tend to homogenise, which would have positive externalities for the Swiss producers that are penalised at the economic level (prices of products, expenditures). The topic of deleting trade barriers is not new and could have positive and negative effects like easier imports of cheaper products, which is negative for the Swiss agriculture competitiveness (The European Free Trade Association, 2017).

In order to limit competition with European companies, the Swiss agricultural sector apply border protection with regulating trade barriers. Therefore, imports of fruits and vegetables follow two phases. When indigenous fruit production is not possible, especially due to climatic conditions (e.g. bananas, mangoes, pineapples), importation is free of charge (Until June 30 and after September 1) (Roher, 2012). Between these periods, when production does not cover consumption, imports are subject to tariff quotas. When indigenous production covers partially the population's consumption, tariff barriers for imports give priority to Swiss products. When production is sufficient, import tariffs are higher. During the free phases, an important quantity of apricots is imported from neighbour countries, mostly from Spain, France and Italy. The quotas are decided every week in the harvesting period by the representatives of the sector (three producers' representatives, one for each of the two biggest retailers and the director of the Interprofession des Fruits Et Légumes du Valais). The indicative price is discussed every two weeks with producers and IFELV (B. Lehmann, personal communication, August 5th, 2016).

2.5.2 Description of the Swiss apricot sector

Historical and economic framework

An interview with an expert of the Cantonal Office of Arboriculture was conducted in order to understand the historical context of apricot production. After World War II, national boundaries were opened for trade. Increasing difficulties for farmers were observed. A few years later, a climate of 'revolt and indignation' among agricultural actors resulted in the establishment of border protection mechanisms. In the 1990s, retailers began to refuse to purchase and distribute the traditional apricot variety (i.e. Luizet), which represented 90% of total production at national level. This variety was difficult to manage (e.g. production peak, fast maturity, transport sensitivity), which led to a fundamental orchard reconversion. The financial support provided by the Cantonal Office of Arboriculture was intended to renew the apricot orchards and extend the production period in order to compete with imports. In the period 1995-2006, 6.3 million Swiss Francs were provided, 1.5 million Swiss Francs between 2006 and 2009 and the same amount between 2010 and 2014. Nowadays, Luizet represents less than a third of the total production in the country. This traditional apricot is mainly produced for the distilling industry for Abricotine brandy.

The Swiss apricot production is mostly concentrated in the canton of Valais (96% of the national production in 2015) (Valais-Wallis Promotion, 2015). Therefore, domestic competition is limited between regions (e.g. canton of Valais and German speaking areas). During the period without market protection, an important quantity of apricots is imported from neighbour countries, mostly from Spain, France and Italy. 90% of the market share is detained by three companies responsible for placing the products on the market. Therefore, domestic competition is limited between regions (e.g. French speaking and German speaking areas). The national surface of apricot production was 703 hectares with a national production of 8,717 tons in 2016 but 4,400 tons in 2017 due the strong frost occurring in April (Office Fédéral de l'Agriculture, 2015; Roher, 2012). 143 producers stated to the Interprofession des Fruits Et Légumes du Valais (IFELV) (R. Zambaz, personal communication and the brand and event manager from Valais-Wallis Promotion, December 12th, 2017).

In the region, apricot is cultivated by different types of producers; 300 smallholder farmers performing family farming, harvesting less than one hectare of the traditional apricot variety; 70 smallholder farmers harvesting between one and three hectares of traditional and new apricot varieties; 15 professional farmers harvesting mostly new varieties representing 29.4% of the total surface; and 75 diversified professional farmers harvesting 44% of the total surface. The latter cultivate different fruits and vegetables crops for income diversification (Roher, 2012).

The graph below presents the steps of the fruit production chain (Figure 2-1).

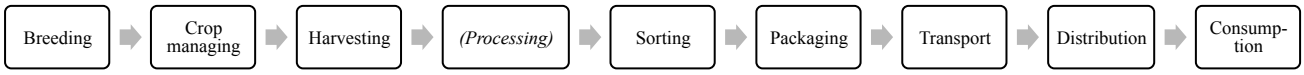

Figure 2-1: Agricultural value chain

The organization of the Swiss fruit sector has sharply evolved in the 2000's. The sector shifted from an unorganized supply chain with multiple intermediates to a chain with "reliable long-term partners of Migros and Coop" based on food quality and food safety (Réviron & Chappuis, 2005).

Breeding is the first step with varietal innovation as seen in the previous section. The orchard management covers different activities, amongst others irrigation, fertilization, pruning of trees, thinning. The harvesting part comes after and is different according to the fruit, especially the orchard structure and crops characteristics. Some treatments and activities are made post-harvesting (e.g. quality inspection with non-destructive devices, grading, sorting) before the potential processing and distribution of the goods. The interactions between the different actors of this chain arise at diverse steps. Producers are in relation with intermediaries that perform activities like sorting (e.g. calibration, sugar rate measurement and external aspect of the fruits) and packing that send the products to the retailers. The latter control the products (visual, size, sugar rate of 11 Brix degrees +/- 10%). These controls are correspondingly done during the harvesting period in order to get an overview of the production in terms of quantity and quality.

The agricultural sector is characterized by a majority of SMEs in both developed and developing countries. The European industry is composed by 99.1% of small firms (Food Drink Europe, 2013). They highly contribute to employment and welfare of countries. In the European framework, small and medium firms with 250 employees or fewer contribute to 58% of gross added value and 67% of employment, according to the European Commission (2014a). These features are of importance regarding limited resources available and the extent to which firms are active in the economic structure.

The diamond model of Porter highlights the intertwined factors of efficiency and quality that are important for firms, regions or countries that want to be competitive. Companies' ability to adjust to unforeseen changes in the marketplace and the ability to furnish diverse products with qualitative advantages faster than its competitors are fundamental (Porter, 1990). Competitiveness of firms on both international and national levels is essential. Moreover, the Swiss industrial sector benefits from a good image, based on a high quality. The traceability and food safety denote challenging topics since the beginning of food crises in the 90's. Besides, with the increasing use of social networks and communication tools, information is faster transferred and can quickly influence public opinion. Hence, tracing products and ensuring safety become substantial goals in order to satisfy the consumers and ensure chain sustainability (Codron, Siriex, & Reardon, 2006). Norms and regulations applied in Swiss agriculture sector allow an important differentiation. The Swiss standard of good practices related to integrated production of food products is more restrictive than the European equivalent.

Nowadays, Luizet represents less than a third of the total production in the country. This traditional apricot is mainly produced for the distilling industry for Abricotine brandy. There is a constant search for new varieties to overcome various emerging and recurring problems such as adaptation to climate change or increasing problems with pests and diseases. Thus, the harvesting period and consequently the offer to consumers has been extended. This innovative change has impacted prices, which have substantially increased (2.10 CHF/kg in 2002; 3.02 CHF/kg in 2013). The gross return was around three times higher in 2013 (23.8 million CHF) than in 2002 (9 million CHF).

To conclude this chapter, innovation is not built around a unique configuration. It stems a paradox between scientific innovation and standard innovation. Firms are embedded in different innovation models. They stand between different knowledge ecologies: on the one hand an innovation model that is science-driven, where public research is producing knowledge and innovation that firms can expect to benefit and value and, on the other hand, a sectoral structure that is supplier-dominated, where firms mostly rely on external sources to innovate, where informal interactions between actors of the value chains prevail, knowledge is sticky and highly tacit, and Research and Development is limited in small firms. The agricultural and food innovations are structured by an institutional hybridity, in which combinations of several information exchanges to develop and diffuse knowledge are fundamental (Allaire & Wolf, 2004). Different authors argued that two paradigms of agro-food innovation co-exist; genetic engineering or life sciences and agro-ecological engineering (Levidow, Birch, & Papaioannou, 2012; Vanloqueren & Baret, 2009). The aim of the former is the modifications of plants for productivity or nutritional purpose. The latter is based on the use of minimum inputs and energy possible. The life sciences vision uses knowledge from public and private research, while the agroecology vision supports knowledge from farmers and know-how of agro-ecological methods (Levidow et al., 2012). Furthermore, the paradigms are balanced towards innovations nature. Genetic engineering displays disruptive innovations when agro-ecological engineering produces more incremental innovations (Vanloqueren & Baret, 2009).

This chapter presented important characteristics of the agricultural sector, the evolution based on economic and innovation approaches, factors of structural change, formal and informal instruments for knowledge transfer and innovation development. Roles of substantial stakeholders in food and agricultural value chains were exposed. All these elements are investigated in the different research projects presented in the dissertation.

Chapter 3 Productive interactions in a low technology-intensive sector: Insights from the Swiss fruit industry

3.1 Introduction

Innovation arises from different sources and is measured differently depending on specific features of the domains in which it has been diffused. In domains dominated by un-codified and informal knowledge transfer processes, observation and measurement of innovation become difficult. Hence, the usual metrics adopted by economists like patents do not work and therefore different approaches should be applied. In this chapter, the 'productive interactions' approach has been chosen. This type of interaction was defined and described in the Social Impact Assessment Methods Through Productive Interactions (SIAMPI) project (Molas-Gallart & Tang, 2011). Few studies have investigated the structure of interactions in a minor crop frame. Hence, the present study focuses on (productive) interactions, as a marker of interactions that might lead to innovation.

This study has two main objectives: testing the SIAMPI approach and exploring the field conditions and innovation impact to understand how the productive interactions are efficient for innovation. This is done by matching the analysis of interactions with an analysis of the market and the actor structure in the agricultural sector. Thus, this research contributes to the understanding of what makes interactions productive in terms of innovation under domain-specific conditions in which the interactions take place.

The chapter is organized as follows. The first section sheds light on previous works related to the interaction structure in agriculture. Characteristics of the sector are then presented, followed by the methods used. The results section introduces the structure of the interactions occurring in the network and the observed innovations. An analysis of the collaborations occurring in the network is conducted. Finally, in the last sections findings are discussed and conclusions presented.

3.2 Measurement and observation of innovation

3.2.1 Technological change in agriculture

Technological change has been studied via two models - 'technology-push' and 'demand-pull' (Dosi, 1993; Ruttan, 1997). The former relates to technology as a factor of technical change, starting from science and technology through the economic sector, while the latter relates to changes in market demand. However, these theories do not emphasise economic and structural sectoral characteristics as factors of change. Furthermore, technological change in agriculture has greatly evolved. In the post World War II period, the main goal was productivity increase to satisfy growing population needs (Dosi, 1993; Ruttan, 1997). Therefore, biological technology and mechanisation targeted land productivity and labour productivity respectively (Ruttan, 2002), depending on the characteristics of the countries, demographic pressure, soil and climate features and capacities to adopt technology (Giampietro et al., 1999; Hayami & Ruttan, 1970b; Ruttan, 1997; Wright, 2012). As agricultural technological change is endogenous, the choice of resources to increase productivity on either the land or labour level will be made in favour of scarce resources in order to sustain them. Productivity growth can be explained by factors like endowment of resources, technological capital, human capital and investment in private and public research (Hayami and Ruttan, 1970a). The latter factor is highlighted in this study and is explored through collaborations between agricultural sector and research on innovation generation. Hence, innovations are at the core of the sector dynamism.

3.2.2 Innovation with an interaction perspective

Economists have stressed the importance of codified indicators like patents, co-publications, licenses and spinoffs as proxy for innovation have been extensively studied (Foray and Lissoni, 2010; Norn et al., 2014; Rossi and Rosli, 2013). Nevertheless, these approaches to innovation are inadequate in sectors where informal interactions prevail. Many domains do not use research and development (R&D) as a driver of economic growth, do not use patents, or do not even innovate. Taxonomy of Pavitt (1984) resulted in a shift of how innovation is perceived, according to patterns like technology sources, users' requirements and appropriation possibilities. Four categories were created. Agricultural sector belongs to the supplier-dominated class. Technology originates from researchers, suppliers of inputs (e.g. chemistry, machines) and partly from the downstream side of the chain (e.g. retailers). However, users' needs became important in terms of innovation objectives (Rossi & Rosli, 2013). Users are an important source of innovation, especially farmers. The "locus of almost the entire innovation process is centred on the user", however the commercialisation is carried out by the manufacturer (von Hippel, 1988c). Firms may be involved earlier in the innovation process by looking for users who innovate or lead users. These experienced users can provide accurate data on 'future' needs.

OECD (2005) defined an innovation as

> 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations […]. Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations.'

Innovation is divided into four types: product, process, marketing and organisational. In farming, product innovation is the most implemented one (Oreszczyn, Lane, & Carr, 2010). Generation of innovation arise through steps like generation of ideas, screening of ideas, testing of concepts, development and launch (H. Chesbrough, 2010; Roy, Sivakumar, & Wilkinson, 2004).

Interactions between various actors of the value chain during the innovation process are critical for the innovation itself like interactions between buyer and seller in supply chain framework (Roy, 2004). Interactions between customer and supplier differ between sectors and stage of the innovation life cycle, relationships with customers being increasingly seen as critical for innovation performance in the introduction stage while less important in maturity stage (Codini, 2015; Johnsen, Phillips, Caldwell, & Lewis, 2006). Furthermore, internal factors (e.g. information technology adoption, commitment and trust) and external factors (e.g. network connections stability within and across industries, and implied knowledge related to technology) of these interactions have moderating impact on innovation generation (Roy et al., 2004). The interactions occurring between different stages of the innovation process are profitable for the innovation itself (Kaufmann & Tödtling, 2001). Innovation is a by-product of network collaboration activities (Knickel, Brunori, Rand, & Proost, 2009; Teece, 2000). Thus, interactions are one of the driving forces for innovation generation. This study is focussing on that interaction aspect of a network where innovations have been introduced.

3.2.3 Knowledge and information transfer through interactions

Firms use different channels to access knowledge like patents and publications. In the frame of university-industry collaboration, D'Este and Patel (2005) defined interactions as "creation of new physical facilities, consultancy and contract research, joint research, training, and meetings and conferences." This definition is adequate to the agricultural setting. Furthermore, interactions are mostly established on a long-term basis and target knowledge exchange (Wood et al., 2014). Nonetheless, knowledge and information transfer is costly and depends on knowledge patterns like codification degree (codified versus tacit) and technology embeddedness (Schartinger et al., 2002). Von Hippel (1994) used the term 'stickiness' to define information that can be transferrable to different environments, depending on the nature of the information, its amount and the characteristics of the future user. This stickiness is related to the tacit nature of knowledge which is difficult to diffuse due to its un-codified nature (Cowan et al., 1999). Moreover, knowledge is embedded in local contexts, hindering its transfer to other settings (Ruttan, 2002a). Local

knowledge is transmitted via 'social processes' because rooted within a social framework (Ingram, 1985). Thus, informal interactions are a good channel through which knowledge can be diffused (Dahl & Pedersen, 2004).

Knowledge structure in agriculture

Literature has emphasised an efficient model for knowledge transfer, which is the Agricultural Knowledge and Information System (AKIS) (Barjolle et al., 2014; EU SCAR, 2012; Leeuwis, 2004). AKIS purpose is to strengthen communication and knowledge flow to rural communities (EU SCAR, 2012; Spielman & Birner, 2008). This involves interactions between farmers, associations and stakeholders of the value chain with administration, public extension services and the policy sector, universities and national public research organisations. The main outcome of this model is adoption of technology and innovation in agricultural domain. Involvement of stakeholders at different stages of the innovation process has now been stressed (Girard, 2015). This framework is commonly used in different domains.

In agriculture, horizontal networks are more used by small firms in an open innovation context. For Mc Kiterrick et al. (2016) horizontal network strengthens the 'local productive capabilities' thanks to collaborations between firms, other producers and other actors established in the network. This aspect is investigated in the study by the analysis of interactions' partners.

Proximity and interactions

Proximity can be defined in different dimensions: geographical, institutional, cognitive and organisational (Boschma, 2005). Geographical proximity between actors can improve innovation efficiency and knowledge transfer with lower transaction costs (Schartinger et al., 2002). Nevertheless, some studies found that cognitive proximity surpasses geographical proximity and is stronger for knowledge transfer, technology transfer and innovation diffusion (Breschi & Lissoni, 2006; Lissoni, 2001; Rallet & Torre, 1998). These features are investigated in this study.

Network theory: measures of degree, betweenness and clustering coefficient

In network theory, Social Network Analysis (SNA) is used to measure how network is structured in terms of density (i.e. number of nodes) and connectivity (i.e. number of edges between the nodes). An important measure is degree. This measure is the number of links coming and exiting from nodes (in-degree and out-degree respectively). The average degree of a graph G is expressed as

$$\frac{2|E(G)|}{|V(G)|} = \frac{1}{|V(G)|}\Sigma v \in V(G)\ \deg(v).$$

Equation 3-1 – Average degree of a graph G

Another essential measure introduced by Freeman (1977) is betweenness. This measure indicates the importance of a node located in the shortest path between other nodes (Guns, Liu, & Mahbuba, 2011). In a network G = (V, E), with a set V of nodes (vertices) and a set E of edges between them, betweenness is expressed as

$$C_B(a) = \sum_{g,\square \in V} \frac{p_{g,\square}(a)}{p_{g,\square}}$$

Equation 3-2 – Betweenness

with $p_{g,h}$ as the number of geodesics between nodes g and h and $p_{g,h}(a)$ as the number of geodesics between nodes g and h that pass through a. The number falls between 0 and 1 with normalization. When the value is close to 1, the node is considered as central because it can facilitate communication or retain information, leading to partial control of information flow between the nodes (L. C. Freeman, 1977; Newman, Watts, & Strogatz, 2002).

For an undirected network with n nodes, betweenness becomes

$$C_B(a) = \frac{2}{(n-1)(n-2)} \sum_{g,\square \in V} \frac{p_{g,\square}(a)}{p_{g,\square}}$$

Equation 3-3 – Betweenness for undirected networks

Clustering coefficient indicates whether graphs are small-worlds. These are graph where each node is connected randomly to the closest neighbours with a low average path length, hence connectivity is high (Newman et al., 2002). It is the ratio of the number of links between a node and its immediate neighbours and the existing number of links (Tulip, 2017; Wilson, Boe, Sala, Puttaswamy, & Zhao, 2009). For an undirected network with N neighbours and E edges between neighbours, clustering coefficient is equal to

$$\frac{(2E)}{(N(N-1)}$$

Equation 3-4 – Clustering coefficient equation

Values are comprised between 0 and 1.These measures are providing insights on how connected are the actors in the network. Connections occurring between them are investigated through the lens of ‘productive interactions’ that are presented in the next section.

3.3 Productive interactions

3.3.1 Higher Education Institutions frame

University-industry relations are stronger in applied fields than in science-based fields (Meyer-Krahmer & Schmoch, 1998). Furthermore, previous common work experience might increase knowledge exchange relationships in the future. Informal contacts are more likely to be generated with former students of a local university than students of a non-local university. Thus, in the fruit industry interactions between university and industry can be expected.

In the innovation system, universities perform different activities into three domains: scientific research, knowledge production directed towards industry use and human capital formation inducing mobility between academia and industry (Schartinger et al., 2002). Universities of Applied Sciences (UASs) are more oriented towards the labour market than traditional universities. Jongbloed (2010) focused on the interactions of UASs with external partners that are mainly informal. A part of knowledge transfer occurs through learning.

Knowledge development has evolved at different rates between sectors. The education sector is characterised by its limited development (Dominique Foray, 2001). This sector is an example where R&D is not the centre of gravity. R&D is about experimentation, evaluation and tests of different methodologies tailor-made to classrooms with defined characteristics. Murnane and Nelson (1984) opposed this research to the research done in science-based sectors like pharmaceutics where R&D is separated and represents a substantial source of innovation. Technology transfer and required skills is easier in this sector than in education.

In conclusion, focus is placed on productive interactions, as a marker of interactions, which might lead to innovation. The approach adopted by a European project was selected to study these interactions.

3.3.2 Presentation of the SIAMPI approach

The European project Social Impact Assessment Methods through Productive Interactions (SIAMPI) was included in the Seventh Framework Program (EU-FP7). The goal was to assess the social impact of four research fields (e.g. social sciences and humanities, nanosciences, healthcare and information and communications technology) in four countries, using collaborations inducing innovation, designated ‘productive interactions’, defined by Spaapen and van Drooge (2011) as

> ‘exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant […] through various “tracks”, for instance, a research publication, an exhibition, a design, people or financial

> support. The interaction is productive when it leads to efforts by stakeholders to somehow use or apply research results or practical information or experiences'

Three categories of productive interactions were used: direct, indirect and financial. Direct interactions were defined as personal interactions like face-to-face contacts, phone contacts or digital contacts (e.g. emails or videoconferencing). Indirect interactions occurred by means of texts or exhibitions for example. The financial interactions were of a formal type (e.g. research contract). The social impact was investigated by focusing on the researchers' interactions to understand 'how researchers communicate with their environment'. This is one of the main differences from our present study (Molas-Gallart & Tang, 2011).

The ASIRPA project (Socio-Economic Analysis of the Impacts of Public Agricultural Research) also used an approach emphasising the process of research impact (Joly et al., 2015). The authors used case studies and built a framework taking into account actors' characteristics to understand the contribution of these actors to generated impact, but still not going beyond the productive interactions processes. In the SIAMPI project, market characteristics were not included (Molas-Gallart & Tang, 2011). Therefore, these features are investigated in the present study. Formal collaborations are defined in the study as any contractual collaboration between two partners including financial research contracts. Informal collaborations concern all contacts like face-to-face, phone calls, emails exchanged and field visits.

An interaction is considered productive when an innovation has been created and implemented due to the collaboration established. The interactions could be direct (i.e. two or more actors engaged in the collaboration) or secondary (i.e. other actors have participated in the process without being clearly involved in the collaboration).

The study tries to determine what generated the observed interaction structure, what makes interactions productive in terms of innovation and which methodological implications can be drawn in terms of innovation analysis and the impact of public interventions. These questions will be investigated and presented in the following sections.

3.4 Presentation of the stakeholders

The market characteristics of the sector (see section 2.7.2 for further details) influence the innovation system, further investigated in this chapter.

Roles of stakeholders in the supply chain

Market structure is governed by different types of actors as presented in Figure 3-1.

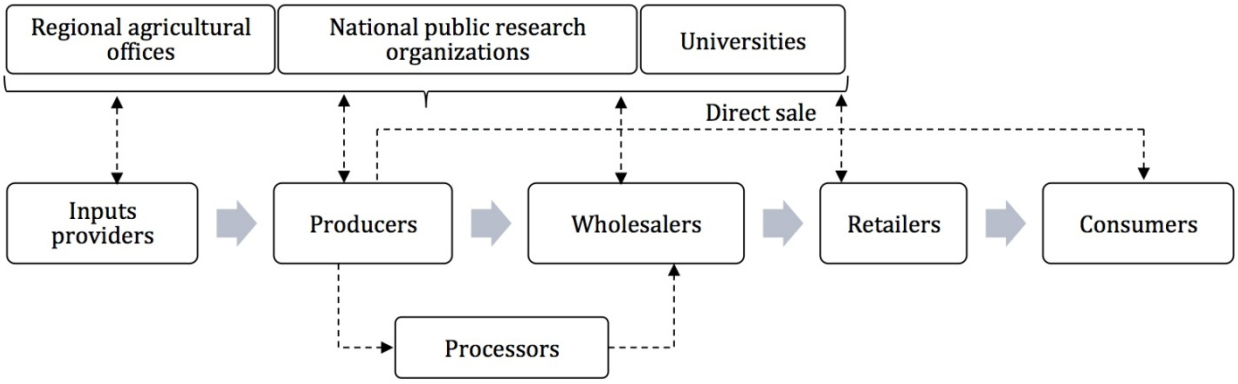

Figure 3-1: Actors in the apricot sector in Switzerland

Production activities are managed by farmers from crop planting to harvesting. A part of the harvested fruits is either sold by direct sale or sent to trader-shippers or wholesalers. The latter carry out sorting and conditioning for their customers. They send the goods to retailers, caterers, specialised and local shops (Roher, 2012). From 2004 to 2016[1], Swiss apricot production rose by 14.8% to 6,730 tons[2]. In 2016, the majority (85.8%) was sold through retailers as fresh fruits.

Producers

There are three types of producers in the apricot sector. The first category comprises 300 producers that own less than three hectares for traditional production. They perform family farming. About 70 smallholder farmers are harvesting between one and three hectares of traditional and new apricot varieties; 15 professional farmers harvest mostly new varieties representing 29.4% of the total surface and 75 diversified professional farmers harvesting 44% of the total surface. The latter cultivate different fruits and vegetables crops for income diversification (Roher, 2012). The average surface is around 2.47 hectares but drops to 1.38 when farms exceeding 10 hectares are excluded.

National public centre for agricultural research

Agroscope is the Swiss centre of excellence for agricultural research. It is mandated by the Federal Office for Agriculture (OFAG) to conduct research activities in agriculture, nutrition and environment. It provides bases for decision-making in the framework of public-authority legislation and is involved in 'knowledge exchange and technology transfer with practitioners, the advisory sector, industry, science, the teaching sector and the public' as mentioned on the Agroscope web page (Agroscope, 2016). Its position in the value chain is favourable for strengthening network connectivity and linking the region with potential partners located outside the region. Researchers are working with producers to define the best new varieties that could meet their expectations by organizing meetings, information days and crops monitoring. Finally, different activities are

[1] The data were provided by the *Interprofession des Fruits et Légumes du Valais*. These are estimated amounts of production.
[2] The data concern new varieties of apricot, i.e. without taking into account the traditional Luizet variety, which is mainly produced for alcoholic distillation.

organised with private sector representatives, the cantonal office of arboriculture, producers (e.g. fruit tasting) and consumers. This enables the transfer of knowledge and innovation and the dissemination of information through science popularisation.

