Perceived Technological Regimes: An Empirical Analysis of the Apulian Wine Industry

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Abstract

Technological regimes define the technological environment in which innovative and learning activities take place within each sector of the economy. However, in our view technological regimes must be interpreted and elaborated by each organisation operating in a specific sector in order to be rationally implemented, thus turning into *perceived technological regimes*. We test this argument on a sample of wine companies in the Apulia region (Italy). We find empirical evidence that the perceived technological regimes exist and that firms' perceptions tend to vary uniformly across different wine technologies. In addition, we find evidence that different firms' characteristics have a strong impact on firms' perceptions both at the aggregate level and when distinct perception groups are identified.

Keywords: *Technological regime; SMEs; Wine industry*

1 Introduction

Innovation is widely recognised as being at the core of companies' competitiveness and growth. Business success in the market depends crucially on the ability to develop, acquire and recombine knowledge from different sources and use it to develop new products and processes. Firms no longer rely on their internal knowledge resources, but need to find efficient ways to manage a complex set of knowledge inflows and outflows within the boundaries of their organisation (Chesbrough et al., 2006; Amesse and Cohendet, 2001).

The ability of firms to innovate, compete and thrive is often crucially determined by their success in dealing with the technological environment in which they work. However, these dynamics are so complex and uncertain that various early scientific attempts to systematise them have reached a limited applicability. In this respect, the technological regime approach (Nelson and Winter, 1982; Winter, 1984) seems to take a clear step forward to overcome these limitations. Assuming that economic agents are provided with bounded rationality, Nelson and Winter claimed that firms evolve through local search and that therefore a knowledge-based theory of production could explain why organisations may follow different strategies and innovation patterns. This body of research dealt with the effect that the technological characteristics of the sector could have on the knowledge building and innovative dynamics of the firms belonging to that very sector.

Among the contributions of those scholars that integrated the technological regime model (Dosi, 1982), the characterisation introduced by Malerba and Orsenigo (1993, 1996, 1997) and Breschi et al. (2000) is particularly relevant since it provides a more pragmatic and operational emphasis to the concept of technological regime. There is empirical evidence that technological regimes determine the pattern of innovative activity (Breschi et al., 2000), varying across different industrial sectors but being invariant across different geographical contexts, at least when they are not mediated by the specificities of the national and local systems of innovations (Malerba and Orsenigo, 2000). Indeed, there is extensive empirical evidence that industries differ in terms of frequency and intensity of innovation activity. These evident and significant intersectoral differences in firms' innovative dynamics have stimulated the emersion of a rich stream of economic literature aiming at studying the common and uncommon characteristics of different economic sectors, explaining the distinct patterns of innovative activity.

In this paper we introduce an important revision to the technological regime model, stressing the relevance of the process of firms' adaptation to a chosen regime. We argue that the technological regimes as described by the literature (i.e. defined by the characteristic of the technology and invariant within the same sector) must be interpreted and elaborated by each organisation operating in a specific sector in order to be rationally implemented, thus turning into a *perceived technological regime*.

The purpose of this paper is then to introduce the notion of *perceived technological regimes* and to test it on empirical grounds. We aim at integrating the theory of technological regimes by including the possibility that the technological environment is differently interpreted and elaborated by each firm operating in a given sector. In this process of adaptation, which can determine a substantial cognitive distance among firms, absorptive capacities play a main role. We argue that different firms operating in a sector perceive distinct technological regimes differently and test empirically whether the difference in firms' opinion about each fundamental dimension of the regimes is statistically significant. In addition, we test whether this hypothetical variability is either casual or determined by some of the firms' characteristics, such as the age or the size of the firm, the relationships with customers and suppliers etc.

The paper is organised as follows. Section 2 sets the theoretical background to technological regimes. Section 3 presents our empirical results: In this section we apply descriptive statistics and regression models to analyse the data on wine companies in Apulia. Section 4 discusses the results and their implications for policy.

2 Theoretical Background

2.1 The Relevance of Technological Regimes in Innovation

The concept of technological regime defines the technological environment in which innovative and learning activities take place within each sector of the economy. The studies on technological regimes build on the key argument that firms differ in their innovation behaviour. Firms are characterised by bounded rationality and tend to evolve through local search. This dynamic can explain why even firms operating in the same environment can adopt different strategies, if the context in which they interact is complex and uncertain enough. In particular, in a rugged environment (Levinthal, 1997) the peculiar capabilities and research efforts of firms might induce them to follow very different paths and finally find distinct local optima. This happens because firms are not aware of all the possible choices and results; instead they deal with a range of satisfactory options (Simon, 1955).

The notion of technological regime can be ascribed to Nelson and Winter (1982) and Winter (1984), that attribute to the concept primarily a cognitive meaning, by referring to the research heuristics of engineers in an industry in order to determine "what is feasible or at least worth attempting" (Nelson and Winter, 1982:258). More generally, a technological regime refers to the nature of technology with respect to a knowledge-based theory of production in which innovation is intended as a problem-solving activity drawing upon the knowledge base that is embodied in routines. In addition, Nelson and Winter underline that a technological regime defines the technological environment in which firms' innovative activity takes place and that, in each sector of the economy, the characteristics of the technology impact on the orientation and on the intensity of knowledge building and learning processes of the involved economic agents.