University of Applied Sciences of Western Switzerland

One of the aims of UAS was the accomplishment of applied research activities (Jongbloed, 2010; Lepori, Huisman, & Seeber, 2012). Hence, UAS in the region of Valais (UAS Valais-Wallis) is working on topics like processed fruits. This university is geographically close to Agroscope (less than 10 km). The links established between both research actors lie in formal collaborations like national or international projects.

Retailers

The Swiss retailing market is oligopolistic. Two major retailers share the turnover: Coop and Migros, through which 70% of fresh food products is traded (Lauterburg, 2015). These two cooperatives were founded in 1890 and 1925 respectively. Migros sells exclusively its private brand (with some exceptions) based on a low to medium price range. Coop sells its private brand, certain trademarks established by partnerships with processors, organic products of its own brand and alcoholic products.

3.5 Methods

We expand the SIAMPI method by moving beyond a focus on interactions towards an analysis of the network structure, for a more precise understanding of how interactions become productive. The methods used in this chapter rely on the SIAMPI developed methods (for more precisions, see section 3.3.2).

Figure 3-2 highlights the research design. Sectoral characteristics have been collected to understand the structure of the sector. Interviews have been conducted to determine the interactions characteristics of the main actors in the research centre for agriculture and in the apricot value chain. Financial collaborations have been added thanks to data collected from the UAS Valais-Wallis. Finally, implemented innovations were a part of the survey addressed to Swiss stakeholders of the apricot sector. These data allowed the identification of productive interactions in this network.

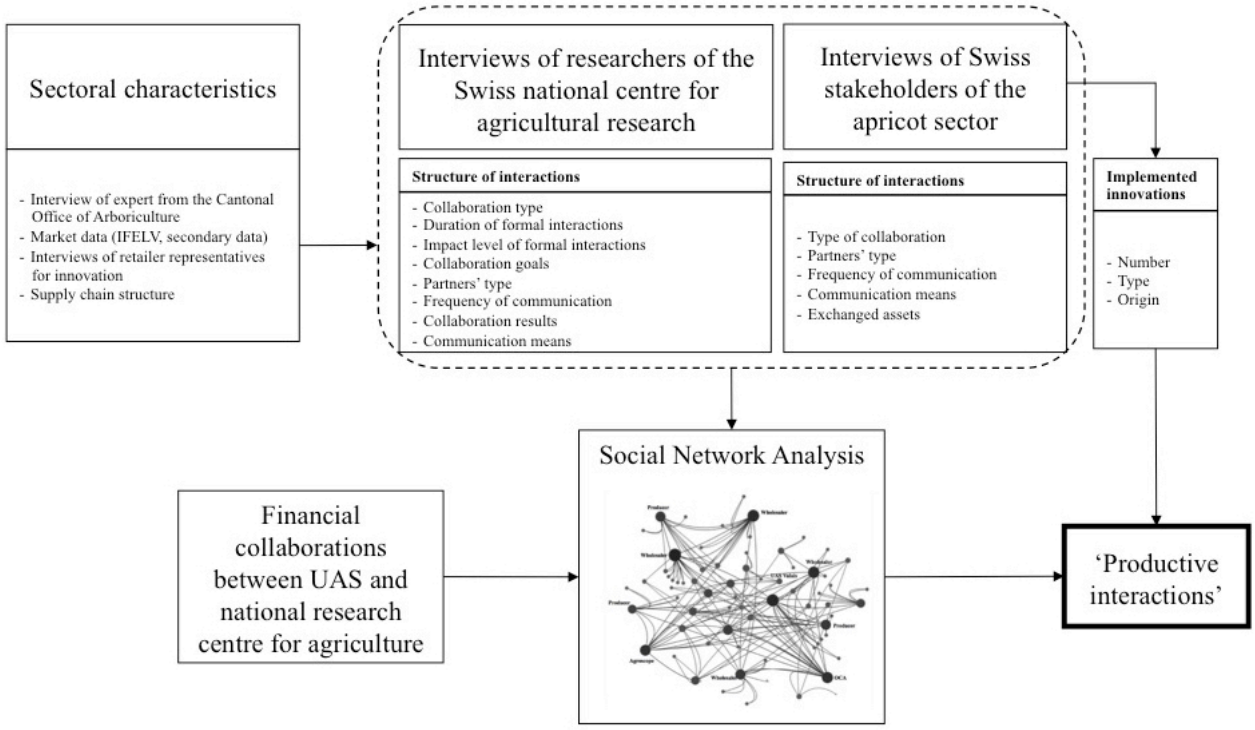

Figure 3-2: Data collection for the understanding of productive interactions features

3.5.1 Data and interview configuration

Two surveys were designed to map the interactions that lie within the Swiss apricot network. Data for the study were partially derived from the EU-FP7 project on Traditional Food Network to improve the transfer of knowledge for innovation (TRAFOON). The project concentrated on traditional food production by small and medium-sized apricot and berry enterprises in Switzerland. Data on stakeholders of the sectors were identified.

For the first survey, semi-structured questionnaires were used. Interviews lasted around one hour and a half. Collaborations concerning innovation had to be specified with partner name, collaboration type, collaboration method (e.g. emails exchanged, phone, visits), reciprocity (bilateral versus multilateral), communication channels, intensity of contact and resources exchanged (information, material) (Burt, 1997; Nicolaou & Birley, 2003).

The second survey identified different types of collaborations between the national centre for agricultural research, Agroscope, and partners in several spheres. The survey structure was similar to the survey dedicated to apricot stakeholders.

Finally, financial interactions between the Swiss research centre for agricultural research and UAS Valais-Wallis were investigated. The Head of the Institute of Life Technologies of the University of Applied Sciences provided data on the collaboration projects between UAS and Agroscope. These data allowed to map financial collaborations between the actors, the third type of collaborations defined in the study.

3.5.2 Analytical methods

The semi-structured interviews were used to build a network map. A social network analysis (SNA) was conducted thanks to TULIP 4.8.0 software. Each respondent is a node in the network. Every collaboration reported by the respondents is a link or edge between two nodes. The resulting map displays connections in the apricot sector at the regional level but also outside this area thanks to the identification of foreign partners.

Measures of network connectivity, degree, betweenness centrality and clustering coefficient were computed. Frequency of interactions, goal of collaborations, means of communication used are reported in the results section.

3.6 Results

3.6.1 Interactions through collaborations: a network approach

The network is shown on Figure 3-3, with 138 nodes and 187 links. The nodes framed by bold black lines are the actors interviewed (i.e. producers, traders, transformers).

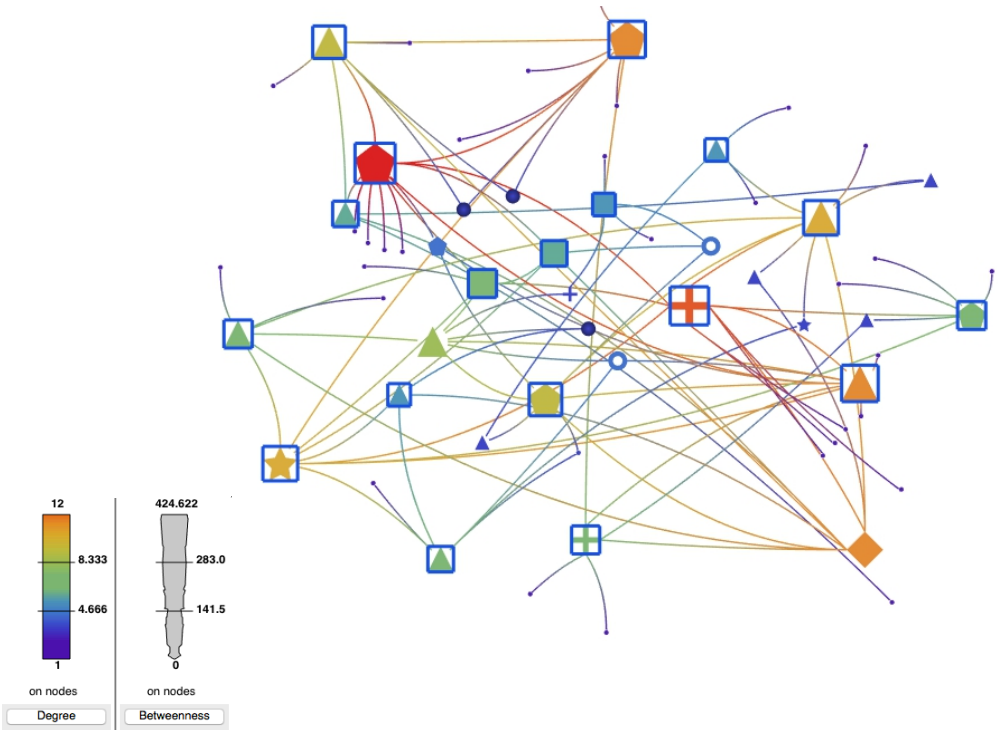

Figure 3-3: Cited collaborations in the Swiss apricot network[3]

[3] Legend: star: public research centre; triangle: producer; pentagon: trader; cross: wholesaler; square: transformer; flipped square: public support institute; bubble: nursery; circle: universities; square with bold upper line: association, private support institute; hexagon: private firm (e.g. phytosanitary firm)

Indicators like degree, betweenness and clustering coefficient were computed in order to analyse the connectivity and the structure of the network. Figures 3-4, 3-5 and 3-6 present these measures.

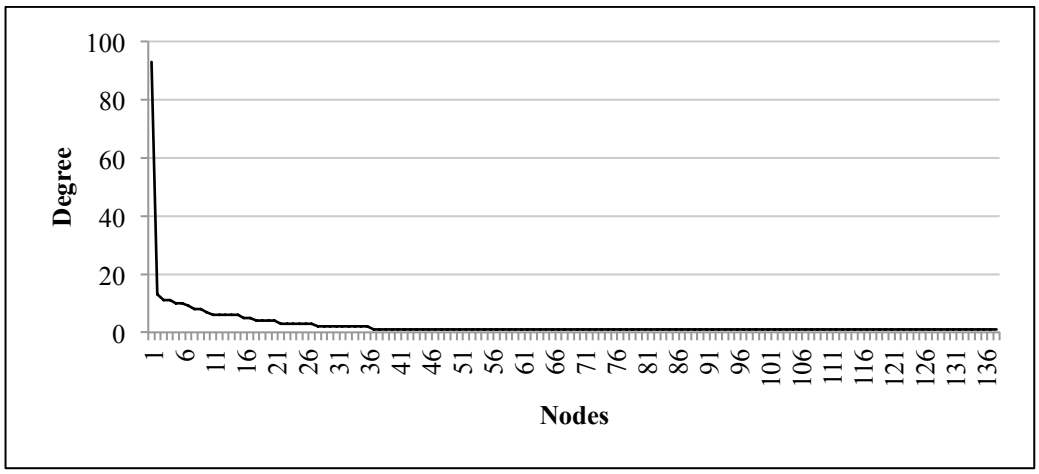

Figure 3-4: Degree of actors constructing the network

The curve in Figure 3-4 displays the degree of every node in the network. The degree represents the number of neighbours of a particular node, thus the number of collaborations cited. The curve suggests that one node has many connections in the network (left side of the graph), but the majority of nodes have a few connections (right side of the graph). This is explained by the fact that many apricot stakeholders interviewed cited different collaboration partners. Many weakly connected actors have a low degree value. Moreover, the bigger the nodes, the bigger their degree are (Figure 3-3). The biggest nodes are research centres, producers, wholesalers, traders, and support services.

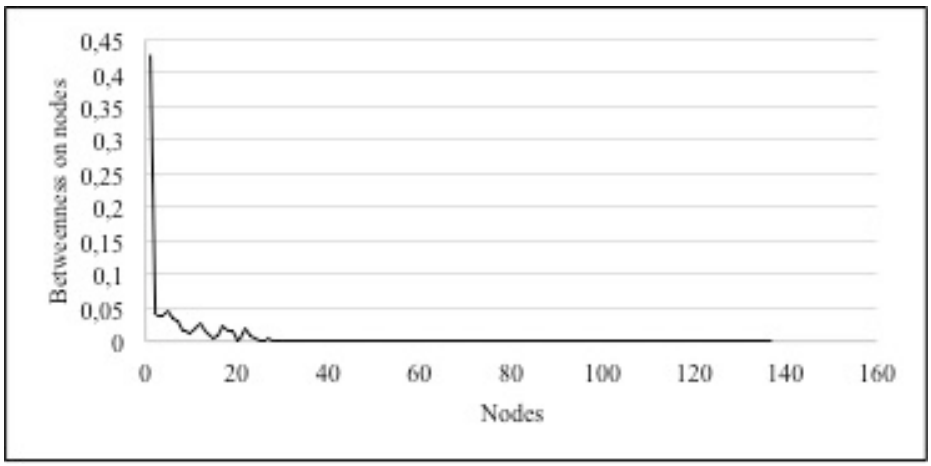

Figure 3-5: Betweenness on nodes

Figure 3-5 plots betweenness of actors. Like Figure 3-4, a few actors have higher value than the majority. Betweenness falls into 0 and 0.42 with 10% of the nodes ranging from 0.014 to 0.043. The node with a betweenness of 0.43 is central in the network.

The national research centre is the biggest central node that is connected to 88 partners, followed by wholesalers (e.g. degrees of 23, 21, 20 and 19). Furthermore, betweenness reveals the

information flow control through specific nodes, following the shortest path between them. In Figure 3-3, the highest betweenness (red) is concentrated on a few nodes.

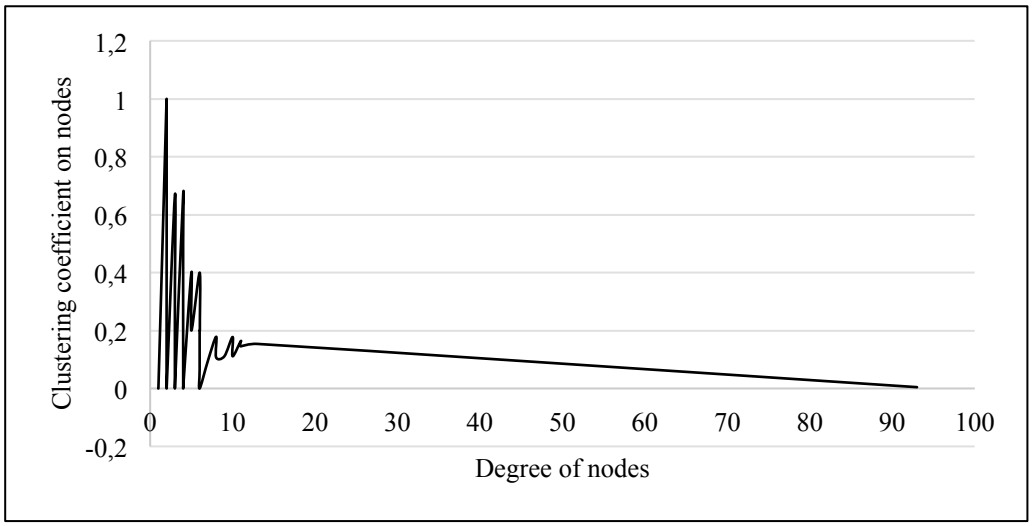

Figure 3-6: Clustering coefficient of actors as function of their degree

Figure 3-6 presents clustering coefficient of nodes as function of their degree. The left side of the graph indicates that clustering coefficient is higher for nodes with lower degree. However, this is not homogeneous since there are peaks and troughs, demonstrating a low-clustered behaviour. Thanks to these figures, the graph cannot be considered as a 'small-world'. Even if the network is small in size (i.e. number of actors), nodes in the network are not linked to each other and do not form tight connections or cliques with their neighbours, as it can be expected in such domain.

Survey of firms producing apricot

Nineteen interviews were conducted (52.7% of the sample targeted), including 40% of producers, 20% of transformers, 14% of traders and 10% of wholesalers. The mean apricot surface of Small and Medium-sized Enterprises (SMEs) interviewed is 15.82 hectares per farm (from 4 to 54 hectares). There are mainly incumbent companies established on average in 1962. The management of the labour force is highly variable according to season. The average number of employees in winter is 13.83 full-time equivalents and 40.06 full-time equivalents in the summer period.

Cited interactions are presented in Table 3-1.

Categories of actors	Number of citations	Percentage
Nurseries	13	7.8
Producers	84	50.6
Transformers	8	4.8
Wholesalers	60	36.1
Customers (retail and specialised stores)	1	0.6
Total	**166**	**100%**

Table 3-1. Swiss apricot network interactions concerning knowledge and innovation transfer

Producers are strongly connected with 84 ties mentioned. This is the main category cited (50.6%), followed by wholesalers (36.1%). The actors exchange information and materials like fruits and packaging.

Figure 3-7 indicates the frequency of communication between the respondents and their partners. Emails and phone are the main communication means used, ten and eleven respondents expressed to use emails and phone respectively frequently and very frequently. Other means are used occasionally and rarely. These findings support the network structure, which is based on informal collaborations with interpersonal contacts.

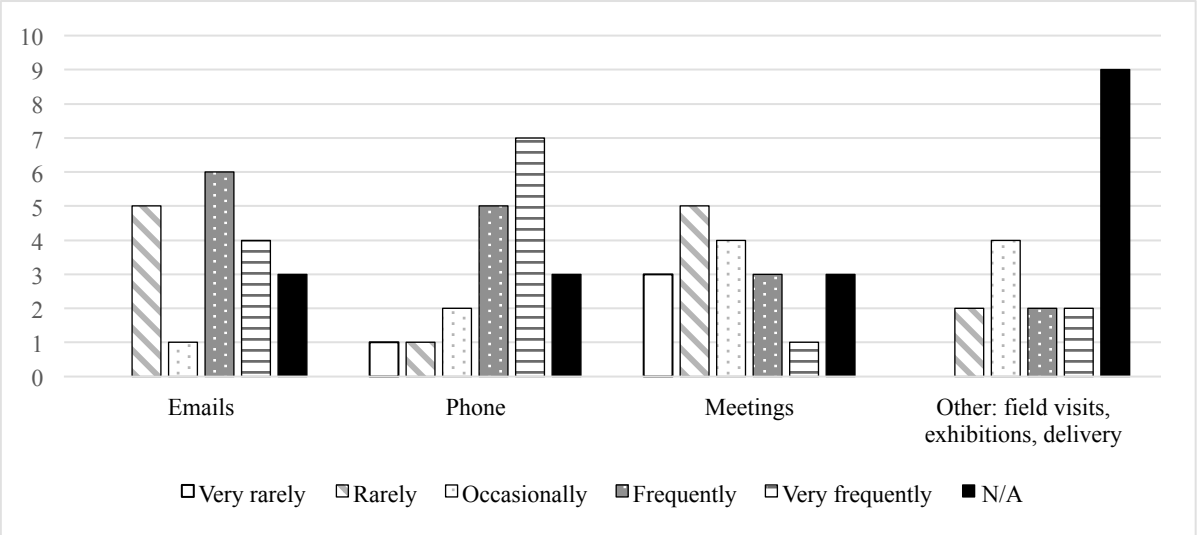

Figure 3-7: Frequency of communication means of apricot stakeholders with collaboration partners[4]

Interviewed stakeholders cited different goals of collaborations. These goals can be categorized into four groups: information exchanged, material exchanged, on-site experiences and advices. The first category, information exchanges, includes market information (e.g. price and volume

[4] Legend: Very rarely: maximum once a year, rarely: one to two times per year, occasionally: once every two months, frequently: several times per month, very frequently: several times a week.

evolution), logistics – both on national and European markets. The second group targets exchanges of new varieties, rootstocks and fruits to be transformed into juices. The third group concerns field visits and panel tastings. The last group includes advices to producers (e.g. climate adaptation of specific varieties, organic production and industrial transformation). It can provide theoretical support.

Searching for other sources of innovations besides interactions

The cited informal collaborations are supplemented by other sources of information to acquire new knowledge about innovation. Communication tools used to exchange information and materials are displayed in Figure 3-8. There are mostly emails and phone. Face-to-face communication and field visits increase during summer. Stakeholders consulted written sources of information to acquire knowledge about innovation. Patents and good practices guides are rarely consulted. Fairs and exhibitions are rated rarely. The other sources are the most frequently used, especially Internet websites (42.1% frequently used). Reports and academic articles are rated occasionally, mostly because of subscriptions to specialised agricultural journals (31.6% each). According to these findings, informal interactions are the most exploited channels for transmitting information, materials and other assets leading to innovation.

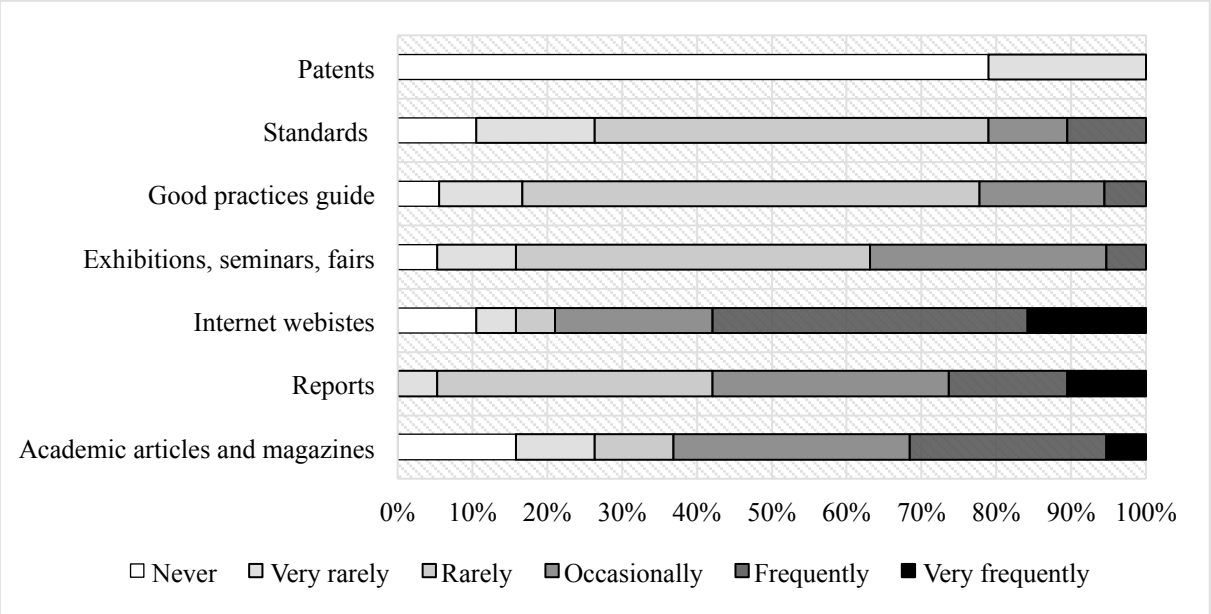

Figure 3-8: Sources of innovation except interactions[5]

These findings confirm the trend of a network that relies mainly on personal contacts using phone calls and meetings to communicate on a daily basis. Internet is the other channel mostly consulted.

Finally, positive and negative experiences in collaborations were asked during the interviews. Table 3-2 summarizes these rationales.

[5] Legend: Very rarely: maximum once a year, rarely: one to two times per year, occasionally: once every two months, frequently: several times per month, very frequently: several times a week.

Topics	Positive experiences	Negative experiences
Trust, anticipation, preparation	Experience: Tasting panels close to retail stores to promote damaged fruits due to hail and rain. Results: Retailers' support through selling of the products using specific trademarks	Experience: Difficult climatic conditions in specific years Results - Poor cohesion at cantonal level because products' quality decreased and difficulty of storage - Lack of anticipation of different stakeholders and bad agreement on prices
Product analysis, marketing strategies	Experience: new fruit variety placed on the market Results: collaborations with retailers, tasting panels on site, good market penetration	Experience: new apple variety placed on the market Results: important planting areas, however insufficient market launch, poor marketing strategies, insufficient sales conducting to trees grubbing
Active listening	- Agricultural inputs choices - New varieties proposition to cope with organic crops challenges (e.g. diseases)	
Stakeholders availability	Off-ground cultivation feasible in collaboration with different stakeholders	
Financial resources		Experience 1: experimentation of sensors at different levels in the ground Results: short and long-term follow-up needed but not feasible due to financial lacks. Numerous experiments required to collect results on farm scale and not only on plot scale Experience 2: collaboration with university and agricultural school to develop analytical device for fruit maturity Result: Product price not affordable for customers
Partners' relationship	Experience: Collaboration with competitor for packaging and sorting according to harvesting period Result: Commercial relationship establishment	Experience: collaboration between HEI and firm specialised in processed fruits Results: HEI focused on product valorisation strategies. However, this has been experimented informally by the firm. The relationship between the two partners failed.

Table 3-2. Rationales expressed by stakeholders for positive and negative collaborations

Positive rationales in past collaborations included listening, understanding, helping, confidence, trust and reliability in other partners. Regular discussions, facility to meet each other's, availability of partners, simplicity to talk and competence of partners were cited as being important for collaboration success. Anticipation and preparation were cited to be important for positive and successful collaborations. Bad agreement between partners, lack of listening to expectations and needs (e.g. varietal choice not adapted, price of material not adapted to needs of customers), imbalance of power, financial risks, lack of anticipation (e.g. storage problems during harvesting in critical periods), insufficient support (e.g. in marketing activities), lack of cohesion between partners and bad analysis of the market were pointed out to be important negative rationales for collaboration failures. Thus, understanding who the partner is, what the expectations are,

availability and trust appeared to be determinant for successful interactions. This is accomplished by frequent and informal contacts within the network.

Survey of the Swiss centre for agricultural research

The second survey was dedicated to researchers of the Swiss centre for agricultural research. They were four group chiefs and four scientific collaborators. The main area of research was fruits and medicinal plants. The respondents reported 113 collaborations; 65 formal collaborations and 48 informal collaborations with external partners. The average length of the formal collaborations was 66 months with a lot of renewable contract of minimum 12 months. Figure 3-9 highlights the links between the Swiss research centre for agricultural research and its partners.

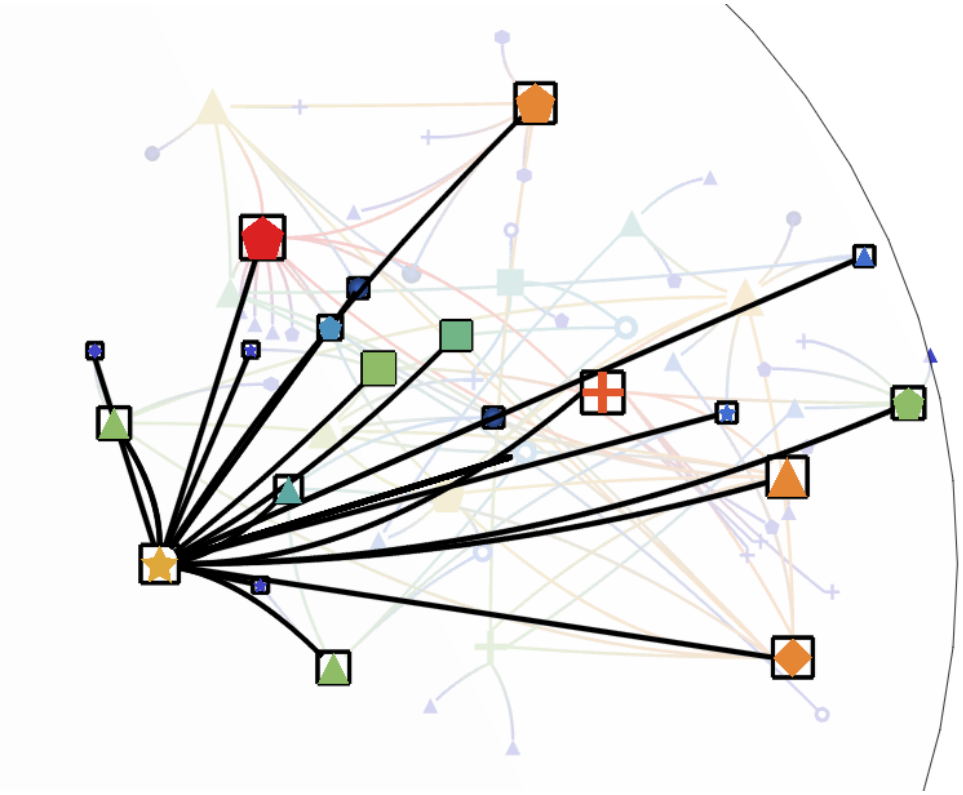

Figure 3-9: Edges of the Swiss national research centre for agriculture

In Table 3-3, actors are aggregated in categories like research and technical institutes or universities. The goals of exchanges in both formal and informal collaborations were knowledge transfer, information exchange and materials (i.e. fruits, analysis devices) exchange. Collaborations topics were diverse including marketing, quality, diseases, preservation, storage, breeding, post-harvesting, co-publication, students' internships, project redaction. Laboratory analyses are also performed. Outputs are diffused through co-publications, common reports, oral presentations in conferences and thematic days targeting the sector, society and scientific community.

Categories of actors	Geographical proximity[6]	Number of citations	Percentage
Research and technical institutes		15	44.1
Agroscope	+	*10*	*29.4*
FiBL	-	*2*	*5.9*
INRA	-	*2*	*5.9*
CTIFL	-	*1*	*2.9*
Policy and professional associations		11	32.4
Cantonal Office of Arboriculture	+	*10*	*29.4*
IFELV	+	*1*	*2.9*
Universities		8	23.5
EPFL	-	*1*	*2.9*
UAS Valais-Wallis	+	*3*	*8.8*
University of Bologna	-	*1*	*2.9*
Ecole d'Agriculture du Valais	+	*2*	*5.9*
Ecole d'Agriculture de Changins	-	*1*	*2.9*
Total		*34*	*100%*

Table 3-3. Swiss apricot network interactions on knowledge and innovation creation

Many links are established with research and technical institutes, cited by 44.1% (15 citations) and policy bodies and associations (11 citations). Agroscope predominated in collaboration activities with 29.4% of the total collaborations reported. However, UAS Valais-Wallis had few connections with stakeholders (three citations).

Eighty-six collaborations have been reported by the eight researchers interviewed. 44.58% are formal collaborations, 27.71% are informal and the rest are both formal and informal. These collaborations are established with many partners, ranging from the apricot value chain to research centres in Switzerland and abroad. 21.25% of collaborations are with other research centres in Europe, 16.25% with nurseries, 15% with universities, and 15% with other private firms. The remaining partners are phytosanitary firms, producers, transformers, warehouse keepers, retailers, public bodies, associations/advisers, professional organisations and working groups/forums.

Additionally, market data was collected through archival data and two interviews with an agro-scientist collaborator of the Cantonal Office of Arboriculture and the director of the Interprofession des Fruits et Légumes du Valais (IFELV). The innovation strategy of one of the two biggest retailers in Switzerland was investigated by interviewing the chief of fresh products using an open questionnaire.

[6] Geographical proximity is defined as close (+) if the organization or firm is located in the Valais region, far (-) otherwise

Most actors are located in Switzerland. Therefore, geographical proximity is not sufficient to establish interactions. This result is surprising as 28% of the respondents are training agronomists and oenologist engineers who studied in the UAS. This can probably be explained by the mandates of the different institutions. The high implication of Agroscope and the Cantonal Office of Arboriculture in collaborations reveals a catalyst role by transferring knowledge through translation of research outputs into ready-to-use information and innovation in practice. They have closer cognitive proximity to the respondents than other nodes in the network.

The contacts established with collaboration partners were mainly previously established contacts (60 times cited). Twenty-two collaborations started without previous established contact with partners and ten collaborations were made through common intermediaries. Previously contacts are a basis for new collaborations. Furthermore, the level of impact was reported by respondents. Three levels of impact of collaboration projects were defined; regional (Valais), national (Swiss) and international (Europe). Twelve collaborations had a regional level of impact, 54 national and 47 international. This supports a trend of openness of the network.

Except for one stakeholder and the high rate for rarely contacts cited, the overall trend is a scarce use of communication with partners. This might be explained by the nature of collaborations established. Since there are more formal collaborations, calendar meetings are defined all along the projects. Hence, there might have a mid-term frame for these contacts, consequently less frequent communications.

Financial collaborations were investigated between the University of Applied Sciences and Agroscope. Four projects were started between 2013 and 2016 (question asked to the respondent)[7]; one European project of FP7, one Swiss Food Research Call and two national projects. These include research on quality parameters of berry fruits, related to agronomic factors; valorisation of berries with extrusion technology; improvement of knowledge transfer for innovation (TRAFOON project); and exchanges of services like analytics of plant compounds or fruits. The project duration varied from one to five years, ending with diverse co-publications. These projects endorsed the formal type of collaborations that exist between the two partners in the region. Nevertheless, the two actors are poorly connected in the network.

3.6.2 Implemented innovations

Actors of the apricot supply chain create and adopt different types of innovations through collaborations. To identify the rate of innovation, the question asked to the producers was ‘Did your firm introduce a new product, process, marketing or organisation in the last three years?’, hence in the period 2012-2015. They had to tell how many innovations were concerned.

[7] Only projects including the Agroscope site in Valais and the UAS site in Valais are reported. A few more projects concerned UAS-Valais and Agroscope-Liebefeld-Posieux. The purposes of the two projects were related to the crystallization of cocoa butter and reducing of sugar in yogurt.

Table 3-4 reports types of innovations implemented recently cited by in the 19 interviews of the apricot value chain stakeholders.

	Yes	No	N/A	Total
New product	16	2	1	19
New process	7	11	1	19
New organization	6	12	1	19
New marketing	9	9	1	19

Table 3-4. Type of innovations implemented between 2012 and 2015

The main type of innovation implemented is product innovation (16). Process innovations, organization innovations and marketing innovations were implemented approximately at the same rate. Stakeholders implemented 122 product innovations, 15 process innovations, 7 organization innovations and 10 marketing innovations.

Innovations implemented by producers

Sixteen firms have implemented at least one product innovation, mostly new varieties. It was developed in collaboration with the public research institute. Seven firms implemented process innovations (e.g. juices, dried fruits, liquors). Six firms applied organisational innovations and nine firms are concerned by marketing innovations. A firm reported trends to ‘get closer to consumers’ and ‘fresh and local products’. To ‘ensure economic valorisation’, e-shop platforms should be improved. Explanations about varieties like hedonic criteria and maturity date would be provided. Lastly, distillers are limited with regard to innovation possibilities because of legal requirements concerning advertising. Hence, one firm launched a social-product innovation to meet the evolution of consumption trends.

Innovations implemented by retailers

An interview with two representatives of one of the biggest retailers was conducted. In the apricot sector, the retailer traded only 70 tons over 6,000 tons produced. It is not ‘possible to impose any variety on the producers’. This hinders the possibility of steering innovation and is partly due to the decentralisation of the management system. Apricots do not represent the retailer’s highest sales; 1,100 tons of apples, 450 tons of grapes and 300 tons of pears are traded.

One important partner of the retailer for innovation is the Cantonal Office of Arboriculture. Collaborations begin with a request from the retailer for specific products like forgotten vegetables or fruits or new products not yet harvested in the region. Collaborations with producer(s) are then initiated with technical tests and economic analyses conducted throughout the production. Finally, innovation regarding packaging is limited because sorting and conditioning are done by the wholesaler.

Marketing innovation

Competition on the one hand with direct sale and on the other hand with other fruits is strong. Apricot prices are high on the supermarket shelves compared to other summer fruits. Over the last three years, because of bad weather conditions (e.g. rainfall too high, frost or low amplitude between night and day), quality has decreased. Consumers might prefer other fruits with an appropriate quality-price balance. 'Consumers are not attached to a specific variety' unlike in the case of apples and pears, according to an expert from the Cantonal Office of Arboriculture. The origin, location of production or the variety are not indicated in supermarkets (Bourdin, Gerz, Réviron, & Siegenthaler, 2015). Furthermore, the umbrella brand 'Marque Valais' was developed to promote regional production and prioritise fruits of high quality. A criterion like minimum rate of sugar (11 Brix degrees) was added to the size criteria. However, retailers developed their own brands, focusing on the higher quality products, hence higher prices. These brands are increasing the competition on the market. In these conditions, innovation is quite limited for apricots.

Finally, Table 3.5 reports origin of innovations.

	Firm itself	Collaboration with partners	N/A
New product	6	9	4
New process	5	2	12
New organization	4	2	13
New marketing	8	1	10
Total	23	14	39

Table 3-5. Origin of innovations implemented between 2012 and 2015

Table 3-5 reports the number of innovations implemented by only by the firm or via collaboration. For this category, respondents cited four times wholesalers, three times Agroscope, two times the Cantonal Office for Arboriculture, two times producers, once the Research Institute of Organic Agriculture (FiBL), once association Valais-Wallis Promotion and once 'other firms' (i.e. adaptation of new elements developed by other firms).

These findings support the productive nature of interactions. Innovations presented in tables 3-4 and 3-5 were partially implemented through collaborations (14 innovations). However, the predominance is the innovation implementation by firms themselves (23 innovations).

3.7 Discussion

This research attempted to investigate the productive feature of interactions in a peripheral sector in Switzerland. The long-term collaborations were established over several decades with some partners and are essential in order to produce innovations. The research has mainly focused on three

questions, raised at the beginning, what generates the observed interaction structure (proximity, etc.), what makes interactions productive in terms of innovation and what methodological implications can be drawn in terms of analysis of innovation and the impact of public interventions. These questions are answered in the next sub-sections of the discussion.

Network structure resulting from diversified collaborations

Formal and informal interactions between stakeholders have been recognised to spur knowledge and innovation (Agrawal & Henderson, 2002; D'Este & Patel, 2005). In the study, interactions between three types of environment were observed (Spaapen, 2011): (i) non-academic research environment including public research organisations, (ii) academic research environment and (iii) commercial environment grouping value chain actors (e.g. nurseries, producers, transformers, retailers, wholesalers, warehouse keepers). Academic research environment and non-academic research environment collaborated as in the case of UAS Valais-Wallis and Agroscope. The latter collaborated with other organisations in non-academic research environment category like agronomy and food research centres in France. Non-academic research environment collaborated with commercial environment. These are all the informal collaborations cited by respondents of the apricot sector. Researchers working with nurseries, warehouse keepers, retailers, and others expressed only formal collaborations. Firms in the commercial environment collaborated with other firms in the same environment. This is the supply chain goal (e.g. on the one hand collaborating to produce goods, on the other hand transferring innovations between competitors). Professional actors used informal relationships with public bodies such as the Cantonal Office of Arboriculture, associations and customers. Thus, this category has few connections with non-academic research environment. In the academic research environment, UAS Valais-Wallis established all types of collaborations but was weakly connected to the apricot sector. Financial collaborations existing between UAS and the Swiss centre for agricultural research were limited.

McKiterrick et al. (2016) argued that informal networks are of crucial importance in rural areas. Strong ties with informal network actors mainly drive knowledge exchange and innovation, more than weak ties (e.g. formal and institutional actors). Poncet et al. (2010) who showed that formal intermediaries do not dominate the innovation networks in irrigated crops like vegetables, sugar cane, sugar beet and maize. These findings confirm what has been found in our study; Swiss agricultural stakeholders favoured informal collaborations with either competitors or suppliers and customers. Moreover, frequency of communication between partners in the network was important when actors used phone calls and emails. Trust and exchange of information, knowledge and materials were at the core of their interactions. These findings are in line with the findings of Dahl and Pedersen (2004) that stated informal interactions between firms in a small geographical area allows frequent meetings, trust and mutual knowledge exchange.

In their study concerning university and industry relationships, Bercovitz and Feldman (2006) assumed that informal links potentially precede formal links, especially in applied research. Thus, formalising and promoting current informal interactions may be the next step to enhance network cohesion. This is confirmed by the work of Grimpe and Fier (2010) who asserted that informal

interpersonal contacts complement formal interactions by improving the quality of interactions through communication skills. In a study about technology transfer between universities and the private sector, Harmon et al. (1997) found that existing ties between the partners are fundamental to develop further projects. However, as Freel (2003) asserted, 'the probability that local ties can offer all complementary resources is low'. Therefore, in the study, links and boundaries have to be extended, especially in a setting of small firms in a peripheral sector. Moreover, in sectors dominated by informal interactions, stakeholders' diversity is an indicator of interaction quality, especially for productive interactions (Belcher, Rasmussen, Kemshaw, & Zornes, 2016).

Human capital formation and education has been hardly studied and should be examined in the setting of agriculture. Actors' backgrounds and career paths could foster network connectivity. The interviews revealed that even when actors had graduated from universities in the region, the connection would not necessarily be maintained in the future. Finally, the study confirmed the need of trust, availability of partners, anticipation, understanding of partners' needs for successful collaborations.

In conclusion, the observed interaction structure in the study is generated thanks to a balanced cognitive vs. geographical proximity with actors operating in the research sector (i.e. UAS in the region and the Swiss centre for agricultural research), the traditional (low-tech) nature of the domain and the low degree and betweenness values experienced by network actors.

Roles of actors from the research sector in the region

The study highlighted the importance of combining cognitive and geographical proximity to spill over localised knowledge (Breschi & Lissoni, 2006; Lissoni, 2001; Rallet & Torre, 1998). Nevertheless, there is a gap between sector characteristics (i.e. apricot as a traditional fresh product) and mandates of Agroscope and the University of Applied Sciences. The findings showed a high rate of collaboration between Agroscope and the apricot value chain, but little collaboration between UAS and the apricot value chain. Agroscope is an intermediary actor that links the research community outside the region. The findings are in line with McKiterrick et al. (2016) that found institutional actors played a bridging role for network firms.

In the fresh product sector, activities conducted by the research centre are closer to producers' concerns and expectations than the university's activities, which are closer to those of actors in processed products. Kaufmann and Tödtling (2001) found that "interactions with science and technology often require personal collaboration favoured by short distances which enables frequent contacts." Thus, geographical proximity appears to be important for interaction success. However, this is not sufficient. Our study demonstrated that cognitive proximity is another important aspect to take into account in small and informal network. The sample included 40% of producers, which may have affected the results. This figure could be a reason explaining the low collaboration currently established between the University of Applied Sciences and the apricot value chain. Our results are not in line with the work of Meyer-Krahmer and Schmoch (1998). They found that

application-oriented fields exhibit the 'closest' interactions between industry and universities, using informal channels.

Tödtling et al. (2009) demonstrated in their empirical research on the Austrian manufacturing and service sector that reliance on business partners or university partners depends on the innovation degree. Incremental innovations require less research and development. Conversely, radical innovations need collaboration with universities and have higher R&D requirements. The results obtained are in agreement with Tödtling's work; there are more collaborations with national centres for agricultural research and fewer collaborations with universities.

Innovations resulting from public-private interactions

Agriculture falls within the supplier-dominated category that can receive technologies from science-based and production-intensive firms in other sectors (Pavitt, 1984).

Majority of producers interviewed dealt with more than one type of fruit. Thus, firms can benefit from technology-relatedness and cross-fertilisation of knowledge by transferring and applying knowledge and skills from one sector to the apricot sector. Product innovation was the main type of innovation adopted. This was expected because of the constant search for fruit variety improvement and the prominence of upstream actors sampled. Nevertheless, SMEs reported willingness to allocate resources for marketing innovations. Strategically, small firms adopt product differentiation and market segmentation in a situation of information asymmetry on the markets and imperfect competition (Smith, 1995). Niche markets could be a solution for this small-scale sector. Hence, researchers are working in this area to meet expectations of producers and consumers, who ask for local apricots and target a broad set of taste preferences for example. Constructing different consumers' cognitive perceptions should be a future path for this type of sector. A study of the Italian spirit grappa was conducted by Delmestri and Giuseppe (2016) on how a radical change in the status of a product can impact its market through consumer perception and willingness to pay more for a different product. A theorisation by allusion has been carried out several times with the aim of creating new product categories. The authors defined three types of categories: detachment category, emulation category and sublimation category. These represented the steps to define grappa known as "a coarse spirit consumed 'at the margin of society' by peasants and alpine soldiers". The cognitive perception of consumers has changed. The product was categorised as being different from previous similar alcohols like cognac. Thus, consumption practices for premium products were applied for grappa and targeted consumers belong to wider groups on the social and cultural levels. In the Swiss apricot case, in order to encourage consumers to buy this fruit rather than other fruits, marketing strategies like theorisation by allusion may redefine the position of the apricot to place it in a different segment.

To conclude, interactions are productive in terms of innovation thanks to informal collaborations that dominated the sector when involving the value chain stakeholders (excluding research sector); frequently exchanged phone calls and emails; balanced geographical and cognitive proximities; trust, anticipation, reliability of partners, institutional and financial support (e.g. marketing).

Limitations

Stakeholders targeted by the study were the most productive ones in the sector, hence the sample was small. The size of the sector influences the interaction rate (Schartinger et al., 2002). Including every actor in the study was not possible but may have led to different results. Therefore, the approach outlined in the study should be replicated to a bigger sample, representative of the population and to other similar sectors in order to examine similar or different patterns.

Moreover, as innovation is difficult to measure in this specific setting, the productive interactions defined at the beginning of the chapter were hardly investigated. Producers, transformers and wholesalers expressed to have collaborated with the national research centre for agricultural research, the association Valais Promotion, the Cantonal Office for Arboriculture, producers or other firms of the value chain and the Research Institute of Organic Agriculture. However, the analysis of the interactions' structure revealed dynamic and personal contacts established in the fruit sector between stakeholders. These findings could be used as a basis for further empirical research within different sectors, would it be fruit and vegetable sector or wider sectors.

Finally, innovations are constrained by market structure. If the constraints were different, the University of Applied Sciences might have interacted more with the sector for example. Therefore, the study helped to investigate the 'productive' aspect and can be applied in other settings.

Methodological discussion of network analysis

The focus on formal vs. informal nature of collaboration was partially adequate to highlight the importance of interactions in the network. According to Roy et al. (2004), the extent of interactions is manifold: quantity (e.g. number and duration of meetings), scope (i.e. quality and nature of interaction) and mode (i.e. formal versus informal relationships) (Roy et al., 2004). These aspects were explored in the study. However, more systematic relations between quantity, scope and mode should be investigated. This would facilitate the understanding of the domain structure. Furthermore, nodes with high clustering coefficient tend to form cliques with their neighbours (Wilson, 2004). In the study, a few nodes had high clustering coefficient, leading to a lack of cliques. Exploring interactions with more details, e.g. computing other network indicators or interviewing related sectors' actors, could counteract this gap. Longitudinal analysis should be conducted in order to gather a broad overview of the sector dynamism and potentially relations to other types of sectors.

Finally, the methodological implications that can be drawn in terms of analysis of innovation and the impact of public interventions are the following; analysis of network structure (who is connected to whom), domain constraints (number of actors, size of firms, economic status (e.g. trade barriers)), innovation types (product, process, organization, marketing), innovation degree (radical vs. incremental) and dissemination of knowledge that favours actors' access to new information. These aspects might be included in further studies.

3.8 Conclusions

The focus was put on the determination of innovations by understanding the interplay between the network of actors and structure of the domain. Interactions are required to transfer knowledge, but only some of them will become productive given the structural conditions of each domain. The Swiss apricot network is characterised by a limited number of actors, more or less porous boundaries, constant search for innovation and implementation of innovations partially thank to actors' interactions. This network is mostly dominated by informal interactions between stakeholders of the value chain. Nonetheless, the Swiss centre for agricultural research established formal and informal collaborations with a diversity of partners. The University of Applied Sciences has a few interactions with actors of the apricot value chain. Both public actors are complementary. The former is closer to upstream actors like producers; the latter is closer to transformers. Consequently, combining this cognitive proximity with geographical proximity enhances innovation implementation. Furthermore, indirect links can be crucial for connecting people and thus transferring substantial knowledge and innovation. Some categories of stakeholders are voiceless, depending on their power in the value chain. Hence, the Swiss centre for agricultural research plays the role of linking research outcomes and producers by localising knowledge so that it becomes accessible to local producers.

On the innovation level, structural characteristics of the domain and market constraints are so strong that this hinders the type of innovations implemented, on the producer side. Therefore, the production period of apricots was extended to better exploit the trade barriers. However, competition remains high on the shop shelves; retailers marketing strategies and the regional trademark Valais® were tools to compete either with imported apricots or other imported fruits.

Finally, indicators for measuring productive interactions could rely not only on the degree of centrality, betweenness and clustering coefficient that nodes display in the network but also on the type of interactions (i.e. formal, informal, and financial), nature of the sector, innovation degree and connections with diverse environments.

In conclusion, observing and measuring innovation is difficult in sectors where R&D is not central and informal and interpersonal interactions prevail. Market and structural contexts are determinant factors as to whether or not an interaction becomes productive. This can shed light on potential for interaction that is not realised because of market conditions.

Chapter 4 Are innovation needs of low-technological Small and Medium-sized Enterprises in line with knowledge production by research institutions?

4.1 Introduction

In a context of globalisation, structural characteristics and size of firms influence the perception of challenges. Adaptation to a new environment might be easier for bigger firms due to higher availability of financial and human resources (Acs & Audretsch, 2006). However, small, medium and large-sized companies use innovation as a way of boosting their performance and competitiveness. Firms rely on the complementarity of internal and external sources for innovation like Research and Development (R&D) (Cassiman & Veugelers, 2006; H. W. Chesbrough & Appleyard, 2007). Small and medium-sized enterprises (SMEs) are often lacking competencies and resources. They need to rely to a certain extent on external partners in order to reduce innovation risks and costs (Pierre & Fernandez, 2018). Private and public R&D is conducted to overcome firms' obstacles and meet their needs. Private and public universities are conducted research on specific topics that matter at the societal, environmental or economic levels. Until now, few studies have investigated the links between the scientific outputs and important challenges of SMEs in the agricultural sector. In this chapter, these links are investigated in the Swiss fruit sector. Traditional fruit is important at regional level in Switzerland. The sector has received little attention in terms of knowledge production and innovation implementation. Hence, the study investigates whether solutions that the research environment can provide effectively meet SMEs needs.

The research project brings insights for the whole value chain. Research activities should be oriented towards the needs and the priorities of the fruit sector analysed. Producers, transformers and retailers should share their prioritized needs with the research actors to be involved in the innovation process.

Substantial patterns of the agricultural sector are presented together with the importance of innovation and knowledge transfer. The empirical part presents the methods and data collected to identify the needs for innovation of the SMEs in the traditional fruit sector in Switzerland. A multi-

actor approach including different SME owners along the food supply chain was used. Findings are then analysed, discussed and linked to future research axes. A final section presents the conclusions.

4.2 Conceptual framework

4.2.1 Patterns of the Swiss agricultural sector

The diamond model of Porter highlights the intertwined factors of efficiency and quality that are important for firms, regions or countries that want to be competitive. The ability of companies to adapt to unforeseen changes in the marketplace and the ability to furnish diverse products with qualitative advantages faster than its competitors are fundamental (Porter, 1990). Competitiveness of firms on both international and national levels is essential. In order to limit competition with European companies, the Swiss agricultural sector applies border protection with regulating trade barriers (see section 2.7.2). Moreover, the Swiss industrial sector benefits from a good image, based on high quality. Traceability and food safety denote challenging topics since the beginning of food crises in the 90's. Besides, with the increasing use of social networks and communication tools, information is faster transferred and can quickly influence public opinion. Hence, tracing products and ensuring safety become substantial goals in order to satisfy the consumers and ensure chain sustainability (Codron et al., 2006). Norms and regulations applied in Swiss agriculture sector allow an important differentiation. The Swiss standard of good practices related to integrated production of food products is more restrictive than the European equivalent (i.e. Global GAP). Innovation is required in order to maintain the good quality image of the Swiss agricultural products and enhance traditional food firms' competitiveness.

4.2.2 Definitions of traditional food and value chain

The study focuses on the agricultural value chain of a traditional product. Value chain merges all activities from the product or service conception to its delivery, implying inputs use and transformation steps (Kaplinsky & Morris, 2000). According to Gellynck and Kühne (2010) traditional food products are authentic foods (i.e. raw material origin, mix of ingredients) that are manipulated and/or transformed in a specific defined area like local, regional or national levels. The traditional product must represent the gastronomic heritage of this area and must be available on the market for at least 50 years.

Tradition and innovation can be complementary (Cannarella & Piccioni, 2011; Vanhonacker et al., 2013). Ingredients, composition and process are the three most important criteria to respect in order to keep the traditional aspect of food products (Trichopoulou, Soukara, & Vasilopoulou, 2007). In this study, apricot is defined as a traditional product, where innovation is part of the product improvement to constantly comply with value chain expectations.

4.2.3 Innovation and knowledge: keys for bringing partners together

Innovation is defined as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD and Eurostat, 2005)[8]. Innovating is an iterative process from discovery and invention to commercialization and diffusion with many feedback loops. This is the chain-link model of technological change of Kline and Rosenberg (Arbo & Benneworth, 2007; Evangelista, Perani, Rapiti, & Archibugi, 1997; Kline & Rosenberg, 1986). These back and forth actions are possible thanks to interactions with external partners. Moreover, innovation induces disruptive or smooth changes. Disruptive and incremental innovations are commonly opposed (Afuah & Bahram, 1995). Therefore, innovation adoption is conditional on firms' capacity to adapt to change. As Pavitt (1984) asserted, diffusion of innovation is important for its success. Agriculture is a supplier-dominated sector; innovation mostly comes from input suppliers and research but users' needs are an increasing source of concerns for innovators (Rossi & Rosli, 2013). Consequently, if disclosed innovation does not target an appropriate audience, diffusion would fail and so the innovation implementation. Understanding and targeting what are the challenges of the value chain is fundamental for innovation success.

Furthermore, the promotion of Research and Development and Innovation (R&D&I) is an objective of the European Union set out in the Article 179 of the Lisbon Treaty. Research should be conducted in a freely space, benefiting from technology and other resources required (European Commission, 2014b). Hence, the chain of R&D&I in projects is involving the research community and the practice community. In this respect, knowledge has been recognized to have an important role in the economy and its transfer is increasingly studied, partly because of the appropriateness to solve value chain issues and enable innovation establishment (Braun & Hadwiger, 2011). Transferring the outcomes of research is fundamental for successful implementation. Competitiveness of SMEs partially depends on this effective implementation of innovations emerging from national and European research projects. Hence, features of knowledge become important for an efficient transfer. Different dimensions have been studied: the types (i.e. codified and tacit) and the levels (i.e. embedded in individuals, institutions, generic or specific) (D. Foray & Lundvall, 1994).

Furthermore, Callon (1994) stated that knowledge could be perceived as a quasi-public good. Knowledge is structured by its communication modes and the embeddedness of its information. Codified knowledge is easier to transmit than uncodified knowledge. Nevertheless, knowledge is non-appropriable and quasi non-rival; when one uses knowledge, the others can also use it without

[8] The Oslo manual was edited after studies driven by OECD countries about innovations and its measurement. It is the international source of guiding principles of collecting and using of information about innovation activities in industry.

impediment. Besides, the more knowledge is used the more valuable it becomes. Hence, knowledge and to some extent scientific publications are valuable to transfer and translate to users.

Knowledge is transferred through structured network composed by actors like universities, industries or government. However, the dichotomy "demand-pull" versus "technology-push" has been replaced to some extent by other approaches (B.-A. Lundvall, 1985) like Mode 2, National Innovation System (NIS), Triple Helix (TH) or "Triangle". These approaches are not unilateral. Mode 2, introduced by Gibbons et al. (1994) is referring to a mechanism of new knowledge production. The linear, scientific, homogeneous, hierarchical, controlled production of knowledge was transformed in a more context-dependent, transdisciplinary and interactive mode of knowledge production. The TH approach differs from those of NIS and "Triangle" in terms of actors' importance. In the TH approach, university is considered to play a greater role than firms do in the NIS approach and government does and in the Triangle approach. Moreover, in the third version of the TH approach, focus is put on the overlap emerging from the communications and interactions between the three types of actors (Etzkowitz & Leydesdorff, 2000; Leydesdorff, 2012). Therefore, connecting the chain actors in order to link one's needs to one's solutions is crucial for added value and for building structured networks between knowledge producers and practitioners (e.g. SMEs).

However, the generic models presented above are not fully adequate to the agricultural sector, especially the traditional food value chains where informal collaborations using tacit knowledge and interpersonal contacts prevail. Furthermore, in the existing approaches the analyses took the universities, governments or research organizations as the centres of the system. The present study is end-user-oriented. The starting point of the study is the SME and its needs in terms of innovations. Hence, it aims to analyse knowledge and innovation transfer between researchers and practitioners and to understand to what extent the needs of the sector are in line with knowledge production by research institutions and what the scientific community has been provided so far. The focus of the present study is placed on the Swiss apricot value chain, from producers to consumers.

4.3 Materials and methods

The next sections describe the steps of the methodology used in the study. The intersection between innovation needs of the value chain and the outputs of science (grey area in Figure 4-1) represents the solutions of issues faced by value chain actors that were produced by researchers for the fruit sector.

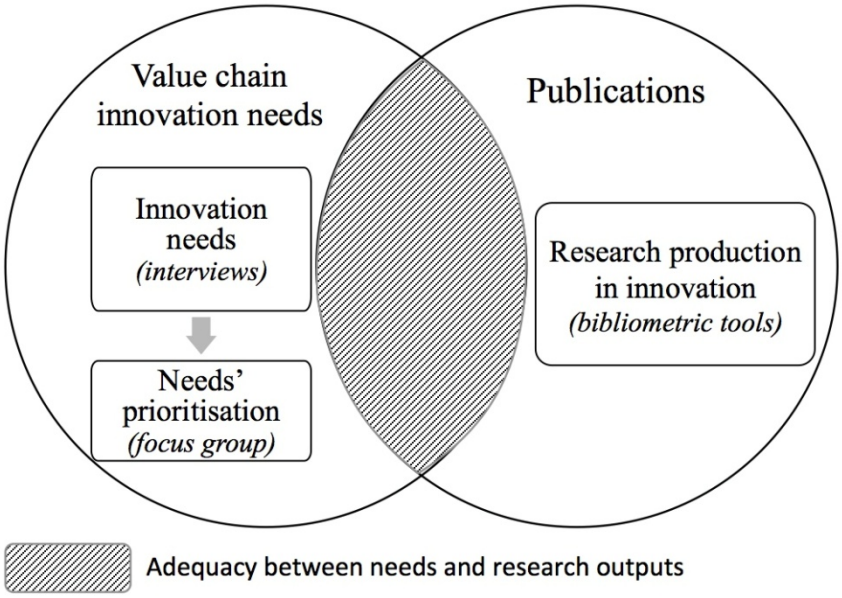

Figure 4-1: Structure of the study: confronting innovation needs of traditional food value chain and innovation production by scientific community

SME owners' needs were collected through individual interviews and prioritized by stakeholders in a focus group. Bibliometric tools were exploited to investigate available research outputs.

4.3.1 Identification of the needs of the apricot value chain in Switzerland

The first step was to identify the needs thanks to semi-structured surveys addressed in face-to-face interviews of SME owners of the apricot supply chain (e.g. producers, traders and processors, wholesalers and retailers).

Survey structure

The questionnaire was divided in two parts. The first part aimed to identify structure of the firms with interviewees' characteristics and their economic activity (i.e. type of production, processing or supplying and surface harvested). The second part was dedicated to the inventory of needs of the firms. A section focused on the production type like organic, conventional or integrated, as well as technological equipment used. Another section comprised questions about the value chain, from breeding to distribution. Consequently, each step of the production chain was highlighted and addressed regarding the potential issues and solutions needed.

With the aim of avoiding answer bias, all the questions were uniformly framed;

- What are the important challenges you faced within the last fifteen years in the topic of […]?

- For the already solved problems, which solution did you choose?

- For the unsolved problems, which solution may help?

- If you have not faced any challenges, what type of techniques do you use for this topic?

The questionnaire structure facilitated discussion between individuals interviewed and the researcher, allowing useful insights for further understanding of the needs identified.

Sample selection

The questionnaires were distributed among SME owners involved in the apricot production and supply chain. Producers for whom apricot production represents a significant part of their income were highly interesting in this study. The participants were contacted by email and phone. Between April and September 2014, 37 SME owners were interviewed, including twenty-one producers, six traders and processors, four inter-professional organizations, and ten retailers. Either the owner or the senior manager represented the companies. The face-to-face interviews lasted 90 minutes and allowed open discussion. The sample included producers, traders and processors, retailers and inter-professional organizations. Some SME owners had several parallel functions like producers, processors and traders. Apart from retailers and inter-professional organizations, the firms included in the survey were well established SMEs in the apricot market.

Prioritization of needs via Swiss apricot sector representatives as a focus group

The inventoried needs were categorized by following themes: pre-harvest techniques, post-harvest techniques and supply chain management activities. The listed needs were distributed to five representatives of the SME associations involved in the apricot fruit chain in Switzerland as a focus group that aimed to validate, categorize and prioritize these needs. The representatives were experts of the apricot sector. A moderator animated the discussion and presented the needs identified during the interviews performed in the first stage of the survey.

The pre-harvest and post-harvest themes were kept for further analysis. A Likert scale was used to rate the innovation needs from 1 (not important), 2 (slightly important), 3 (moderately important), 4 (important) to 5 (very important). The frequency of citation was reported for each need. Finally “very important needs” were analysed with bibliometric method.

4.3.2 Bibliometric analyses

Needs identified during the interviews can be related to lacks of innovation or information. The latter might appear depending on the type of issues faced by fruit producers and suppliers and the interactions occurring between them.

Research outputs from the last decades were identified for the technical topics and prioritized as "very important". . The topics related to supply chain management were excluded of the analysis and could be investigated in further research.

According to Leiser et al. (2009), following portals for searching bibliography were used for bibliometric study of scientific production: Scopus, Web of Science (WoS) and OVID databases.

Scopus is a database of peer-reviewed literature managed by the editor Elsevier, containing books, conference proceedings and articles. The search engine displays different levels: document, author, affiliation and advanced search. There are several categories within each level like in the document search level (e.g. article title, abstract, source, language, DOI and abstract). At this level, keywords are of importance for the study (Lokman & Yang, 2007).

Web of Science groups Art and Humanities Index, Social Sciences Citation Index and Science Citation Index. Web of Science Core Collection was used to perform the search.

The third database used was OVID. AGRIS and Agricola are included in this database. They cover agriculture, forestry, human nutrition and animal domains among others in documents like reports, theses, proceedings of conference and unpublished scientific works. The database contains collections of national and intergovernmental centres, making these databases practice-oriented. In WoS "Revue Suisse d'Agriculture" is included, although the title changed in 2010 to "Agrarforschung Schweiz". "Cahiers Agriculture" is part of the database since 2006. Scopus covers the period from 1965 onwards, with 63% of records from 1995. In OVID, Agricola covers the period from 1970 and AGRIS from 1975 (OVID, 2017b, 2017a). WoS is wider, going back to 1945 (Jacso, 2005).

4.3.3 Identification of gaps between needs of SMEs and research solutions

Analyses of specific topics rated as "very important" for the apricot stakeholders in Switzerland were made on different levels. The topics were translated into keywords divided in four levels, i.e. fruit, *Prunus*, apricot and *armeniaca*. The wider level is "fruit", however the outputs might be too broad by using this term. To better target the sector of stone fruit, the term *Prunus* was selected. To specifically target the apricot sector, the terms Apricot and *Armeniaca* (botanical name of apricot) were used. Besides, the bibliometric analysis was realized on the level of apricot. All the key words used for the search are detailed A.1 to A.5.

The gaps were defined based on the level of communication and implementation of innovation between value chain stakeholders. The first gap is related to a lack of generic knowledge like scientific evidence and empirical findings on the topic that can be widen to other sectors for instance diseases. The second gap is related to the specificities of the sector. Many research projects and empirics have been done on pome fruits (e.g. apples, pears). The findings could be generalized and applied to other fruits but this is not the case for every topic, particularly in the topic of diseases and pests. The third gap relates to knowledge and innovation transfer. Firms are aware of the potential innovations developed by external partners. However, translation of knowledge into the

firms' environment is missing. The implementation of available solutions might be lacking. Hence, a scaling up process, the training of practitioners regarding capabilities and technical skills required adopting the innovation, and knowledge transfer within the practice are needed.

Table 4.1 presents the different classified gaps. Thereafter, rates of publications resulting from the analysis of the databases were assigned to the gaps. A low rate of publications (i.e. inferior to 199) means that research has not focused on the topic. Hence, it corresponds to a lack of knowledge on that topic. A medium rate of publications (i.e. between 200 and 9,999) is more related to a lack of precise knowledge on the topic. Finally, a substantial rate of publications (i.e. superior to 10,000) means that literature is rich. The more results found via the databases selected, the more research has been done on the topic. Thus, knowledge is not missing in that domain but the transfer can be lacking. The gap is therefore not located at the academic level, but in the knowledge and innovation transfer.

Rates of publications resulting from databases analysis	Generic knowledge generation gap	Specific knowledge generation gap	Knowledge and Innovation transfer gap
<199	X		
200-9,999		X	
>10,000			X

Table 4-1: Gaps of knowledge resulting from the bibliometric analysis

4.4 Results

4.4.1 Needs of the value chain

Ninety-eight needs were identified with different frequency, bringing the total of needs collected to 369. There were assigned to 22 categories. The first 13 categories are presented in Figure 4-2. The other nine categories concerned supply chain management needs (e.g. quality norms, competition, marketing). These needs concerned the apricot supply chain.

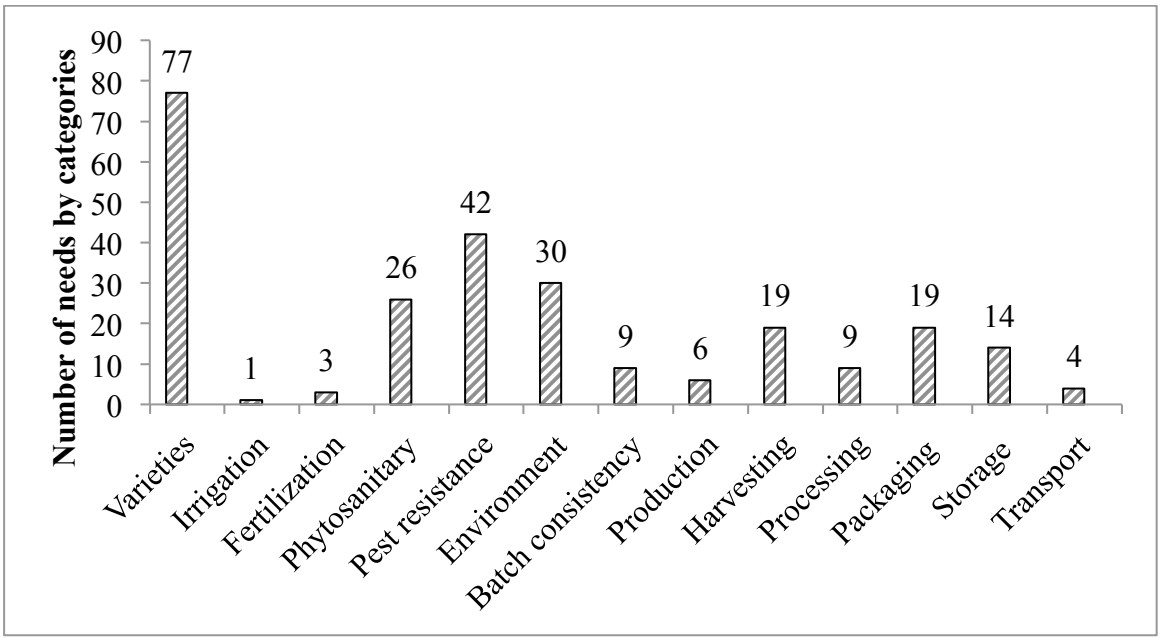

Figure 4-2: Needs claimed by Swiss apricot stakeholders relating to innovation

Some needs were grouped in topics related to technical aspects. It included fruit varieties, orchard management (i.e. irrigation, fertilization, pest and disease resistance and phytosanitary aspects), environmental management (i.e. climate events), homogeneity in production, traceability of raw materials, safety conditions, quality standards (e.g. Hazard Analysis Critical Control Points), water and energy saving, storage, packaging, transport and transformation of products, nutritional and quality aspect of the fruits. Other needs related to non-technical aspects were also grouped as following: certification, voluntary labelling, marketing, communication to consumers, intellectual property rights, competitiveness on domestic and international markets, consumption and supply chain management.

Most needs belonged to the pre-harvest category with a predominance of the category of varieties (77 cited needs). All the respondents cited this category. Improving the trade-off between productivity and quality was highly (need cited ten times) reported by the interviewed SME owners. The needs related to the categories of disease and pest resistance and environment were representative of such evolution (30 needs). Homogenization of rules about use of phytosanitary products and increasing flexibility of use were other important topics, cited by eight and nine SME owners respectively.

Furthermore, the harvesting and packaging categories are burdensome. The harvesting category related to following technical issues: manual thinning (two needs), harvest window for the non-destructive method to assess internal quality and maturity (two needs) and the labour force (availability, succession, cost, training, working conditions, labour management) (fifteen needs). The packaging category concerned costs reduction (two needs), reduction of the diversity of packaging (fourteen needs), and proposing clever packaging (three needs) to increase products' shelf life.

Storage (14 needs) and quality (9 needs) areas are important for basic and applied research. Current trend in food sectors have to evolve along with consumers' expectations like maturity and good balance of taste and appearance (e.g. more sugar, more aromas, less acidity, colour with higher intensity). Process and organizational innovation are in line with the sustainability trend like reducing waste and use of chemical products. Organic production could also be developed in the future, mentioned by some interviewees.

In the category of supply chain management, competition was often cited (38). In the marketing innovation category, segmentation and use of labels could help producers to add value to the production. The principal distribution channel used for fresh Swiss apricots is retailing. Nonetheless, closer contacts between upstream and downstream chain are sought. Finally, lack of resources, knowledge access and implementation were the barriers of SMEs for the implementation of innovation.

Validation and prioritization of identified needs

A focus group with Swiss representatives of the fruit sector were asked to rate the importance of the needs from 1 (not important) to 5 (very important). When differences were important between representatives, it was noted in the column "comments". Thirty needs were evaluated as very important, whereas only six as not important. The very important needs include the categories varieties, phytosanitary, pest and disease management, environment, batch consistency, production, harvesting, packaging, storage, quality, norms, marketing, communication, competition, consumption and supply chain management. A discrepancy was found in the packaging category. Retailers and producers were opposed in terms of packaging diversity. Despite disagreement in some other topics, consensus was found. There is still an exception concerning the topic of norms. Flexibility of norms' application was a sticking point. It was not important for stakeholders representing SMEs.

In order to conduct the bibliometric analysis, the category of varietal innovation, and more particularly the resistance against diseases and the post-harvest behaviour, was selected because of its predominance of needs (77) and high importance for the stakeholders and representatives of the value chain. The next section presents the results of this analysis.

4.4.2 Innovation lacks investigated through bibliometric tools

Three important aspects prioritized by the focus group of the apricot varieties were tackled during the first part of the data collection: increasing disease resistance, reducing the cracking effect of apricot and reducing the speed of post-harvest ripening. The need related to disease resistance was merged with the category labelled 'pests and diseases management' to maximizing targeted

solutions. In this category, 42 needs were cited. It was the second most important category in terms of cited needs from the questionnaire. The three main diseases and pests pressures on apricot were selected: European Stone Fruit Yellow (ESFY), Blossom blight (caused by Monilia laxa) and bacterial canker (caused by Pseudomonas syringae pv syringae). The three needs were translated into keywords to be used in Scopus, WoS and OVID. The first results collected showed a substantial difference in the publications results between the databases. Search formulas are presented in appendices.

Four levels of analysis were conducted (i.e. fruit, *Prunus*, apricot and *armeniaca*). The number of records found per each topic and level of analysis is reported in Table 4.2. The rows total are coloured according to the number of results found. The more the number of results, the more research was conducted.

		Monilia	ESFY	Bacterial canker	Post-harvest behaviour	Cracking
Fruit	*WoS*	1,480	337	523	3,866	18,725
	Scopus	32	384	345	3,934	2,076
	OVID	1,970	558	398	5,861	83,912
	Total	*3,482*	*1,279*	*1,266*	*13,661*	*104,713*
Prunus	*WoS*	279	126	100	409	1,223
	Scopus	27	220	95	477	191
	OVID	855	263	105	521	2,230
	Total	*1,161*	*609*	*300*	*1,407*	*3,644*
Apricot	*WoS*	110	89	31	83	271
	Scopus	1	90	26	70	33
	OVID	162	112	45	117	959
	Total	*273*	*291*	*102*	*270*	*1,263*
Armeniaca	*WoS*	35	23	11	52	119
	Scopus	1	67	17	60	21
	OVID	77	53	19	43	158
	Total	*113*	*143*	*47*	*155*	*298*

>10,000	200-9,999	<199

Table 4-2: Outputs found for five sub-topics of varietal innovation needs using three databases

High rates of results were found at the fruit and *Prunus* levels in each topic, but fewer at the apricot and *armeniaca* levels. The outputs were quantitatively similar between the databases in every level for the topic of ESFY. These numbers are rather small, indicating the necessity to continue investigating that important topic. The trend is the same concerning bacterial canker. There is a high variability in the results found within the three databases, especially for the topic of cracking. In every level, Scopus is the one that delivered limited outputs. In the topic of bacterial canker at the *Prunus* level, there are around three times results than at the level of apricot, which is two times higher than the level of *armeniaca*. This sharp decrease is found in all the topics. In the

topic of Monilia, the differences between the databases were important. 110 hits were provided for WoS, one for Scopus and 162 for OVID. This difference decreased when specifying the keywords and going at the level of *armeniaca*: 35 hits for WoS, one for Scopus and 77 for OVID. This difference is probably due to the topics covered by each database. Scopus contents 15% of life sciences and agriculture. A striking result is that the unique publication in Scopus is not found in WoS and OVID databases, neither at the *armeniaca* level nor at the apricot level.

For each topic outputs could be exclusive to one database. At the level of *armeniaca*, 52 results for Web of Science, 60 for Scopus and 43 for OVID were found in the category of postharvest behaviour. Twenty-two among the 52 outputs of WoS are not present neither in Scopus nor in OVID. Respectively, there are 13 results in Scopus and 5 in OVID that are exclusive to those databases. This trend can be found within the other levels and topics. Lastly, OVID database tends to provide more results than Scopus and Web of Science. One reason is the difference of document types. OVID comprises not only peer-reviewed articles, proceedings of conferences and reviews but books, doctoral and master dissertations, guides, reports, questionnaires or meeting papers.

Matching between innovation lacks and value chain needs

An inventory of Swiss apricot value chain needs was conducted. The needs were prioritized by representatives of the sector and were analysed using bibliometric tools to determine the match between value chain issues and scientific outputs. Three levels of analysis were conducted (i.e. fruit, *Prunus*, apricot and *armeniaca*). The number of records found per each topic and level of analysis is reported in Table 4.2. Three gaps of knowledge and innovation generation and transfer were identified. These gaps were highlighted in Table 4.1 where the number of records was assigned to the gaps' categories (refer to section on materials and methods). Titles and abstracts of the results of the databases were investigated to classify them into the three types of gaps. Finally, the results of the "apricot" level were assigned to the gaps identified and are presented in Table 4.3.

	Knowledge generation		**Knowledge and Innovation transfer**
Topics	**(i) Generic knowledge gap**	**(ii) Specific knowledge gap**	**(iii) Implementation gap**
Monilia		X	
ESFY		X	
Bacterial canker	X		
Post-harvest behaviour		X	
Cracking			X

Table 4-3. Highlighted gaps between the fruit sector challenges and the research sector outputs

The knowledge and innovation generation category included generic knowledge on fruits and specific knowledge on a particular crop (*i.e.* apricot). *Monilia*, ESFY and post-harvest behaviour topics have been placed in the gap relating to the absence of specific knowledge, because of the few outputs provided by the databases (273, 291 and 270 respectively). There is a necessity of insights and empirical findings for European Stone Fruit Yellow and *Monilia*, especially for stone fruits. Furthermore, the physical evolution of the fruits after harvesting and before consumption requires more proofs.

The three databases found 102 results for the subject of bacterial canker. However, the difference between the level of apricot and the highest levels (i.e. *Prunus* and fruit) is stronger for this topic than for the others. Hence, this topic is placed in the gap of absence of generic knowledge. Deepening the state of the art of knowledge is essential for coping with the pressure raised by the bacterial canker problem. According to the classification initially realized, the cracking topic at apricot level (1263 hits) would place this topic on the second gap (absence of specific knowledge). However, due to the high variability at the other levels and according to SME owners of the value chain interviewed, this topic would better correspond to the implementation gap.

4.5 Discussion

In the Swiss fruit value chain, small firms are facing important issues and must adapt to the evolving societal and economic environment. This research attempted to assess whether the research managed by public and private institutions is linked to the needs of the SMEs in the Swiss apricot sector. Needs were collected thanks to interviews with apricot supply chain actors. These needs were prioritized by representatives and experts of the sector during a focus group session. In this setting, all stakeholders should have a common understanding of key words. The main concern for the focus group is the potential bias arising from the influence of the researcher on stakeholders. Special care has been taken to avoid it. In this study, a consensus was found on rating innovation needs of Swiss fruit SMEs. Cohesiveness, spontaneity and participants' view arise within focus group discussion (Sim, 1998). Thus, during the prioritization session by the focus group, discussions between the representatives of the apricot sector helped smoothing the differences existing in the understanding of a few needs.

Furthermore, it was not possible to investigate whether the generated knowledge was actually reaching the SMEs so that they appropriate what was created, and finally closing the loop and reducing the list of needs. For the implementation gap, the linguistic translation of science results is missing, hindering Swiss stakeholders to use it. Moreover, the translation of science results into ready-to-use solutions hinder stakeholders to efficiently access and appropriate the solutions. The applicability of the solutions may lack at this step, therefore the value of knowledge and innovations generated differs from the stakeholders' point of view. The priorities are put on different topics; consequently the value of the topics differs across actors' category.

Economic importance of varietal innovations

The prioritized needs related to the fruit varieties were the focus of the bibliometric analyses because of the economic importance for the sector.

Climate change impacts, evolution of the meteorological conditions and other environmental factors influence crop management. This confirms the results found in the study: varietal innovation is essential to counteract these impacts. Producers interviewed regularly mentioned three diseases to be major sources of issues. Monilia, European Stone Fruit Yellow (ESFY) and bacterial canker were included in separated searches. ESFY is a disease with symptoms like leaves' rolling, yellow coloration, fruits' withering (Desvignes & Cornaggia, 1982). Its impact has economically substantial losses for the producers (Carraro, Ferrini, & Ermacora, 2002). Bacterial canker causes "leaf spotting, bud necrosis and blast, twig die-back, cankers on branch and trunk, fruit scab" and the death of the trees (Scortichini, 2010). Blossom blight and brown rot are caused by pathogens, mostly Monilinia laxa and Monilinia fructicola. Brown rot is the first cause of postharvest losses (Walter et al., 2004). In their study, Rohrer et al. (2012) stated that the mortality reduced the potential return on investment because of the costs of replacement of trees. Therefore, this parameter is crucial for the economic success of producers.

Another "very important" need investigated through bibliometric analysis was the post-harvest behaviour of the fruits. In order to provide consumers with an optimal fruit maturity, the evolution should be slowed down during storage in traders' cold rooms. Even if this topic is related to the gap on specific knowledge generation, this was not a mainstream criterion for economic benefits of the crops. Finally, apricot cracking is partly due to rainfall (Sekse, 1995). The production losses could be very high for farmers.

Combination of bibliographic databases

Three tools were used to perform the analysis, Scopus, Web of Science and OVID. These databases are quantitatively different (60 million of records for Scopus, 90 million for WoS, more than 5.2 million for Agricola and 3.2 million for AGRIS in OVID) (OVID, 2017b, 2017a; Scopus, 2016) . There is an overlap of several disciplines, but some content can be present exclusively in one of the databases. Besides, the type of records differed; there are more articles in WoS (95.85% in 2006) than in Scopus (59.97%) (Bosman, van Mourik, Rasch, Sieverts, & Verhoeff, 2006). The use of several tools was useful for specific areas of research, that is in agreement with those of Archambault et al. (2009). Furthermore, using other languages than English to conduct the bibliometric analyse would have been useful. The over-representation of English may bias the results, especially without the national databases in the analysis (Mongeon & Paul-Hus, 2016). As the authors demonstrated, research outputs related to local level, targets more efficiently local needs. Using the databases of European research organizations (e.g. INRA) would enable identifying research outputs that are not included in other databases because a substantial part of these results is done in national language. Besides, unpublished results can be important for the

sector by highlighting specific areas of peripheral fields. Based on our study other specific databases could be investigated to collect different types of documents like university and official publications, digitised printed publications and empirical works at the national and local levels.

Using databases such as Scopus, Web of Science and OVID might narrow the available scientific outputs, however, private firms R&D and other actors from the public sector (B.-A. Lundvall, 1985) were not taken into account.

The differences found in the outputs of the three databases can be partially explained by their creation date. Scopus was created after Web of Science and OVID. Furthermore, Scopus is partly managed by the authors themselves, explaining why in almost all topics, WoS and OVID provided more scientific publications.

Finally, the homogeneity analysis by means of altering at least one square (HOMALS) could be performed to analyse the association between keywords given by the joint appearances' frequency. This method enables a visualisation of the distance between keywords on a map. The closer the keywords the higher their association in a significant pool of articles (Marzi et al., 2017; de Leuuwe and Mair, 2009).

Development of a Strategic and Research and Innovation Agenda for future European projects

Three gaps of knowledge and innovation generation and transfer were identified. These findings provide evidence for adaptation of future research projects. Prioritization should focus on the apricot sector for the topics corresponding to the absence of generic and specific knowledge (e.g. ESFY, Monilia and bacterial canker), as well as to the absence of knowledge implementation.

The amount of results coming from the three databases was low compared to other fruit productions. This was partially expected because apricot sector is an agricultural peripheral production that is more specific to the climatic conditions of South Europe. Even in countries with bigger production than Switzerland, apples and peaches are more spotlighted than apricot in the international projects and scientific activities. Research activities are recent, particularly in the field of diseases. There is still a need to solve the practical issues in order to increase the sustainability of the sector. This is line with the interest of the research sector as environmental pressures are challenging.

Knowledge transfer should be reconsidered for topics lacking of specific knowledge (i.e. postharvest behaviour). Technologies and techniques are available but awareness of SMEs is low, therefore they were not adopted. Moreover, upscaling issue may arise. Methodologies to help firms to implement innovations from a different sector or different level to their local context should be developed. These problems can be solved by using private R&D, or by working with knowledge gatekeepers like advisers or agricultural extension services, involving SME owners at different steps of the innovation process and improving knowledge and innovation transfer. The latter might

provide solutions for technical issues. However, this will be more difficult for topics requiring more fundamental research like diseases' management. Referring to the private sector could be a solution for divergent timelines between research and SMEs (Bettoni, Clases, & Wehner, 2005; Tanguy, 2016).

Gaps existing between the needs of the fruit sector and the scientific outputs of public research might lie in the late involvement of the stakeholders in the research process. Buur and Matthews (2008), Paus and Réviron (2010) and Kemmis and McTaggart (2007) demonstrated that involving stakeholders at different steps of the innovation process can enhance positive impacts on efficiency and relevance of innovations. Involving advisers, SMEs and researchers at different steps of the innovation process should be under interest for future projects. In our study, selected stakeholders have been implicated in the focus group. The combination of the multiple interests of the SME owners was one difficulty of the study and strength because allowing a holistic view.

Public research organizations integrate knowledge from the global environment and translate this knowledge for its diffusion at the local level in regional systems. These actors may increase absorptive capacity from firms locally embedded (Lazaric, Longhi, & Thomas, 2008). Morrison (2008) defined this type of actors to be the network centre where convey information, especially taking it from external sources via informal communication (e.g. most of the ongoing H2020 calls are based on multi-actors approach). Firms should use knowledge on a global level to avoid lock-in issues (Kauffeld-Monz & Fritsch, 2008; Klewitz, Zeyen, & Hansen, 2012). Hence, in the current European projects different actions are used to support this knowledge and innovation transfer. Nonetheless, an action for continuous knowledge flow, from basic research to innovation implementation in SMES, is missing in the current frame of the international projects. It could improve the link between basic research and technology transfer by a practical dissemination or by promoting "knowledge multiplicator" or advisers. A Strategic Research and Innovation Agenda would support research activities to fill in the knowledge and innovation gaps.

Nonetheless, specific knowledge has not the same value or meaning for the researchers, the SMEs or the advisers. They should better internalize what is the value of knowledge for the others. Researchers have to be aware of the knowledge value for SMEs in terms of business impact and could translate knowledge into potential innovation that fits SMEs business and profit expectations. SMEs should be able to understand the knowledge value created by researchers, validate the knowledge created and use it as a potential innovation that fits the business and profit. Advisers may help to define the knowledge value for SMEs in terms of potential innovation and help to translate knowledge into business impact. Providing technical advice is as important as the learning process applied (de Romemont, Macombe, & Faure, 2018). These goals may be reached by enhancing the knowledge flow through the R&D&I chain to increase its transfer efficiency.

The findings of the research can be related to the Technology Readiness Levels (TRL) used by the European Commission. TRL are indicators used in European programs like H2020 to identify the maturity level of technologies (European Commission, 2017a). The nine levels are ranging from

TRL 1 to TRL 9 with an increasing precision of the technology in terms of validation, demonstration and approval in the operational environment. Therefore, the gap on implementation of knowledge and innovation into SMEs could be further investigated in the frame of technology maturity.

Finally, the outputs of the databases did not only concern apricot. The findings cannot be generalized to other countries or similar sectors and have to be analysed in their specific contexts. That provides evidence on the lacks existing in this sector. Innovations can exist in another fruit sector but are not available for the apricot sector. Hence, the technology relatedness is important to fill in the gap. Innovations and solutions found by researchers of other supply chains could be adopted by SMEs and can come from other agricultural sectors.

4.6 Conclusions

This study highlighted the innovation needs of the Swiss apricot sector. Needs have been identified thanks to interviews and prioritized with representatives of the fruit value chain. The importance of improving varietal innovations was homogeneously asserted. Trade-off between productivity and taste has to be increased in order to satisfy producers and consumers. Precise characterization of varieties is necessary to outline the benefits for all supply chain actors. Besides pests and diseases management, phytosanitary products and competitiveness are other major areas. In this frame, SME owners mentioned threats relating to homogenization of European rules (e.g. pesticides use).

Furthermore, fundamental and applied research conducted in research organization and universities were partially linked to the needs of the SMEs. However, the research outputs did not only concern apricot production. Wider study was conducted in order to include important research results related to similar sectors (i.e. sectors with related technology such as stone fruits or fruits). Some needs were specific regarding the production location. Subtopics like food or environmental studies, chemistry, plant sciences and pathology were of interest for the varietal innovation needs initially identified. These domains were integrated in the used databases. Furthermore, a substantial overlap was found between Web of Science, Scopus and OVID. Many sources, mostly journal articles, are present in all databases. However, some publications were exclusive to one database. Thus, specific bibliometric methods or databases should be investigated to better target local requirements.

Three types of gaps were identified: absence of generic knowledge, absence of specific knowledge and absence of knowledge implementation. The gaps identified for varietal innovation needs can provide hints for research program orientations.

Finally, lacks of resources or of knowledge access are barriers to innovation implementation faced by SMEs. The study demonstrated the necessity of better coordination between SMEs,

stakeholders and researchers. Knowledge has to be transferred and shared in the network with a greater efficiency by extending interactions and involving all actors earlier in the innovation process.

Chapter 5 Investigation of market failures in agriculture: case studies on intellectual property rights

5.1 Introduction

In a stationary economy, economic processes are circular. For economists like Schumpeter, Marshall, Knight and Hayek "a knowledge driven economy cannot be stationary" and competition implies a state of disequilibrium (Brouwer, 2002; Dodgson, Hughes, Foster, & Metcalfe, 2011). Thus, market can be stressed as imperfectly competitive. Capabilities of firms to maintain their activities in a more competitive and challenging market are crucial, but have to be complemented with different types of assets and strategies like innovating. Innovation has an impact on the markets that are in turn distorted due to misallocation of resources. These market failures are present at different levels. Literature on this topic is considerably developed and may give solutions to overcome them. How can agricultural firms cope with the failures? Do trademarks strengthen barriers to entry? To what extent do trademarks complement or substitute other formal and informal appropriation tools? The chapter addresses these questions thanks to an identification of innovation needs of small firms in stone fruit production in Switzerland by using case studies. Characteristics of intellectual property rights are explored to analyse whether the introduction of the regional umbrella brand in the apricot sector was an efficient solution to overcome the market failures.

A literature review in section 2 and 3 emphasizes market failures obstacles and strategies to address them. Methods and data are explained in section 4. The fifth section displays the study framework. The results of the case studies are finally discussed in sections 6 and 7. Some important implications for theory and practice are pointed out in the discussion.

5.2 Obstacles to innovation and market failures

There are many obstacles to innovation. These impediments are partly related to market failures, presented in this section. Solutions focused on marketing and organisational

innovation are following.

Even though many studies have been realised on the topic of market failures, there is no unique definition. In this section, a few definitions are reported. When a market failed, it did not succeed to allocate resources optimally. The invisible hand of Adam Smith did not reach its goal of automatic equilibrium. The Pareto efficiency where all economic agents are maximizing their utility and the allocation of resources is optimal has not been reached (Bator, 2009; Jaag & Trinkner, 2011; Steele, 2009). In a perfect market framework, firms have the incentives to invest in innovation and at a socially optimal level (Jaag & Trinkner, 2011), whereas with a market failure there is a discrepancy between private social costs and benefits (Bohman et al., 1999; Steele, 2009). Therefore, private sector underinvest in research because firms do not capture all the benefits from their research investment, leading to higher social benefits than private benefits of the investor (Braunschweig, 1999). Failures could come from private markets, not providing the optimal social quantity (Ervin & Mill, 1985).

Malerba and Orsenigo (1997) defined four types of failures: learning failure (firms are locked-in towards specific technologies), trade-off between exploration and exploitation, appropriability traps and dynamic complementarities failures. Keith Smith (1995) defined four other types of failures: failures in infrastructural provision and investment, transition failures, lock-in failures and institutional failures. Furthermore, Hauknes and Nordgren (1999) stated that markets are failing due to barriers to entry, asymmetric information, externalities, indivisibilities and economies of scale and scope.

Information failure (Boulanger & Messerlin, 2010; Dodgson et al., 2011; Garnsey, Dee, & Ford, 2011) is illustrated by the “lemons” of Akerlof (1970). In his work, Akerlof named bad cars as “lemons”. Buyers that do not possess all information can purchase either good cars or “lemons”. It is only after the purchase that customers will get a closer probability to know which good they acquired. Hence, good cars tend to be withdrawn by lemons on the market (Rangnekar, 2004). Moreover, adverse selection problems like imperfect information impedes firms to enter a market (Stiglitz, 1989). Information collection represents one of the main corner stone in the markets. Small and Medium-sized Enterprises (SMEs) that lack resources to gather essential information take a weaker position on the competitive level. This information asymmetry has been recognized to be important (Bougrain & Haudeville, 2002; Dodgson et al., 2011; Hauknes & Nordgren, 1999). Moreover, asymmetric information can be high for agricultural products as they display mainly experience (i.e. evaluation after product purchase) or credence (i.e. no evaluation possible even after product purchase like pesticides content) attributes (Fernández-Barcala & González-Díaz, 2006).

Ronchi (2006) stated that for agriculture, market failures are mostly characterized by market power. Distortions due to externalities from using agricultural technology are another market failure that can justify public sector involvement in agricultural research (Braunschweig, 1999).

Size of the firms has been identified to be another factor of failure. The smaller is the firm, the higher is its propensity to fail (Barrett, 2011; Watson & Everett, 1996). Moreover, small firms can reply faster to the market than bigger firms, but are more reactive when big firms are proactive. An earlier entry on the market than the competitors would provide an advantage to select distribution channels (Karakaya & Kobu, 1994).

Last, skills and capabilities of the owner or manager of the firm is a critical factor of success (McCartan-Quinn & Carson, 2003). Inefficient management or radical management can be causes of failures (Ortmann & King, 2007).

To conclude, the main market failures recognized in the literature are monopoly power, market power, missing markets (Conner, 2004), merit and de-merit goods, externalities (both negative and positive) (Boulanger & Messerlin, 2010; Bromley, 2007; Garnsey et al., 2011; Pardey et al., 2010; Roberts, 1999; Tripp, 2003), public and club goods (not rival, excludable) (Braunschweig, 1999), leading to the 'free-rider' problem (Bator, 2009; Conner, 2004; Ronchi, 2006), firm size, management skills, information inequality, transaction costs (Boulanger & Messerlin, 2010; Gül Ünal, 2009; Tripp, 2003) and undefined property rights (Alston, Pardey, & Roseboom, 1998; Garnsey et al., 2011; Tripp, 2003).

5.3 Addressing market failures by using patents and trademarks

For the neo-classical welfare economists, market failures have arisen and can be solved by policy implementation to generate higher outcomes potentially naturally emerging in the long run (Steele, 2009). They can arise when there are ill-defined property rights (Bohman et al., 1999; Boulanger & Messerlin, 2010). Many authors worked on the traditional solutions to these failures. Command-and-control and market-based instruments represent one of the solutions to market failures (Steele, 2009). Market-based solutions can be payments for ecosystem service provision, cap-and-trade schemes, pollution taxes, labelling or eco-certification (Lockie, 2013). Market-based policies and direct controls are other solutions to market failures. Corrective measures could include government policy measures like regulations (e.g. interdictions, standards, limitations of the use of inputs), incentive-based mechanisms (e.g. taxes, subsidies, marketable permits) (Bohman et al., 1999) and technical trade barriers like information remedies (e.g. labelling or control on voluntary claims and mandatory technical specifications of products, processes or packaging) (Roberts, 1999). Moreover, product differentiation aims to add value to a product giving it specific patterns (Siskos, Matsatsinis, & Baourakis, 2001; Svendsen, Haugland, Grønhaug, & Hammervoll, 2011). Smith (1995) asserted that it can be used in an imperfect competition environment.

Intellectual Property Rights (IPR) are a solution for market efficiency (Ramello & Silva, 2006) and a mean to address market failure (Garnsey et al., 2011). Ramello and Silva (2006) asserted the importance of IPR through the changes of economic agents behaviour. The focus

of this research is put on the use of intellectual property rights though the study of patents and trademark as solutions to market failures for SMEs. The next sections present a literature review on these topics.

Patents and trademarks: divergence or complementarity?

Patents and trademarks differ in their purpose and their covering period. The former protects technological knowledge of the firm and is usually granted for twenty years. The latter protects marketing assets of the firm, can signal geographic diversification and is granted for ten years with renewal of the fees by the holder (Block, Fisch, Hahn, & Sandner, 2015; Flikkema, De Man, & Castaldi, 2014; Sandner & Block, 2011).

The World Intellectual Property Organization (WIPO) defines a trademark as a "distinctive sign used to distinguish the goods or services of an enterprise from those of another" (World Intellectual Property Organisation, 2017). Trademark and patent represent means to overcome two sources of market failures (i.e. information non-excludability and information asymmetry) (Davis, 2010; Rangnekar, 2004). With information asymmetry, consumers look for intrinsic characteristics (related to the products) and extrinsic characteristics (price signal and quality signals like brands) (Sans, de Fontguyon, & Briz, 2005).

Brand differs from trademark. It is a combination of logos, colours, explicit messages and convey emotions to the consumers (Escalas & Bettman, 2005). Brand definition has been the focus of many studies because of the difficulty to find a unique definition (de Chernatony & Dall'Olmo Riley, 1998). The American Marketing Association (AMA) defines a brand as a "name, term, design, symbol, or any other feature that identifies one seller's good or service as distinct from those of other sellers" (Maurya & Mishra, 2012). For de Chernatony and DallOlmo Riley (1998), a brand is wider than the AMA's definition. The focus of the case study presented in section 5.7 is put on a trademark that is structured as an umbrella brand.

Trademark is mostly important for incremental innovations because it is easier to obtain than to develop disruptive innovations and get protection by patenting (Davis, 2010). Hence, trademark is more used by small firms than large firms (Block et al., 2015). These two property protection mechanisms embody fundamental divergence. Patents are more associated with technological innovations and related to inventions while trademarks are associated to non-technological innovations like organizational and marketing innovations. It can be an indicator of sectoral change (Flikkema et al., 2014; Mendonça & Santos Pereira, 2009). Moreover, strong trademarks can discourage competitors thanks to high investments required to enter the market (Gotsch & Hipp, 2014). They can help in overcoming market failures through the reduction of transaction and search costs by providing information and acts as a quality signal to reduce the perceived risk (e.g. product's origin) (Block et al., 2015; Davis, 2006; Flikkema et al., 2014; Gotsch & Hipp, 2014; Mendonça & Santos Pereira, 2009; Ramello & Silva, 2006). Therefore, it should attract the consumers' consideration (de Chernatony, 2009).

The strategy of umbrella branding is used by firms to benefit from the image and reputation the brand earns (Wernerfelt, 1988). The goal is to transfer these features onto the new branded product belonging to another category, using the quality signal of the known product. The author found that consumers expected a similar quality of the new product based on their experience and quality perception of the known product. However, the brand extension has to be carefully designed because if the consumers perceive a low quality for the new products, that will affect their previous quality perceptions of the old product (Erdem, 1998; Erdem & Chang, 2012; Richards, Yonezawa, & Winter, 2015). Hence, the consumers' loyalty can decrease. Furthermore, an umbrella brand brings advantages to its members like increasing products' visibility and sharing of communication and promotion costs outside the territory (Cheriet & Aubert, 2012).

Competition between brands

Brands are used to communicate different features. Competition between brands can be high. Some products are labelled with different brands, which are complementary (Sirieix, Delanchy, Remaud, Zepeda, & Gurviez, 2013). For instance, organic products are using the association label and the retailer label (Chappuis, Réviron, Barjolle, Damary P., & Praz, 2002).

Brand loyalty portrayed by customers represents an obstacle to enter the market (Silberhorn & Hildebrandt, 2012). Therefore, managers have been using the brand extension strategy for decades. This consists of using the positively perceived characteristics of a branded product to launch a new product using the same brand. It aims to cope with the rate of new product failure. The fit between the parent brand product and the new product has to be high to ensure success for the new product (Erdem, 1998; Silberhorn & Hildebrandt, 2012; Wernerfelt, 1988). Siberhorn and Hildebrandt (2012) found that the loyalty of customers still holds between the parent product category and the extension product category. If the customers are loyal to the former, they remain loyal to the latter. Kavaratzis and Ashworth (2005) defined place and product co-branding as the marketing of a product " by associating it with a place that is assumed to have attributes beneficial to the image of the product" (Kavaratzis & Ashworth, 2005). The case study in this chapter focuses on a co-branding strategy with the trademark Marque Valais.

Retailers' brands compete with national brands. Both are important for consumers. Retailers become "active" in the creation of brands (Huang & Huddleston, 2009). Thus, they develop brand for different types of products and create private label brands. If a consumer becomes loyal to a retailer based on a positive experience with one product category, the likelihood of building loyalties with other consumers rises as this quality perception is extended throughout the store (Richards et al., 2015). Private brands can benefit from spill over effects of other brands (Richard et al., 2015) because of their perceived similarity

(Erdem & Chang, 2012; Richards et al., 2015). Finally, price is a quality signal for the brand. Until a few years ago, retailers' brands were synonymous of lower quality and lower price. There were an alternative to national brands, usually more expensive, providing consumers with basic packaging product and getting rid of any mark of advertisement. Nonetheless, retailers are becoming harder competitors by developing premium brands with high quality and high price (Chematony, Riley, & Harris, 1998). Additionally to the Protected Denomination of Origin (PDO) and Protected Geographical Indication (PGI) products, regional brands appeared in a frame of consumers' expectations of local food. The PDO and the PGI were defined by the World Trade Organization's (WTO) Trade-Related Aspects of Intellectual Property Rights (TRIPS) treaty. PDO relates to "the quality or characteristics of which are essentially or exclusively due to a particular geographical environment with its inherent natural and human factors, and the production, processing, and preparation of which take place in the defined geographical area". PGI products disclose "a specific quality, reputation or other characteristics attributable to that geographical origin and the production and/or processing and/or preparation of which take place in the defined geographical area" (Rangnekar, 2004). These GI are recognized to add economic, environmental and cultural value through stakeholders' organization (Paus, 2010). The use of PDO and PGI fosters globalisation through territorial visibility (Boisseaux & Leresche, 2002).

5.4 Methods

The literature review highlighted substantial market failures. Two case studies on different mechanisms of intellectual property rights were conducted. The dedicated methods to collect data are exposed in the next sections regarding the description of the cases. Briefly, the research was performed following the method presented on Figure 5-1 below.

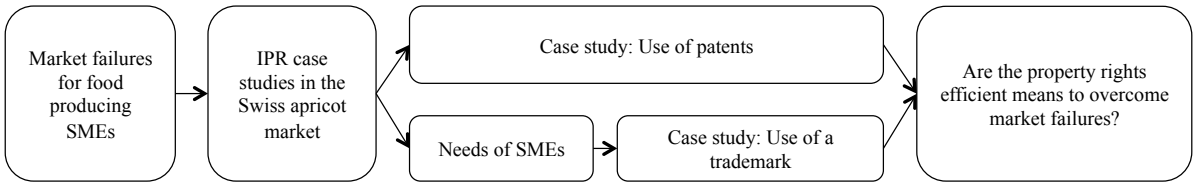

Figure 5-1: Methodology of the research project

For the first case study, it is assumed that patents and trademarks protect innovations and incentivize them. Two descriptive case studies were used in the study. Multiple case designs were chosen for theoretical replication logic. The selected cases are expected to predict different results and have different settings. This methodology was useful to understand whether IPR are used and help overcoming market failures. We used multiples sources of evidence for triangulation (Yin, 1994).

Agricultural sector uses different protection mechanisms depending on the market patterns and existing networks. The assumption is that protection mechanisms help the supply chain actors to innovate in the agricultural field. There are differences in the patents adoption between categories of the supply chain. Adoption by Swiss actors is higher when the technology is generic. If some gaps or failures come up, economic, political and/or social solutions have to be drawn. The study aims to highlight the stock of available knowledge into the fruit industry, using patents as a proxy for innovation.

Relating to the second case study, triangulation of data was performed using primary and secondary data. Primary data consisted of interviews with experts of the regional system to collect their perspectives. Interviews were open-ended and based on the structure of the market, sales distribution and trademark promotion and perspective. Secondary data collection (stakeholders' websites, reports and statistics) was conducted in order to highlight the market structure and the position of the trademark in the market. Quantitative data supported qualitative data to draw the framework of the sector of concern (Vohra, 2014).

The methods of each case study are explained in the section 6 for the case study on patents and in the section 7 for the case study on trademark.

5.5 Description of the fruit landscape in Switzerland

The majority of apricots (96%) are produced in the canton of Valais (Valais-Wallis Promotion, 2015). 90% of the market share is detained by three companies responsible for placing the products on the market. Therefore, domestic competition is limited between regions (e.g. French speaking and German speaking areas). The national surface of apricot production was 703 hectares with a national production of 8,717 tons in 2016 but 4,400 tons in 2017 due the strong frost occurring in April (Office Fédéral de l'Agriculture, 2015; Roher, 2012). 143 producers stated to the Interprofession des Fruits Et Légumes du Valais (IFELV) (R. Zambaz, personal communication and the brand and event manager from Valais-Wallis Promotion, December 12th, 2017).

The organization of the Swiss fruit sector has sharply evolved in the 2000's. The sector shifted from an unorganized supply chain with multiple intermediates to a chain with two main important partners. The long-term partnership is focused on food quality and food safety (Réviron & Chappuis, 2005).

European and Swiss agricultural policies

Switzerland does not apply the Common Agricultural Policy (CAP) that is used by the

countries of the European Union. Switzerland developed around 120 bilateral agreements with European countries, containing a free trade agreement in 1972[9]. Two sets of sectoral bilateral agreements between Switzerland and the EU were signed. Bilateral I was signed in 1999 and entered into force in 2002. It encompassed mutual market opening and free movement topics. Bilateral II was signed in 2004 and entered into force in 2005. It was related to the reinforcement of economic cooperation and extending cooperation on asylum and free travel within the Schengen borders. In terms of market trade, 60% of the Swiss export goes to the EU and 80% of the imports of Switzerland are coming from the EU. Hence, the two actors are bilaterally crucial. The CAP instruments did not success to solve market failures related to multi-functionality of agriculture (European Parliament, 2017).

A reform of the Swiss agricultural policy was initiated in 1992 based on a separation of price and income policies. Product prices were reduced and direct payments were introduced. Direct payments were rapidly linked to environmental performances. Nowadays, all farmers must comply with different environmental requirements (i.e. proof for ecological performance (PEP)) if they receive any direct payments. Around 95% of the land is cultivated according to the PEP conditions (Chappuis et al., 2006). Moreover, farmers can participate in specific programmes with additional criteria and receive ecological direct payments (organic agriculture, special animal-friendly husbandry of livestock, etc.). In 1996, the contract between the Swiss society and its agriculture was embodied in the Constitution after a popular vote than won the support of 78 % of the population.

Furthermore, Switzerland belongs to the European Free Trade Association (EFTA) that aims to create a free trade area in Europe. This association deleted custom duties for industrial products, but not agriculture. Therefore, each country applies its own economic and border policy. 7% of the Swiss exports are going through these EFTA agreements. Deleting trade barriers has been a sensitive subject addressed for years. This could lead to substantial externalities like easier imports of cheaper products, which is negative for the Swiss agriculture competitiveness (The European Free Trade Association, 2017). Currently, Switzerland exhibits trade barriers that are presented in the section 2.5.1.

5.6 Case study: Patents use in traditional stone fruit sector

Economic agents are maximizing their utility in the neo-classic theory. This can be performed by protecting innovations and intangible assets that firms possess through patents, trademarks, certifications or other mechanisms (Teece, 2010). In Switzerland, apricot

[9] These agreements were important for the chase of economic integration, especially after the anti-immigration initiative result in February 2014. The basics of population free movement and single market that support those connections were called into question.

production remains traditional with manual harvesting activities and a great portion of households cultivating that product for individual consumption. Notwithstanding, patenting in agriculture may account for a part of the intellectual property tools used to add value to the production chain.

Method

A literature text search was done with taxonomy of the production chain as on Figure 2-1. The keywords “fruit OR stone fruit OR apricot” were firstly used. Specific keywords were added respectively to the steps of the production chain, i.e. “harvest”, “collect”, “shaker” for the harvesting part. The patents extracted provided a list of 82 International Patent Classification (IPC) and eight Cooperative Patent Classification (CPC) codes that allow a checking on Espacenet to verify the adequacy of the apricot production. The same has been done for the rest of the chain. A part of the IPC codes used are listed in appendix A.6. Thomson Innovation device was used to identify the patents over the value chain of apricot sector. An assisted patent research was made at the Swiss Federal Institute of Intellectual Property. The cartography was made thanks to the software Intellixir.

Findings on the use of patents in the apricot sector

The first search on Thomson Innovation provided 261,430 patents with the list of IPC codes on a time span of 1980-2014. The description aiming the keywords “fruit OR stone fruit” provided 26,652 patents. However, Switzerland did not disclose any of them. A second search was done with patent experts of the Swiss Federal Institute of Intellectual Property. First, 349 patents have been found concerning the harvesting, quality inspection and sorting activities. Then, the time span chosen was 1995-2015 to better capture recent innovations patented in the entire sector (i.e. all the steps of the value chain). The selection criterion was the publication year. The key words « stone fruit OR drupe » were used to search in the all documents of the patents (i.e. abstract, claims, description).

A first map was designed that identified several areas of technologies patented. On Figure 5-2, each grey plot symbolises a patent. The software creates pools of similar technologies patented. Nonetheless, some noise (e.g. patents that not concern stone fruits, patents that are more general, etc.) was included like the sections entitled « morphological » or « watermelon » at the top left of the map. Consequently, a selection of the relevant technologies was made (i.e. exclusion of “morphological”, “watermelon plant”, “desired trait”, “marker” and “encode”). Another map was created without these patents.

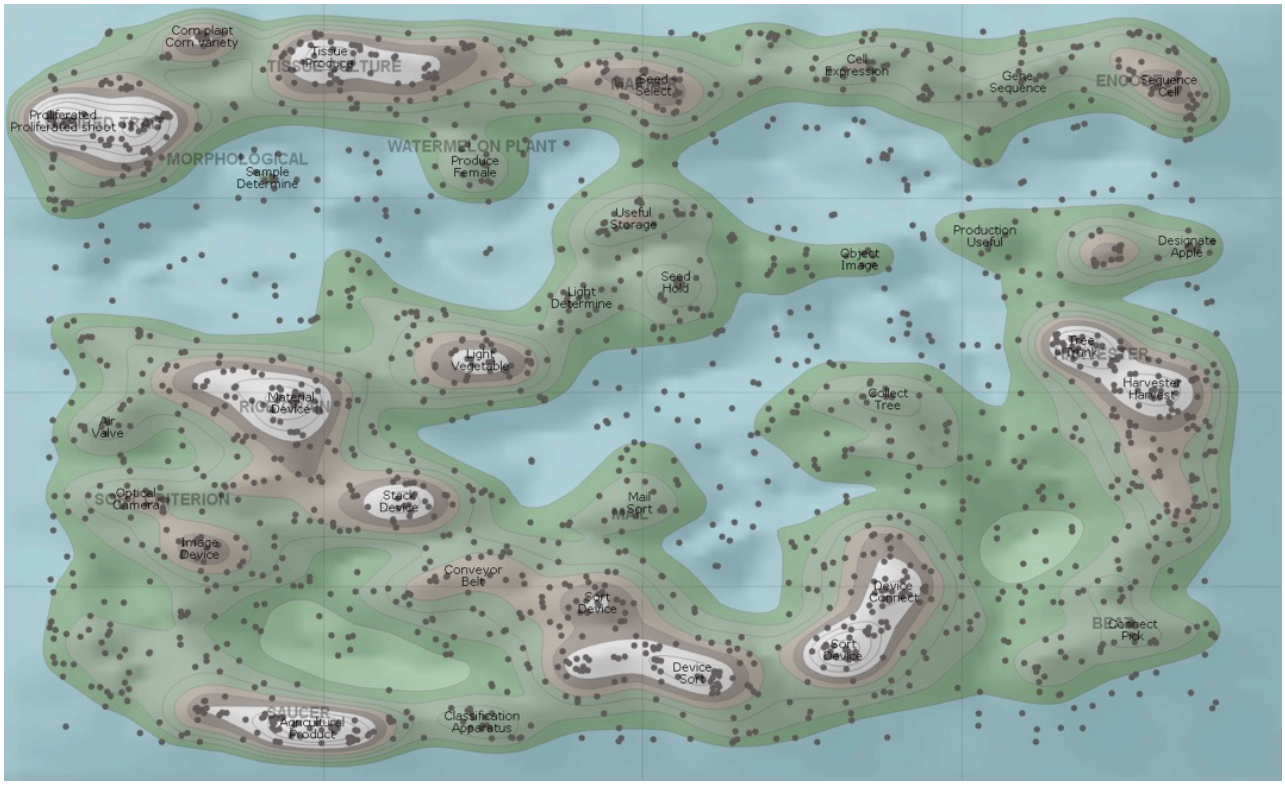

Figure 5-2: Mapping of patents eligible for apricot

Between 1995 and 2009, the number of patent applications increased by 150%. Since this year, the applications have remained above 180 per year. The originated countries that patented apricot technologies were China, Japan and the U.S.. Concerning Europe, Germany, Italy and France were the top countries with respectively 220, 130 and 110 applications. The protected countries' profile was similar due to strong applications made by Asian countries. Therefore, Europe is in the fourth region where the patents are valid. Switzerland is less far behind. The major publications were made by a French inventor with 20 applications on a total of 50. Authors had 6 applications in the time span in average. The main affiliations were Yanmar Co, Siemens, Kubota and Seminis Vegetable Seeds. The most patented technology is the technolgy that sort and grade fruits.

Around 3,000 patents have been identified. Cleaning of the reported names was conducted and provided 2,000 patents. There was heterogeneity in patent publications over time; there were no increasing applications over time or by specific applicants. The technology area may not be attractive and do not capture enough novelty to evolve substantially. Finally, only 5 patents were valid in Switzerland, presented in Table 5-1.

Publication number	**Patent title**	**Applicant** [Nationality]	**Inventor** [Nationality]
EP2628551	Device for sorting products, in particular fruits or vegetables	Calibrex	Durand Michel
WO2007017732	Method and apparatus for determining quality of fruit and vegetable products	- University of Bologna Alma Master [IT] - Costa Guglielmo [IT] - Noferini Massimo [IT] - Fiori Giovanni [IT]	- Costa Guglielmo [IT] - Noferini Massimo [IT] - Fiori Giovanni [IT]
US2010294143	Classification of Impinging Bodies		- Schmitt Peter [DE] - Scholz Oliver [DE] - Kosta Guenther [DE]
EP1841651	Apparatus and method for sorting and/or automatic packaging of vulnerable fruit	Greefs Wagen Carroserrie [NL]	De Greef Jacob Hendrik [NL]
EP2277020	Method and system for processing items	Scanvaegt Int AS [DK]	Skyum Henrik Frank [DK]

Table 5-1: Patents of apricot technologies valid in Switzerland in 2014

Private firms and universities have patented specifically in this sector. Even if generalization cannot be made with these results, one can see the internationality of applicants and inventors.

To conclude, this type of IPR is not a suitable and efficient mechanism in the traditional crop sector, especially because the fruit is mainly consumed fresh. There are future avenues for development and disclosure of patents from related fields and sectors that can be applied for stone fruits and applications for processed fruits (e.g. beverages, alcohol content, jams). The next section is presenting another Intellectual Property Mechanism used; trademark.

5.7 Case study: Trademark use in traditional stone fruit sector

The main goal of this case study is to assess whether a trademark helps to overcome market failures. Product differentiation allows promoting the products' differences from the product of competitors. Hence, the case chosen target that strategy. However, investigation of the needs of the small firms producing apricot was realized in order to understand where the issues are located in the value chain and whether the use of labels and trademarks were challenging.

5.7.1 Innovation needs of the Swiss SMEs producing apricot

Method

An inventory of needs of the apricot stakeholders was collected using face-to-face interviews. The structure of the questionnaire targeted different activities of the product life cycle (i.e. from breeding to distribution). A part on the management of the value chain and marketing were included. The answers to this part are further analysed in this chapter. The questions were uniformly framed to avoid any type of bias and asked whether the firms faced important challenges in the last fifteen years. The solutions chosen for the already solved problems and the solutions firms think that may help for the unsolved problems were considered. Finally, in the case of none challenges faced, firms cited the techniques they used. These questions targeted each step of the value chain. The semi-structured frame of the questionnaire allowed discussion between individuals interviewed and the researcher, enabling a deeper understanding of the situation.

Then, a focus group bringing together five representatives of the SME associations involved in the apricot fruit chain in Switzerland was conducted. The aim was to validate the needs cited by the stakeholders and prioritizes them, based on a Likert scale using 1 (not important), 2 (slightly important), 3 (moderately important), 4 (important) to 5 (very important).

Findings

The sample included 22 producers, 3 retailers, 6 processors and 4 inter-professional organizations. Some stakeholders were working in several functions like producers that process their goods. Apart from retailers and sectoral organizations, the firms included in the survey were SMEs. All were well established on the market and created between 1889 and 2009. Respondents of the interviews claimed 369 needs grouped in 22 categories. Table 5.2 gives these categories and the frequency of needs' citation.

Categories of needs (frequency)	
01. Varieties (77)	12. Storage (14)
02. Irrigation (1)	13. Quality (9)
03. Fertilization (3)	14. Transport (4)
04. Phytosanitary (26)	15. Norms (23)
05. Pests and diseases management (42)	16. Labelling (1)
06. Environment (30)	17. Marketing (9)
07. Batch consistency (9)	18. Communication (7)
08. Production (6)	19. IPR (1)
09. Harvesting (19)	20. Competition (38)
10. Processing (9)	21. Consumption (8)
11. Packaging (19)	22. Supply chain (14)

Table 5-2: Categories of needs of the apricot sector in Switzerland

The category with the highest importance in terms of claimed needs is varietal innovation. Nevertheless, Supply chain (SC) management category indicates an important aspect of traditional fruit production chain. Competition was often cited (38).

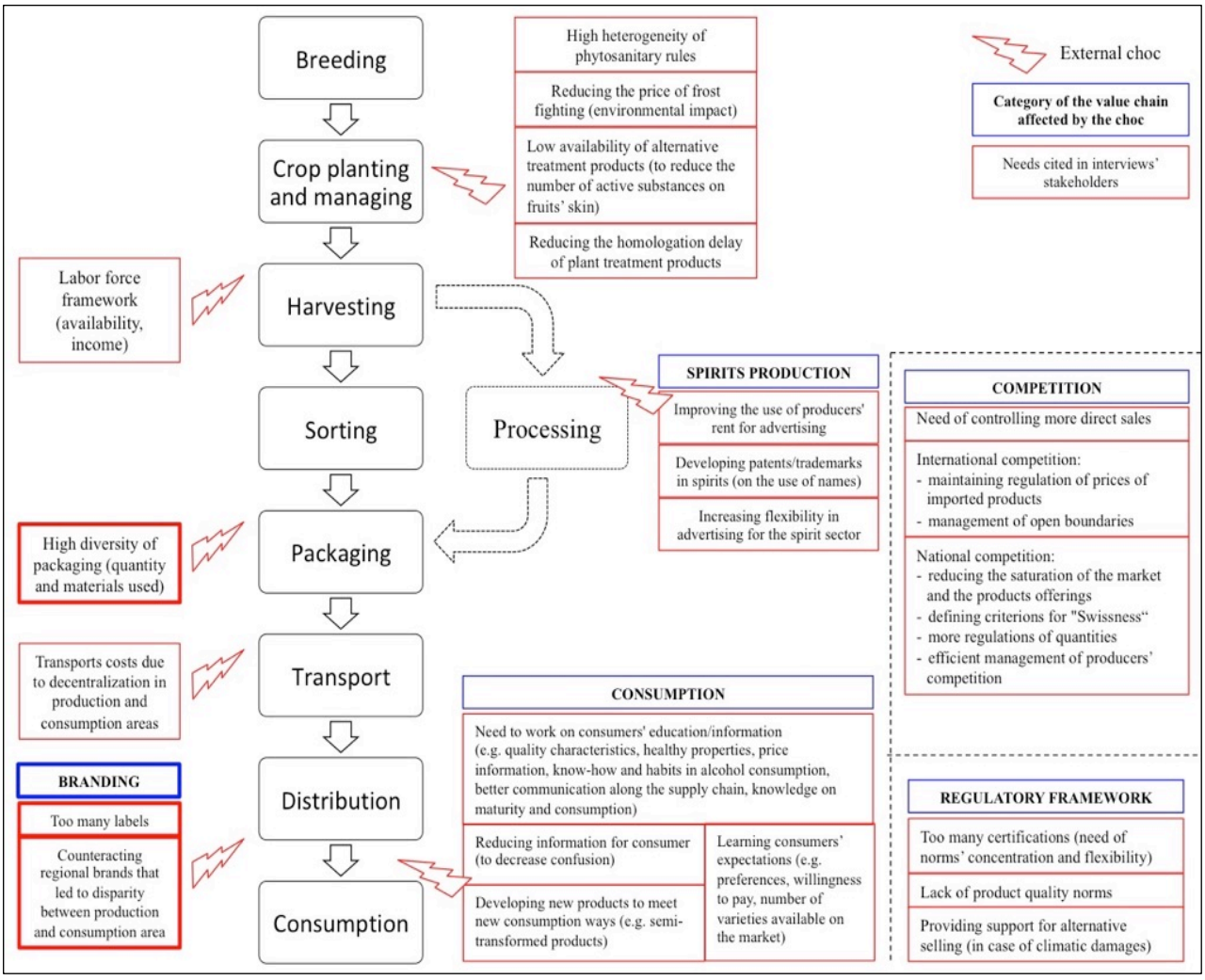

Figure 5-3: Needs of the apricot value chain collected with semi-structured interviews

The diagram on Figure 5-3 presents the cited needs related to the categories of spirit production, branding, consumption, regulatory framework and competition. The focus group prioritized of these needs. 30 needs were evaluated as “very important” and 32 as “important” by the stakeholders. Table 5-3 consolidates the description of the “very important needs” of the supply chain management category.

Topics	Description of the needs
13. Quality	Getting a higher trade-off quality-productivity
15. Norms	Harmonization between countries (e.g. hygiene, use of pesticides)
17. Marketing	Better use of the rent of producers for publicity
18. Communication	Increasing consumers' education and information *Quality characteristics, healthy properties, price information, know-how and habits of alcohol consumption, better communication along the supply chain, knowledge on product maturity and ways of consumption.*
19. Competition	International competition and importation management *Maintaining regulation of prices of imported products, management of open boundaries, regulation of prices.*
	National competition *Getting transparency, loyal competition.* *Creating a national market (e.g. importance of a national observatory of the sector).*
21. Consumption	Consumers' surveys *Increasing knowledge on consumers' preferences, their willingness to pay and their thoughts about number of varieties available on the market.*
22. Supply chain	Management of food waste
	Management of actors' balance: *"It is very important to find a balance between the forces of the various actors in the chain."* *"It is not important to reduce the number of actors."*

Table 5-3. Description of Swiss apricot and berries needs of the supply chain management rated as "very important" by the Swiss stakeholders

Technical and management issues have to be solved to improve competitiveness and stability of the sectors. In apricot production chain, norms and management of food waste was pinpointed. This topic can be applied in other food sectors, as well as trust and coordination along the supply chain and actors' power balance. Economic international and national competition is one of the main challenges for small firms. Trade barriers induce additional obstacles for companies for differentiation on the market. Furthermore, even if the supply chain management constitutes strength, there is a lack of communication with consumers. Therefore, knowledge and added value of products is lost along the chain. The quasi-monopole of retailers weakens small producers that have slight bargaining capability. Besides, there is a myriad of quality standards, norms and certifications. Consequently, this causes overload of paperwork and hinder producers to implement innovations.

Finally, the aspect of local production of apricot displays major strengths, traducing a regional identity of apricot. There is an opportunity to shorten even more distances between producers and consumers to reallocate added value along the chain. Moreover, the proximity between producers and consumers has a non-negligible weight in the good image of this fruit. The canton of Valais benefits from an umbrella brand, which covers agriculture, agri-tourism,

food, craft, administration, building, finance, real estate, social institutions, industry, training, tourism, recreation services, transport, wine production, hotels and restaurants respecting the requirements of the brand. It has been launched a few years ago and wishes to promote the canton image at regional and national levels. This brand constitutes a case study, described in the next section. A major difference in this project and the literature on trademark and the link to innovation is that the conducted studies focused on firms' incentives to trademark. The level of analysis was the firm, while we study an umbrella brand; consequently firms selling their goods trademarked are not the firms that created the trademark.

5.7.2 Presentation of a regional trademark: Marque Valais

The non-profit association called Association des Entreprises Valais Excellence (AVEX) created two types of labelling: Valais Excellence and marque Valais. These are multi-level brands strategy that promotes a specific territory and focuses on territorial emblematic products. Valais Excellence is the certification for firms. Marque Valais is the certification for products. The logo is presented in Appendix A.7 and direct sale in Appendix A.8. The former is designed for enterprises that are from the region and applying the ISO norms; ISO 9001 for the quality management, ISO 14001 for the environmental responsibility and are engaged towards corporate social and environmental responsibility initiatives. The latter is a brand that does not brand any product or enterprise that is localized in the region of Valais. The aim of the brand was to involve private and public actors; entrepreneurs, umbrella organizations and public authorities are suitable. Hereafter, several sectors are part of Marque Valais (e.g. agriculture, tourism, catering, industry, administration, transport, social institutions). Specific requirements are designed and have to be fulfilled in order to be able to use the brand (Michelet & Giraut, 2014). This induces exclusion by quality and excellence criteria as in the marketing taxonomy "club-excellence". The economic and political goals of such label have positive and negative externalities. A significant brand spillover is a pension effect due to strong assets present in the local area (e.g. Cervin Mount) (Michelet & Giraut, 2014). This type of trademark is a combination of private and public goods and fits the definition of basket of goods stated by Bernard Pecqueur (2001). The global promotion of goods and services for which the global pension is higher than the sum of the pension of each elements of the basket. Hence, marque Valais is an organizational innovation, which is communication-oriented whereas Valais Excellence is more economic and environment-oriented. The logo acts as a "federating role" at the regional level and as an "identifier role" at a broader level.

Fifty products are certified through Marque Valais; among them, 47 are agricultural products. Around fifteen apricot producers are members and can use the label to sell their fruits. However, this does not reduce infringements, even though controlled by the association Valais-Wallis Promotion. Human and financial resources dedicated are too low to have an

efficient impact on these infringements. This situation is partly due to the dichotomy of the brand. Communication is made on the territorial aspect of the brand. The claim "Valais gravé dans mon coeur" (i.e. Valais engraved in my heart) is appealing to the identity feeling of the consumers for the region. However, the quality attributed to the products respecting the requirements of the brand is not communicated. Hence, consumers are aware of the brand and the origin of the products but they do not systematically associate the brand with high quality products. Furthermore, producers do not perceive the added value of using the brand. Concrete marketing measures are planned to be developed in the near future in order to communicate to the producers and the consumers what and how the brand can bring positive impacts like marketing measures used for other products and applied for apricot (R. Zambaz, personal communication, brand and event manager Valais-Wallis Promotion, December 12th, 2017).

Trademark evolution and competition

In 2017, Italy produced 241,736 tons, France produced 151,297 tons, Spain produced 102,571 tons and Greece produced 77,000 tons. Switzerland produced 8,717 tons in 2016. Switzerland imported 6,914 tons of French apricots in 2017. This is the third country of export for France after Germany and Italy (FranceAgriMer, 2017). In 2012, imports were coming from France by 49.8%, 28.2% from Spain 18.7% from Italy and 3.2% from other countries (IFELV, 2012). These imported fruits were of high quality and competing with Swiss fruits sold under Marque Valais. Hence, competition was strong, especially because European products quality increased in the past few years together with decreasing prices. Moreover, Marque Valais is also competing with retailers' trademarks and producers' trademarks. All the fruits sold with Marque Valais represent all the products produced in Valais. Thus, quality is not the determining factor, although producers and retailers' trademarks propose selected apricots. Therefore, competition between Marque Valais and imported products and other trademarks is difficult, especially when the tariff barriers do not reduce the incentives to favour imported products. In 2017, due to a relatively hot spring, three quarters of the production was available in July in France. This offer was competing with the imported Spanish fruits that came later on stores shelves due to the delay in the Spanish production. Therefore, in May the offer was higher than the demand, the market was clogged (Agreste, 2017).

In recent years, the trademark has been facing challenges for its agricultural products, especially apricots. The packaging is progressively dropped. Finally, this trademark is becoming a territorial trademark based on product origin requirements and not quality differentiation. Moreover, producers and retailers developed their own brand that competes with Marque Valais, based on quality sign and not origin. This was feasible because of the high volumes produced and distributed by the firm.

5.7.3 Obstacles and perspectives: implications of societal, market and political levels

Expectations and trust of consumers

Trust of consumers in apricot tends to decrease. Difficult climatic conditions (hail, freeze, rain, gel) on several consecutive years negatively impacted the production, reducing fruits quality. Besides, "consumers are disappointed with apricots sold with the trademark Marque Valais", because the highest quality of fruits is expected but not found (B. Lehmann, personal communication, Fruit and vegetable product manager of one retailer, August 5th, 2016) and (R. Zambaz, personal communication, brand and event manager Valais-Wallis Promotion, December 12th, 2017). Furthermore, traditional variety remains the reference for consumers. Therefore, the new developed varieties should not be too far on a hedonic level to that reference. Besides, consumers prefer to consume locally. "They have a relationship based on trust that they usually know". This trust is also essential in the value chain and long-term established (i.e. 40 years of partnerships between producers and wholesalers or retailers) (B. Lehmann, personal communication, Fruit and vegetable product manager of one retailer, August 5th, 2016).

Exports of products from Valais are quasi non-existing, except for big productions like cheese. Hence, outside this area the brand is not competitive with others and the consumers are too far to be aware of the added value the trademark can bring.

International competition

Between 2010 and 2016, an average of 8,000 tons of apricots has been produced in the country and the same amount was imported. In 2016, 58% were imported from Spain, 33% from France, and 9% from Italy, Serbia, Hungary, Portugal, North Africa and South Africa. These imports are made during the non-protected phase (i.e. until June 30). The retailers have therefore the incentives to buy the imported fruits that are competitive on the quality and the price. In this setting, it is difficult for the Swiss market to be competitive, especially with variability in the quality of the production. This represents an important hindering factor for both retailers and consumers. The latter are not aware of the varieties available along the season so they cannot know how and when to consume the fruit after the purchase (e.g. storage for a few days), like it could be the case for apples or pears. Two levers could be used; consumers' education and production stabilization. The first would target the knowledge of consumers on the better period of consumption (e.g. whether to wait a few days before consuming the fruit or not). The second regards the number of varieties produced. If there

were a dozen of new varieties with bigger harvested surfaces, the homogeneity could be enhanced and so the production and the quality. However, constant improvement of varieties to increase diseases and pests' resistance, climate change adaptation and other agronomic features are conducted. This is the opposite of what could be done to stabilize the production (O. Borgeat, personal communication, secretary general from IFELV, December 5th, 2017).

National competition of products, labels and trademarks

Apricot products are competing with other summer fruits like peaches that could be attractive to consumers. Another substantial hampering factor is the pressure put by diseases and pests like Drosophila suzukii, monilia or chlorotic leafroll that are becoming important threats for the orchard. Finally, all these factors are put in the trade-off and the negotiations with the retail sector (O. Borgeat, personal communication, secretary general from IFELV, December 5th, 2017).

The Swiss apricot sector could foster higher quality by proposing less but more homogeneous and stable varieties and production over the years. Furthermore, the use of a Protected Designation of Origin could have been feasible. The alcoholic product Abricotine is a PDO since November 2002. 117,000 bottles of 7 dl are produced (1 million kg of apricots) (O. Borgeat, personal communication, secretary general from IFELV, December 5th, 2017). Several types of labels are used in Switzerland: compliance labels, environmental labels, social labels, quality labels and regional labels. Among them, the most famous labels are « Pro Montagne » that is assigned to products originating from the mountain areas, the organic production and the PDO-PGI products.

Finally, the two biggest retailers in Switzerland developed private brands based on origin and quality segmentation for instance. For the latter, premium fresh and processed agricultural products can benefit from this differentiation sign, increasing the market share of the retailer. These successful brands provide solutions to overcome market failures by proposing alternive solutions to access the market.

Political load

Trademark management is politicized to some degree. For instance, dry meat uses a PGI differentiation. To obtain this certification, one of the production activities must be made in the region. The raw material can come from other regions and processed in Valais. Discussions are taking place on the potential to integrate this emblematic product of that region that is time-consuming and involves different stakeholders that should find consensus and similar paths. Furthermore, Marque Valais is owned by the State of Valais and is managed by the Valais-Wallis Promotion association. The different layers of decision-making involved and the different stakeholders are important. Thus, individual relations underlying

crucial decisions and works become important for the management of the brand.

One of the difficulties with the cross-sectoral brand is the creation of tailor-made solutions because of the products' diversity and firms' profile in the frame of limited financial resources. These have to be split between all the labelled products. The core products of the region (i.e. apricot and cheese "raclette") are benefitting from substantial promotional efforts. Nonetheless, small firms producing other raw or processed products cannot capture the externalities of such promotion, at least not enough.

In the other regions of the countries, territorial brand are used. The only case similar to Marque Valais was conducted in the canton of Grisons (Alpinareva). This brand was finally divided in two differentiation labels; one to promote the territory and the other to promote the quality of the products (R. Zambaz, personal communication, brand and event manager Valais-Wallis Promotion, December 12th, 2017). This solution could be explored for the case of Marque Valais. This strategy could bring added value for both new labels and actors of the value chain. Producers and consumers could distinguish better what and which label is made for.

To conclude, cross-sectoral synergies have to be investigated like working with service providers in tourism to create positive spillover for all the products, producers and consumers related to the brand.

5.8 Discussion

Different mechanisms are highly used by firms for innovation appropriation. The knowledge produced through innovation activities is particularly important for inventors (B. Hall et al., 2014). The appropriability regimes and choice of IPR tools differ across sectors, particularly because of differences in legal systems, exogenous and endogenous firms' characteristics and firms' strategies. On the one hand, patents are not considered as significant mechanisms for protection for 50% of the interviewed firms, according to the Community Innovation Survey, Yale I survey and Swiss survey. On the other hand, secrecy or lead-time are considered more effective for protection (Gotsch & Hipp, 2014; B. Hall et al., 2014). Consequently, combining different intellectual property rights like patents and trademarks has been used by firms to leverage economic returns and build entry barriers. It gives incentives to pursue innovation. The combination of copyrights, patents and trademarks is used in service industries. Trademarks, design rights and patents are used together in knowledge-intensive business services (KIBS) (Flikkema et al., 2014). However, this strategy might create positive externalities only in the short-term, cutting resources to generate new products or services (Davis, 2010).

In the study, patents have been investigated to understand their use in traditional

agricultural sector. The findings show that very few patents are used in the country with applicants and inventors of universities and firms based in Europe. Hence, this intellectual property right can be combined with another mechanism to cope with market failures faced by small agricultural firms. Another appropriation mechanism was investigated in an empirical case study to understand its efficiency for the stone fruit sector in leveraging added-value for producers. The results suggest that the regional and umbrella trademark is associated with a good image but consumers are not aware of the requirements related to its adoption. Hence, high quality of products is not systematically associated with the trademark. Moreover, this trademark is poorly recognized outside the region. The association managing the regional differentiation sign has to adjust and orientate segmentation strategy for trademark efficiency and visibility.

Factors for brand success

Trademarks' economic analysis can be "elusive" (Ramello & Silva, 2006). Brand success can be explained by consumer-based criteria (i.e. brand associations and perceived differential advantage and added values) and business-based criteria (i.e. profitability, shareholders' equity and market share). The former have a longer-term orientation than the latter. Therefore, both categories are crucial for analysing success of brands (Chematony et al., 1998). Donner et al. (2014) identified two types of factors to understand trademark success. Brand equity or impact of the brand on consumers' consciousness through awareness, perceived quality and brand associations; and consumers' behavioural response to the brand through purchase intention and loyalty would give more insights for brand improvement (Donner, Fort, & Vellema, 2014). These criteria should be investigated in further research to highlight potential levers for improvements. The example of a successful place brand is "Sud de France". The umbrella trademark was designed as a common export label for small producing wine firms facing difficulties in a frame of economic crisis in 2006. The brand was extended to other agri-food products and used as an institutional brand to support cultural activities and universities (Griffon, 2011). This brand has economic and non-economic outcomes like regional recognition, tourists' attractiveness, preservation of products' typicality, network cooperation strengthening, better market access (Donner et al., 2014).

Competition of similar products, labels developed by competing stakeholders and international market, political load and consumers' trust are crucial hindering elements for trademark success highlighted in the results of the study. The trademark Marque Valais is an organisational innovation that aims to overcome the value chain organisation by directly bounding with the producers through contractual requirements. Trademark competition is developed through producers and retailers innovations. Davis (2010) (see Appendix A.9) built a matrix based on trademarks and innovation to address failures in the market for information. One axe presents exclusive rights through two possibilities (i.e. weak and strong entry barriers). The other axe divides quality sign in "novel" and "non-novel". According to Davis'

matrix, Marque Valais would be placed in Box 3 (strong entry barriers and non-novel quality sign) where consumers pay a relatively high price for a non-novel product. The profits would be high on a short-term basis but low on a long-term basis. With rapid technological change, switching benefits can be higher than switching costs at the consumer level. In this setting, R&D strategy of new entrant firms would overcome entry barriers initially erected by the incumbent firms via trademarks. Moreover, innovations would tend to decrease in the incumbent firms. Thus, diverse strategies should be designed to foster trademark position, to engage consumers' loyalty and to avoid creation of individual trademarks. The four P's of the marketing mix (i.e; price, promotion, product, place) could be revised. For instance, processed products could raise substantial added value, the promotion would have to be differently designed in diverse places.

Promotion of the territory

Peripheral regions that do not benefit from agglomeration economies and competitiveness conditions of the mass market can rely on territorial resources (Michelet & Giraut, 2014). Differentiation of resources are a crucial factor for competitiveness (Maillat & Kebir, 2001). Peripheral regions can escape global competition via a shift from technological externalities to cultural externalities (Michelet & Giraut, 2014). Apricot production is concentrated mostly in one region in Switzerland. This is due to specific agro-climatic and agro-ecological conditions. Traditional production is moreover resulting from particular know-how. Firms can exploit these skills and resources because of their strong territorial anchorage to cope with scale and agglomeration economies issues in a high competitive environment. This constitutes a "terroir" strategy (Rastoin, 2009). Resources that are hardly transferable have a high value in the frame of factors' mobility increase, information technology development and transport costs decrease (Maillat & Kebir, 2001).

Product origin is used as a quality signal promoting the place and its resources. In January 2015, the Association Suisse des produits régionaux (regio.garantie) has been created to foster interests for regional products and replace the previous geographical indications created in 2007. Four members are included in the association corresponding to the four geographical supra-regions of the country (alpinavera, Culinarium, «Das Beste der Region» and Pays romand – Pays gourmand) (Association suisse des produits régionaux, 2017) This initiative falls within the tendency to homogenize information provided to the consumers.

Communication and promotion of differentiation signs

Communication becomes an economic aspect included in public policy that support the development of sectoral local policies in a globalised market (Griffon, 2011). The Swiss Confederation can allow up to 5% of its budget for the promotion of sales of agricultural products in projects promoting regional food products. In addition, most of Swiss regions

have a promotion budget dedicated to regional food products. These promotion plans are dedicated either to a generic regional promotion (including all products) or specific products ("terroir" products) (Chappuis et al., 2006). At the European level, different signals controlled by public authorities exist like Product Denomination of Origin (PDO), Product Geographical Indication (PGI) and traditional specialty guaranteed. In France, similar trademarks were developed to guarantee higher quality (Label Rouge), organic production (Agriculture Biologique), « Certification de Conformité » (products or services respecting specific characteristics initially defined) or Appellation d'Origine Contrôlée (AOC) equivalent to the European PDO. Private trademarks have completed this landscape of quality signals. These are national brands mainly performed by industries; private brands developed by cooperatives of producers and retailers' brands that are exclusively sold in the shops owned by the retailers. Association of private and public signals has increasingly arisen. PDO and retailers' brand can be used for a same product. This proliferation of information have become counter-productive implying too much information for the consumer and too much work for producers (Hassan & Monier-dilhan, 2002; Sainte Marie & Casablanca, 2000).

Increasing interest for local food

For some years, consumers have been requesting more local food. On the one hand, food scandals occur in several places in the world. On the other hand, there are increasing pressures on environmental resources and greenhouse gas impact. To answer consumers' needs, governments and firms developed labels of geographical origin. Moreover, agricultural products are slightly different from industrial products. Quality decreases with transports, an argument in favour of domestic products (Siskos et al., 2001). This advantage can be exploited through the use of labelled local food products. A debate concerning the impact on the environment of local food has been going on for several years. Furthermore, the willingness to pay for local products depends on different factors. For Grebitus et al. (2013), "a mile is not a mile". The willingness to pay for a local product relies upon the type of product. In their study, the authors studied the apple versus the wine sectors. The price of the former is more affected by the distance travelled than the latter. Hence, products freshness is an important motivation in purchasing decision.

Limitations

Two case studies were conducted in this research project. In order to ensure external validity of the research, replication logic is required. The analysis conducted to a generalization that is of "a particular set of results to some broader theory" (Shakir, 2002; Yin, 1994). However, extrapolation and statistical conclusions cannot be drawn by using such method. Moreover, the sector chosen in these case studies remains narrow with small firms concentrated in one region of a country. Hence, the specificities of that sector are hardly

emphasised. Including different sectors in the analysis would bring interesting insights to understand the mechanisms and the implications of intellectual property rights in traditional agricultural chains.

The regional professional association works with few resources to perform a formal survey of the fruit industry. Data are collected on a voluntary basis. Data on the use of trademarks by farmers, data on the volumes sold using this regional trademark, and data of the biggest retailers are needed to go further in the analysis of the supply chain. Moreover, in the study, there was a lack of data at product level in one hand and invention level on the other hand. Data are generally aggregated at the firm level, however they diversify their activities and may not apply the same protection strategy to every products. Companies realize trade-off analysis to choose between different appropriation tools. This trade-off is not theoretically well understood. Firms appear to combine different mechanisms to protect their inventions and new products. In the agricultural sector, firms may choose to use a regional trademark to sell their production, others prefer informal mechanisms. An improved understanding of the rationales for selecting one over another informal and/or formal IPR would be useful.

Finally, cross-sectoral research would be interesting to analyse the impact of the political, economic and market frames in using such IPR. A consumer-driven approach should also be considered to determine the value of marketing differentiation instruments.

5.9 Conclusions

Knowledge stock is contained in formal IPR through trademarks and to a certain extent in patents. These two appropriation tools are complementary, while patents are more used in the processed industry and trademark for various products. The traditional production of food is not the intended sector for patents' use. Nevertheless, innovation and tradition can complement each other. The former can be developed respecting the latter. Extended potentialities exist, inter alia, in new process technologies, logistics and value chain organization or distribution systems.

External pushes through cantonal subsidies and direct payments favoured the increase in apricot production in Switzerland. These events impacted positively product consumption in the region. The regional trademark profit from it. The trademark studied, Marque Valais, was an organizational innovation including diverse sectors based in a specific region. Initially created to promote the region and firms respecting required criteria, consumers received diluted information with a focus on the territorial nature of the products they purchase. Notwithstanding products benefitted from high quality; competition of imported products is increasing, based on products' prices and quality. Therefore, repositioning Marque Valais would move toward trademark differentiation based on quality and regional criteria. Resource

differentiation is a determinant factor for competitiveness (Maillat & Kebir, 2001). Consumers should be aware of what are the requirements to get the trademark, hence recognize its value and base their purchase decisions on rational reasons. Repositioning has to be carefully performed to not exclude small firms (Donner et al., 2014).

Segmentation is a solution to market failures. Segmentation can be done with origin/territorial differentiation, PGI/PDO and technical aspects of products. The idea of a geographical indication is quite new in Switzerland. The recognition of PDOs and PGIs is developing rapidly, thanks to the efforts of the Swiss association for the promotion of PDOs and PGIs and to the important press coverage with the recording of each new product (this association owns and promotes a unified label for all Swiss PDO/PGI products). The registration of Gruyere cheese (a well known hard cheese) in July 2001 has been an important step in the development of PDOs knowledge (Chappuis et al., 2002). This strategy could be applied to other products. The establishment of legislation for PDO and PGI products was perceived as a real opportunity for typical traditional products that were seen as having a chance of entering the long channels of large retailers and exports. It has lead, in a number of cases, to the creation of a new market segment like Swiss food products of superior quality (Chappuis et al., 2002). Furthermore, the expressed needs by smallholder farmers could be partially satisfied. Too many packaging were highlighted. However, product differentiation in the frame of competitiveness would increase in the future. Thus, information and quality signals would be disclosed via packaging.

Finally, small firms' expectations and challenges should be investigated to provide and propose them with suitable innovative solutions. Interactions between stakeholders constituting vertical and horizontal networks should create adequate organizational or marketing innovations.

Chapter 6 Conclusion

A discussion about the outcomes of the dissertation, the implications and the potential avenues for future research are presented in this section.

6.1 Overall conclusion

This dissertation studies the innovation capacity of small firms in the setting of an agricultural protected market. We used mixed method research in three different research projects. We first identify the gaps in literature regarding the poor use of informal mechanisms to analyse, measure and observe innovation in traditional food production chains. The first project, in Chapter 3, raised the issue of interactions that could be productive in innovations, based on formal and informal collaborations between stakeholders involved at both vertical and horizontal networks. The second research project, in Chapter 4, emphasized gaps between research results through publications (e.g. articles, books, reports, reviews) and innovation needs of small firms to daily challenges. Knowledge, innovation and implementation gaps were identified according to the topics investigated. Finally, Chapter 5 targets the use of intellectual property rights to overcome market failures that hinder agricultural firms to efficiently capture the benefits of their economic activities.

We describe each project in what follows. In Chapter 3, we focused on the determination of innovations by understanding the interplay between the network of actors and structure of the domain. Swiss apricot network is characterised by a limited number of actors, informal interactions, more or less porous boundaries, constant search and implementation of innovation. Interactions are required to transfer knowledge, but only some of them are productive given the structural conditions of the domain. Hence, the Swiss centre for agricultural research established formal and informal collaborations with a diversity of partners. It plays the role of linking research outcomes and producers by localising knowledge to make it more accessible to local producers. The University of Applied Sciences displays few interactions with actors of the apricot value chain. Both public actors are complementary. The former is closer to upstream actors like producers; the latter is closer to transformers. Consequently, combining cognitive and geographical proximities enhances innovation implementation. Furthermore, indirect links can be crucial for connecting people and thus transferring substantial knowledge and innovation.

Indicators for measuring productive interactions could rely not only on the degree of centrality, betweenness and clustering coefficient that nodes display in the network but also on the type of interactions (i.e. formal, informal, and financial), nature of the sector, innovation degree (i.e. disruptive or incremental) and connections with diverse external environments. In conclusion, observing and measuring innovation is difficult in sectors where R&D is not central and informal and interpersonal interactions prevail. Market and structural contexts are determinant factors as to whether an interaction becomes productive.

The matching and relevance between the potential needs in innovation of small firms and the innovative solutions provided by the research community are investigated in Chapter 4. We emphasize the innovation needs of the Swiss apricot sector through interviews and confront them with research outcomes provided in three different bibliometric databases. Importance of improving varietal innovations was homogeneously expressed by the stakeholders and prioritized in a focus group. Hedonic characteristics, productivity and deepen knowledge on varieties should be strengthened. Pests and diseases management, use and regulation of phytosanitary products and competition are other major areas.

Our findings show that publications of research organizations and universities are connected to some extent to the cited needs of the firms. Both fundamental and applied research is concerned. However, the research outputs are wider than apricot and stone fruit sectors. Some needs were specific regarding the production location, thus publications are not often related. Food studies, environmental studies, chemistry, plant sciences and pathology were integrated in the databases. Overlap and exclusivity are found between the tools. Last, three gaps are emphasised; generic knowledge generation, specific knowledge generation and implementation related to knowledge transfer. Finally, a better coordination of the value chain actors is required to efficiently transfer information, knowledge, innovations related to current crucial issues.

In Chapter 5, intellectual property rights are explored to understand the knowledge stock of the sector and if these tools are efficient solutions for market failures. Traditional production of food is not the intended sector for the use of patents. A regional trademark that includes different sectors like tourism and agriculture was created a decade ago. It is an organizational innovation that promotes the region and firms respecting the required criteria. Notwithstanding, competition of imported products based on products' prices and quality is increasing. The findings show that at marketing level the trademark could be repositioned, promoting differentiation characteristics like quality and regional criteria. This segmentation was performed by private actors through the creation of retaling brands. The successful marketing innovations provided levers for market failures.

Fundamental research is linked to needs' implementation for efficient solutions and productive interactions could be directed towards marketing with development of trademarks. Besides, in the three research projects the main role of informal collaborations with

competitors and external actors of the supply chain like national research centres, regional associations, political and legal regional offices and universities was emphasized. In the first project, some interactions are productive but can be fostered to develop more adequate innovative solutions. In the second project, we recommend involving stakeholders of different environments and connecting their issues, strategic targets and management decisions for effectively connecting fundamental and applied research outcomes to practitioners' challenges. In the last project, extended activities and collaborations with diverse services within the regional trademark are suggested in the frame of trademark repositioning to add value to the sector.

Finally, digital technologies are increasingly highly used in agriculture for different purposes. Precision agriculture appeared in the mid 1980s (Gebbers & Adamchuk, 2010). It groups different technologies used to optimize the use of resources based on varying field conditions like Global Positioning System (GPS), Geographic Information System (GIS), remote sensing, sensors on plants, soil and pests, yield monitoring devices, and variable-rate technologies for applicators of inputs (Seelan, Laguette, Casady, & Seielstad, 2003). Software for agricultural management, product traceability or autonomous machinery are increasingly used (Gebbers & Adamchuk, 2010). Agricultural activities are more sustainable, the use of inputs and negative environmental impact are reduced and work conditions have been improved. Profitability augmentation is another example of what digital technologies can provide. Time and transaction costs can be reduced, especially for information exchange and information asymmetries (Deichmann, Goyal, & Mishra, 2016). Firms and researchers from public institutions can communicate more efficiently.

Machine learning, robotics, Internet of Things, augmented reality are technologies that have potential in the future of agriculture (European Commission, 2017b). E-extension system can be an information bank or an online repository where mobile phones are combined with platforms on the Internet. In the near future, social media and crowd sourcing would help monitoring agriculture. Blogs and social networks could provide signals like sudden meteorological phenomenon information and other data (e.g. rainfall, evaporation, temperature) that would be analysed by tools initially developed for Big Data and useful in remote areas where infrastructure is missing. Moreover, social media become an effective mean through which agricultural actors can find support, create communities of practice to leverage common resources and capabilities. Information is disclosed through social media at a faster pace than conventional channels. Furthermore, blogs and professional social media platform are used to diffuse useful comments and news related to advertising (Cone, 2008), market opportunities or linking farmers and producers (Rhoades & Aue, 2010). A study on the use of social media sites showed that 85% of social media users think interactions between customers and firms can be established through social media sites (Cone, 2008). Using different social media sites allows to attaining diverse audiences that could be unreachable otherwise. Finally, crucial features of social media include creating and maintaining

communities and allowing more transparency between farmers and producers (White, Meyers, Doerfert, & Irlbeck, 2014).

Digital technologies would bring interesting solutions in the marketing domain. E-commerce application is a digital tool increasingly used by consumers and firms (Sparkes & Thomas, 2001). International markets penetration of agro-food firms can be facilitated through adoption of this technology, especially for B2B or B2C transactions (Baourakis, Kourgiantakis, & Migdalas, 2002). Firms can build relationships through advertising with their customers like the patent related to interactive food packaging whose Nestec S.A. is the assignee. The packaging provides the consumer with an visual and/or tactile message before, during or after the consumption of the food product (US 6,525,660 B1, 2003).

Local food and short food channels are increasingly requested by consumers and farmers. The Associations for the Preservation of Smallholdings (AMAP in France) link spatially close consumers and producers in order to support competitiveness of smallholder farmers. This type of marketing innovation supplemented with digital features would satisfy new consumers' expectations towards food consumption and social interactions by reducing intermediaries' role.

In the short term, digitalization would spread across farms and industries of the food sector. Diffusion and adoption will be described by an S-shaped curve, where the laggards would implement the new digital products relatively well used in other sectors. Nowadays, the agricultural sector already uses such technologies, especially in big farms for economies of scale. In the medium term, firms' strategies would be questioned by digitalization. Disruptive changes would affect supply chains, especially in the frame of high competitiveness between firms and regions. Communication will be facilitated through the improvement of information flows between stakeholders of the supply chains like information on product quality, data on international standards, traceability (Food and Agriculture Organization of the United Nations, 2017). The professions would shift from crops' monitoring to technology monitoring. Acquiring knowledge on robotics, machinery, digitization would be a real asset and added value for being a farmer. Human capital investment, agricultural training and workshop given by advisers would change, although the proximity to consumers will continue to increase. Furthermore, digitization would modernise the Common Agricultural Policy, especially in terms of time and resource-consuming procedures. On-line applications for agricultural subsidies, audits and other bureaucratic operations could be simplified using digital tools (Kärner, 2017). This type of applications can efficiently facilitate and reduce the time allocated to administrative tasks, that farmers have to undertake.

To conclude, an innovative ecosystem based on interactions between SMEs, governments, researchers, extension agents, entrepreneurs and consumers would contribute to the sustainability and competitiveness of the agricultural sector. New technology applications in

adequacy to the real needs of stakeholders could be designed in this ecosystem (European Commission, 2017b).

6.2 Limitations

The dissertation focused on a small sector in a small-protected European country. This brought important methodological limitations. Firstly, agriculture and the primary sector is important for providing vital goods in the world, but is not the mainstream economic sector in Switzerland in terms of GDP and labour force employment. Fruit sector and apricot production in particular represents a peripheral sector. The monetary importance of the special crops (i.e. fruits, vegetables, viticulture and horticulture) increased compared to field crops (i.e. cereals, oleaginous, sugar beets and potatoes). The former represents 23% of the total production value in 2016 compared to 17% in 1990, while the latter decreased from 17% to 8% in the same period (Office Fédéral de la Statistique, 2017a). This implies a small number of firms constituting the production chain. Hence, professional farmers mainly diversify their farms with other crops (i.e. fruits, wine or vegetables). In this small sector, connections between stakeholders are mostly based on informal contacts through phone calls, emails, field visits for example. Almost every actor knows who is composing the network. Therefore, measuring innovation is challenging due to the poor occurrence of codified knowledge and innovation transfer.

Secondly, apricot is concentrated in one region of the country (95% of the total production). This facilitated data collection for the research projects. However, this also does not allow comparison between different climatic or environmental conditions. In this setting, statistics were hardly feasible with a small pool of firms in the dataset.

Finally, the most known apricot processed product is an alcohol that is emblematic of the region and benefits a PDO label (i.e. Abricotine AOP). Other products like jams, dried fruits or juices are processed in the region. Nonetheless, the main part of the production is consumed as table fruits, produced with traditional methods. Innovation is mostly related to breeding and new varieties to answer production requirements like irrigation adaptation due to climate change, increasing pests and diseases' pressure, evolving consumers' expectations (e.g. taste, colour, size, maturity). Nevertheless, innovation deals with different aspects of the supply chain; product through breeding for fresh fruits, process for transformed fruits, organisational as it was analysed through collaborations and trademark development and management, and marketing through trademark promotion, producers' improvements like website or direct sales. To conclude, capturing the essence and diversity of the domain, different approaches are necessary based on several levels of analysis in order to involve all relevant stakeholders.

6.3 Future research

Apart from the theoretical implications, future research approaches are exposed below.

Chapter 3 highlighted the divergence between the relations that practitioners of the stone fruit sector established with the national research centre and the local university. This discrepancy is related to the strategic mandates and targets of each institution. Implying the diversity of skilled labour force and their experiences would ease the creation of efficient interactions that can provide different types of innovations. Furthermore, market structure determines the productive nature of an interaction. This should be analysed in further research by identifying criteria that can strengthen or hinder the establishment of stakeholders' links to track innovation. A longitudinal analysis would highlight the sector dynamism and relations with other sectors, bringing useful information for the understanding of the network.

In what relates to Chapter 4, we recommend three main future research avenues. First, investigating specific bibliometric methods or databases to better target local requirements. Then, research activities could foster the filling of the identified gaps (i.e. generic knowledge generation, specific knowledge generation and innovation implementation) by focusing on specific topics highlighted by the stakeholders and supporting local projects aiming at increasing innovation adoption. Last, extending interactions between stakeholders by using external sources, financial and technical support may ease the connections to be established and knowledge to be efficiently transferred. Involving all stakeholders earlier in the innovation process can facilitate this expected connection. A participative approach would ensure that all stakeholders would be aware of the needs and the context of researchers and small firms.

In Chapter 5, small firms' expectations and challenges should be investigated to provide and propose them with suitable innovative solutions. Interactions between stakeholders constituting vertical and horizontal networks should create adequate organizational or marketing innovations. Segmentation is a solution to market failures. Segmentation can be done with origin and territorial differentiation, PGI/PDO and technical aspects of products. The establishment of PDO and PGI products was an opportunity to create new market segment based on premium and superior quality food products (Chappuis et al., 2002). Sectors are concerned by market exports but could be investigated for regional emblematic product like Swiss apricot.

Furthermore, we encourage scholars to investigating related domains in order to understand and potentially observe cross-sectoral transfer of innovations and knowledge, to go deeper in the understanding of what constitutes the informal collaborations and to conduct similar investigations in neighbouring countries, countries with similar settings or countries benefiting higher production, sales, innovations and resources. Informal interactions occurring in the network could be orientated towards different type of innovations: products, marketing,

processes or organisations. These empirical studies should analyse the impact of domain structure on the innovation capacity and capabilities of firms. Extending insights from related sectors would bring substantial evidences to design research and practical orientations that drive innovation creation.

We urge academics in the field of food and agronomic related areas to focus on minor crops, specialized production systems depending on agro-climatic conditions in order to target challenges that small firm have to cope with. Local and regional research centres, financial and political support actors should focus on leveraging supply chain actors like farmers to foster their innovation entrepreneurship.

The transposition of the findings of this dissertation to other countries should be challenging, especially because of the Agricultural Knowledge System and institutional research framework are different in other national settings. The support dedicated to the research construction lies on agricultural technical advisors and Chambers of Agriculture in France, where innovation support and diffusion is provided for example. The development of an innovative and competitive agribusiness is performed on the one hand by traditional agricultural system like described above and on the other hand by alternative supply chains that may not use the same patterns and features to create and implement innovations. The dissertation exposes two main paradigms that are co-existing in the agricultural sector: conventional agriculture that uses high technology, scientific breeding, modern technics and mass distribution of food products; and the traditional agriculture dominated by a reinvention of local knowledge, consumers' aspirations for a return to nature and provision of more local food through short food chains.

The territory became a crucial factor for interactions between actors spatially close. Collective projects initiated by different actors on a territorial network nature rely on environmental, societal and contextual stakes (Torre & Zimmermann, 2015). The linear diffusionist method of knowledge between research actors and farmers is being replaced in the traditional agriculture by a co-production of knowledge and reinvention of local knowledge. An hybridization of secular profane coming from traditions and scholar knowledge coming from modernization (Deléage, 2010). This local knowledge embedded in farmers, the local know-how and the local practices are becoming essential patrimonial resources adding value in collective territorial projects that are initiated (Saidi, 2011). The case studied in this dissertation demonstrated the use of both models in Switzerland. Farmers involved in the traditional supply chain of apricots are using scientific knowledge transferred by researchers and advisors this knowledge is popularized and diffused to different audiences. Simultaneously, local knowledge is used to generate and implement innovations and technics that producers need in specific and idiosyncratic patterns.

Finally, short food channels in Europe are increasingly developed. It is an approach of the Common Agricultural Policy to improve competitiveness and sustainability of the European

agro-food system. The European project SMARTCHAIN on which I will work as a post-doc, will analyse different factors (e.g. technological, social, regulatory, economic) related to short food channels to determine stakeholders' interactions in the value chain. Existing innovations will be classified and prioritized, inter alia, digital innovations (e.g. open data, data analytics, e-commerce) and technological innovations (e.g. smart farming methods, sensors, position systems, robotics). Key parameters that impact the production of sustainable food and rural development across regions in the EU will be identified.

Appendices

A.1 Search formulas respectively used in Web of Science, Scopus and OVID databases on the topic of *Monilia*

	FRUITS	***PRUNUS***	**APRICOT**	***ARMENIACA***
Keywords WoS	TS=(moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND TS=(fruit*)	TS=(moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND TS=(Prunus)	TS=(moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND TS=(apricot*)	TS=(moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND TS=(armeniaca)
Keywords Scopus	TITLE-ABS-KEY((moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND (fruit*))	TITLE-ABS-KEY((moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND (Prunus))	TITLE-ABS-KEY((moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND (apricot*))	TITLE-ABS-KEY((moniliose OR monilia OR monilinia OR monilinia laxa OR monilinia fructicola OR monilia mumecola OR moniliasis OR candidiasis OR yeast infection OR brown rot) AND (armeniaca))
Keywords OVID	((moniliose or monilia or monilinia or monilinia laxa or monilinia fructicola or monilia mumecola or moniliasis or candidiasis or yeast infection or brown rot) and fruit*)	((moniliose or monilia or monilinia or monilinia laxa or monilinia fructicola or monilia mumecola or moniliasis or candidiasis or yeast infection or brown rot) and Prunus)	((moniliose or monilia or monilinia or monilinia laxa or monilinia fructicola or monilia mumecola or moniliasis or candidiasis or yeast infection or brown rot) and apricot*)	((moniliose or monilia or monilinia or monilinia laxa or monilinia fructicola or monilia mumecola or moniliasis or candidiasis or yeast infection or brown rot) and armeniaca)

A.2 Search formulas respectively used in Web of Science, Scopus and OVID databases on the topic of bacterial blight

	FRUITS	***PRUNUS***	**APRICOT**	***ARMENIACA***
Keywords WoS	TS=(bacterial blight OR bacterial canker) AND TS=(fruit*)	TS=(bacterial blight OR bacterial canker) AND TS=(Prunus)	TS=(bacterial blight OR bacterial canker) AND TS=(apricot*)	TS=(bacterial blight OR bacterial canker) AND TS=(armeniaca)
Keywords Scopus	TITLE-ABS-KEY((bacterial blight OR bacterial canker) AND fruit*)	TITLE-ABS-KEY((bacterial blight OR bacterial canker) AND Prunus)	TITLE-ABS-KEY((bacterial blight OR bacterial canker) AND apricot*)	TITLE-ABS-KEY((bacterial blight OR bacterial canker) AND armeniaca)
Keywords OVID	((bacterial blight OR bacterial canker) AND fruit*)	((bacterial blight OR bacterial canker) AND Prunus)	((bacterial blight OR bacterial canker) AND apricot*)	((bacterial blight OR bacterial canker) AND armeniaca)

A.3 Search formulas respectively used in Web of Science, Scopus and OVID databases on the topic of European Stone Yellow Fruit

	FRUITS	***PRUNUS***	**APRICOT**	***ARMENIACA***
Keywords WoS	TS=("EFSY" OR "ACLR" OR phytoplasma) AND TS=(fruit*))	TS=("EFSY" OR "ACLR" OR phytoplasma) AND TS=(Prunus))	TS=("EFSY" OR "ACLR" OR phytoplasma) AND TS=(apricot*)	TS=("EFSY" OR "ACLR" OR phytoplasma) AND TS=(armeniaca)
Keywords Scopus	TITLE-ABS-KEY("EFSY" OR "ACLR" OR phytoplasma) AND TITLE-ABS-KEY(fruit*)	TITLE-ABS-KEY(phytoplasma AND Prunus)	TITLE-ABS-KEY("EFSY" OR "ACLR" OR phytoplasma) AND TITLE-ABS-KEY(apricot*)	TITLE-ABS-KEY("EFSY" OR "ACLR" OR phytoplasma) AND TITLE-ABS-KEY(armeniaca)
Keywords OVID	("ESFY" OR "ACLR" OR phytoplasma) AND (fruit*)	("ESFY" OR "ACLR" OR phytoplasma) AND (Prunus)	("ESFY" OR "ACLR" OR phytoplasma) AND (apricot*)	("ESFY" OR "ACLR" OR phytoplasma) AND (armeniaca)

A.4 Search formulas respectively used in Web of Science, Scopus and OVID databases on the topic of fruit cracking

	FRUITS	***PRUNUS***	**APRICOT**	***ARMENIACA***
Keywords WoS	TS=(fruit* AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	: TS=(Prunus AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	TS=(apricot* AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	TS=(armeniaca AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*)))
Keywords Scopus	TITLE-ABS-KEY(fruit* AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	TITLE-ABS-KEY(Prunus AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	TITLE-ABS-KEY(apricot* AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	TITLE-ABS-KEY(armeniaca AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))
Keywords OVID	(fruit* AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	(Prunus AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	(apricot* AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))	(armeniaca AND (crack* OR explo* OR burst OR chop OR skin damage* OR break* OR cleave OR fractur* OR split*))

A.5 Search formulas respectively used in Web of Science, Scopus and OVID databases on the topic of post-harvest behaviour

	FRUITS	***PRUNUS***	**APRICOT**	***ARMENIACA***
Keywords WoS	TS=((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (fruit*))	TS=((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (Prunus))	TS=((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (apricot*))	TS=((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (armeniaca))
Keywords Scopus	TITLE-ABS-KEY((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (fruit*))	TITLE-ABS-KEY((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (Prunus))	TITLE-ABS-KEY((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (apricot*))	TITLE-ABS-KEY((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (armeniaca))
Keywords OVID	((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (fruit*))	((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (Prunus))	((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (apricot*))	((postharvest OR post-harvest) AND (behavior OR ripe* OR matur*) AND (armeniaca))

A.6 Examples of IPC and CPC codes used for the patent search sold[10]

IPC	Description
B07C5/36	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting apparatus characterised by the means used for distribution
A01D46/26	Picking of fruits, vegetables, hops, or the like, Devices for shaking trees or shrubs
B07C5/342	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to other particular properties, according to optical properties, e.g. colour
G01B11/02	Measuring arrangements characterised by the use of optical means, for measuring length, width, or thickness
B07C5/34	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to other particular properties
B07C5/02	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Measures preceding sorting, e.g. arranging articles in a stream, orientating
A01H5/08	Flowering plants, i.e. angiosperms, Fruits
G01N33/02	Investigating or analysing materials by specific methods not covered by groups
B07C5/00	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature
B65G47/46	Article or material-handling devices associated with conveyers, Devices for discharging articles or materials from conveyers, with distribution, e.g. automatically, to desired points
B07C5/38	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting apparatus characterised by the means used for distribution, Collecting or arranging articles in groups
A01D46/00	Picking of fruits, vegetables, hops, or the like
G01N21/85	Investigating or analysing materials by the use of optical means, i.e. using infra-red, visible, or ultra-violet light, Systems specially adapted for particular applications, Investigating moving fluids or granular solids
B07C5/10	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to size, measured by light-responsive means
G01B11/00	Measuring arrangements characterised by the use of optical means
G01N21/35	Investigating or analysing materials by the use of optical means, i.e. using infra-red, visible, or ultra-violet light, Systems in which incident light is modified in accordance with the properties of the material investigated, Colour, Investigating relative effect of material at wavelengths characteristic of specific elements or molecules, e.g. atomic absorption spectrometry, using infra-red light
A01D46/24	Picking of fruits, vegetables, hops, or the like, Devices for picking apples or like fruit
B07C5/16	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to weight
B07C5/344	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to other particular properties, according to electric or electromagnetic properties

[10] (European Patent Office, 2017)

IPC	Description
B65G57/30	Stacking of articles, by adding to the bottom of the stack
B07C5/18	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to weight, using a single stationary weighing mechanism
A01H5/00	Flowering plants, i.e. angiosperms
G01B11/24	Measuring arrangements characterised by the use of optical means, for measuring contours or curvatures
A01D46/28	Picking of fruits, vegetables, hops, or the like, Vintaging machines, i.e. grape harvesting machines
B65B25/04	Packaging other articles presenting special problems, Packaging agricultural or horticultural products, Packaging fruit or vegetables
G01N21/89	Investigating or analysing materials by the use of optical means, i.e. using infra-red, visible, or ultra-violet light, Systems specially adapted for particular applications, Investigating the presence of flaws, defects or contamination, in moving material, e.g. paper, textiles
B07C5/04	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature, Sorting according to size
B65G61/00	Use of pick-up or transfer devices or of manipulators for stacking or de-stacking articles not otherwise provided for
B07B13/00	Grading or sorting solid materials by dry methods, not otherwise provided for
B65G47/52	Article or material-handling devices associated with conveyers, Devices for transferring articles or materials between conveyers, i.e. discharging or feeding devices
B65G57/32	Stacking of articles, characterised by stacking during transit
B65B35/50	Supplying, feeding, arranging, or orientating articles to be packaged, Arranging and feeding articles in groups, Stacking one article, or group of articles, upon another before packaging
B65G47/82	Article or material-handling devices associated with conveyers, Feeding, transfer, or discharging devices of particular kinds or types, Rotary or reciprocating members for direct action on articles or materials, e.g. pushers, rakes, shovels
CPC codes	**Description**
A23N3/00	Machines for coring or stoning fruit, characterised by their feeding device
B07C5/3422	Sorting according to a characteristic or feature of the articles or material being sorted, e.g. by control effected by devices which detect or measure such characteristic or feature; Sorting by manually actuated devices, e.g. switches - {using video scanning devices, e.g. TV cameras}
B65G2201/0211	Transport or storage devices, e.g. conveyors for loading or tipping; shop conveyor systems; pneumatic; tube conveyors - Indexing codes relating to handling devices, e.g. conveyors, characterised by the type of product or load being conveyed or handled - Fruits and vegetables
B65G2203/041	Storage devices - Indexing code relating to control or detection of the articles or the load carriers during conveying - Camera
B65G47/24	Article or material handling devices associated with conveyors; Methods employing such devices - orientating the articles
G01N21/314	Investigating or analysing materials by the use of optical means, i.e. using infra-red, visible or ultra-violet light -{with comparison of measurements at specific and non-specific wavelengths
G01N21/474	Investigating or analysing materials by the use of optical means, i.e. using infra-red, visible or ultra-violet light -{Details of optical heads therefor, e.g. using optical fibres}
G01N21/49	Investigating or analysing materials by the use of optical means, i.e. using infra-red, visible or ultra-violet light - within a body or fluid

A.7 Logo of trademark Marque Valais[11]

A.8 Apricots sold through direct sale via Marque Valais kiosk[12]

A.9 Trademarks and innovation categories based on exclusive rights and quality signal criteria[13]

		Exclusive rights	
		Weak entry barriers	Strong entry barriers
Quality signal	Non-novel	**Box 1** The trademark protects a non-novel product, process or service and is ineffective as an entry barrier, thereby generating low short-term and long-term profits. Consumers pay a relatively low price for a non-novel product	**Box 3** The trademark is effective as an entry barrier, but protects a non-novel product, process or service, generating high short-term but low long-term profits. Consumers pay a relatively high price for a non-novel product
	Novel	**Box 2** The trademark protects a novel product; process or service but is ineffective as an entry barrier, thereby generating high short-term but low long-term profits (since the invention will be quickly imitated). Consumers pay a relatively low price for a novel product	**Box 4** The trademark protects a non-novel product, process or service and is effective as an entry barrier, thereby generating high profits both in the short-term and the long-term Consumers pay a relatively high price for a novel product

[11] (Valais Wallis Promotion, 2018b)
[12] (Valais Wallis Promotion, 2018a)
[13] (Davis, 2010)

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Glossary

Bibliometric: Statistical analysis of written publications (e.g. articles and books). The purpose is to assess publications or authors based on different criteria. Moreover, it aims to analyse knowledge structure, state of the art of scientific fields and technology trends.

Informal collaboration: Relation between two persons where most of the exchanged information and material are based on tacit interactions.

Digitalization or digitization: Process aiming to transform material and immaterial goods in computing code to increase their efficiency and allow storage. Digital technologies are used to support changes targeted by the firms (e.g. organisational improvements).

Generic knowledge gap: Highlighted differences related to fundamental knowledge that is not context-dependent.

Interactive production: Interaction between two actors that produces outputs like an innovative product.

Inventory of needs: In the TRAFOON project, needs of small firms were collected through questionnaires about innovation performance and technological needs of the companies.

Knowledge transfer: Mechanism of sharing knowledge and information from one entity to another entity. It could be from a part of an organisation to another part; from downstream actors of a supply chain to upstream actors of the same chain. The transmitted knowledge has to be available, understandable and usable for the receiver. This aspect is increasingly important, as a great part is embedded in organizations and individuals, i.e. tacit.

Multi-actor approach: Method used in a study where different actors of a defined network are participating in, in order to gather different perspectives of the same issue.

Multi-stakeholders workshops: The aim of the workshops is to get all the different parties around the table (e.g. consortium partners and representatives of stakeholders among a European project). Stakeholders discuss any topic of concern, take decisions

and design an action plan (e.g. development of suitable knowledge transfer activities in the apricot value chain).

Specific knowledge gap: Highlighted differences related to knowledge that is context-dependent. Specificities of the knowledge arise from the specifities of the concerned sector (e.g. sector of stone fruits).

Traditional food production: Production of traditional food products that are raw materials processed with specific methods in a defined area. In this dissertation, apricot product has been identified as a traditional food thanks to its importance at regional and national level in terms of production and consumption.

Value chain: “Required activities to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use”.

CURRICULUM VITAE

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RESEARCH INTERESTS

Knowledge transfer in agricultural networks with a focus on public-private collaborations that add value for trade and innovation capacity development of small firms for competitiveness

EDUCATION

2014 – Now **PhD in Economics and Management of Innovation**
Ecole Polytechnique Fédérale de Lausanne – Lausanne, Switzerland

- Doctoral researcher in the Chair of Economics and Management of Innovation
- Dissertation topic: "Innovation Capacity of Small Firms in Agriculture"

2012-2013 **Master of Innovations in Agricultural and Food Systems of the World (ISAM-IPAD)**
Montpellier SupAgro – Montpellier, France

- Included modules in economics, global food governance, food resilience
- Dissertation topic: Characterization of innovations of the Swiss plant production

2006-2011 **Engineer Research and Development in Food**
Agrocampus Ouest – Rennes, France

- Included modules in marketing, microeconomics and macroeconomics, management and statistics
- Project: Development of new flavouring for cheese products and implementation on the market

PROFESSIONAL EXPERIENCE

2016-2017 **Seminar series organizer**
Ecole Polytechnique Fédérale de Lausanne – Lausanne, Switzerland

2014-Now **Research assistant**
Ecole Polytechnique Fédérale de Lausanne – Lausanne, Switzerland

- Chair of Economics and Management of Innovation (CEMI)
- Supervisor: Prof. Dominique Foray

2013 **Intern, Swiss centre for agricultural research AGROSCOPE**
Nyon, Switzerland, 4 months

- Research project on the development of criteria for the characterization of innovations (type, impacts on sustainability, adoption rate, etc.) for farmers

PUBLICATIONS

Aouinaït C., Lepori B., Christen D., Foray D. 2018. Productive interactions in a low technology-intensive sector: Insights from Switzerland (under review for Journal of Rural Studies)

Aouinaït C., Christen D., Kosinska A., Andlauer W., Carlen C. 2018. Are innovation needs of low-technological Small and Medium-sized Enterprises in line with knowledge production by research institutions? (under review for Journal of Innovation Economics & Management)

Aouinaït C., Jeangros B., Nassar V., Crole-Rees A. 2014. Innovations in crop production: the example of HOLL rapeseed. Recherche Agronomique Suisse 5 (3), 104-111.

COURSES AND CONFERENCES

Courses attended

- DRUID PhD Course, University of Southern Denmark
- Science and Engineering Teaching and Learning, EPFL
- Social and Economic Networks, UNIL
- Econometrics, UNIL
- Econometrics: data analysis and empirical methods, EPFL
- Ethnographic methods, Università della Svizzera italiana, Lugano
- Publishing in Management, Technology and Innovation, EPFL
- Economics of Innovation and Technological Change, EPFL
- Readings in Organization Economics, EPFL
- Qualitative Research Methods, EPFL
- Research Methods, EPFL

Conferences attended

- DRUID (Danish Research Unit for Industrial Dynamics) Academy Conference, Odense, Denmark, 2017
- WASET (World Academy of Science, Engineering and Technology). Rio de Janeiro, Brazil, 2016
- STI (Science and Technology Indicators) 21st Annual Conference. Valence, Spain, 2016
- World Congress of Food Science and Technology (IUFOST). Montreal, Canada, 2015

TEACHING EXPERIENCE

2014-Now **Teaching assistant**
Ecole Polytechnique Fédérale de Lausanne – Lausanne, Switzerland

- Massive Open Online Course on Smart Specialisation, Prof. Foray (EPFL)
- Organizational behaviour, Prof. Bubenzer (EPFL)
- Information technology and digital strategy, Prof. Viscusi (EPFL)

PROFESSIONAL SERVICES

Reviewer for *Research Evaluation* and *Journal of Innovation Economics & Management*

COMPUTER SKILLS

Word, Excel, Power point
Research tools: Zotero, Mendeley
Social Network Analysis: Tulip
Statistics software: R Stata, SPSS

LANGUAGES

French	Mother tongue
English	Fluent
Italian	Advanced
Spanish	Intermediate
German	Basic

INTERESTS

Swimming, running, traveling, cooking and reading