Dosi (1982) provided another fundamental contribution to definition of technological regimes introducing the concepts of technological paradigms and technological trajectories in order to allow research to go beyond the interpretations of technological change based on demand-pull and technology-push theories. According to the author, a technological paradigm is a "model and a pattern of solution of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies" (Dosi, 1982:152). In other words, a technological paradigm refers to the concept of progress by including prescriptions on the directions of technological change that should be either pursued or neglected. The technological paradigm shows a strong analogy with the definition of a scientific paradigm, which in turn defines the pattern of enquiry, the tasks, the procedures and the problems to be addressed. A technological trajectory is instead characterised as a "pattern of normal problem solving activity (i.e. progress) on the grounds of a technological paradigm" (Dosi, 1982:152), which is the pattern of implementation of concrete solutions based on a paradigm.

The definitions of technological regime by Nelson and Winter and that of technological paradigm by Dosi show a strong and prevailing theoretical nature that hinder their applicability and verification on empirical grounds. Malerba and Orsenigo (1993, 1996, 1997) and Breschi et al. (2000) redefined the notion of technological regimes in a more pragmatic and operational way, more easily applied and tested on empirical grounds. According to these contributions, a technological regime can be identified as a particular combination of some fundamental properties of technology, such as:

- Opportunity conditions refer to the likelihood of successful innovation for any given amount of money invested in innovation activities.
- Appropriability conditions indicate the possibilities of protecting innovations from imitation and of reaping profits from innovative activities.
- Cumulativeness conditions. Cumulativeness reflects the extent to which today's technological innovation depends on past innovation and current innovators are likely to be innovative in the future on the basis of specific trajectories and technologies.
- The knowledge base relates to the nature of the knowledge that lies at the basis of firms' innovative initiatives.

In conclusion, technological regimes suggest the basic guidelines to identify and distinguish the relevant technology strategies and types of organisations of firms. In this regard, Malerba and Orsenigo (1993) claim that, on a general basis, the viability and the effectiveness of these strategies and types of organisations should be favoured by high levels of pervasiveness of technological opportunities, elevated degrees of cumulativeness, low degrees of appropriability and a complex knowledge base.

Extensive literature has provided empirical evidence of the pervasiveness of the notion of technological regime in many respects. Technological regimes may: explain the existence of *sectorial differences* in terms of firms' competitiveness, intensity and characteristics of research and innovation activity (Malerba and Orsenigo, 1997; Crespi and Katz, 1999) and productivity (Castellacci, 2007; Castellacci and Zheng, 2010; van Dijk, 2000; Kim and Lee, 2003); determine Firms' *structural and dynamic properties* (van Dijk, 2000) expressed in terms of turbulence or stability in firms' churn rate (Audretsch, 1997; Lin and Huang, 2008); influence *market structure*, ease of entry in the market, and frequency and type of mergers and acquisitions (Damiani and Pompei, 2008; Kim and Lee, 2011); drive *international technological performance* (Malerba and Orsenigo, 1995, 1996; Malerba and Montobbio, 2003) competitiveness and trade dynamics (Laursen, 1999; Laursen and Meliciani, 2002; Lee and Lim, 2001; Park and Lee, 2006). In sum, studies on technological regimes highlight that technological change in each economic sector depends to a great extent on the characteristics defining the technological environment in which learning activities take place (Castellacci, 2007). Technological regimes determine the pattern of innovative activity of each sector, basically varying across sectors but they tend to be invariant across space, for instance within firms in the same industry but located in different countries. However, little is known about the firm-level process of adaptation of technologies. Indeed, while the technological regime model defines well the pervasiveness of homogeneous dynamics in different sectors, it does not explain equally well how firms adapt to a specific regime. After all, Dosi himself in his 1982 seminal paper stressed that: "…a 'disembodied' part of the technology consists of particular expertise, experience of past attempts and past technology solutions, together with the knowledge and the achievements of the 'state of the art'. Technology in this view includes the 'perception' of a limited set of possible technological alternatives and of notional future developments" (Dosi, 1982:152).

In our view, successive developments in the technological regime literature fail to investigate this 'perceptive' dimension of a firm's decision to comply with a given regime and its determinants. Starting from this gap in the literature, in this paper we acknowledge that technological regimes drive a number of aspects of industrial change and yet we argue that there are a number of factors that influence how a firm 'embraces' a technology and how it is adapted to the firm.

2.2 From Technological Regimes to Perceived Technological Regimes

The sectorial system of innovation framework (Breschi and Malerba, 1996; Malerba, 2002; 2005) highlights that, in addition to the characteristics of technology and of the learning process, other variables and trends have to be taken into account to fully explain the pattern of innovation of a sector. In addition, some authors such as Pender (2010) and Leiponen and Drejer (2007) argue that heterogeneous patterns of innovation characterize many industries, thus suggesting that technological regimes can even vary within the same sector.

In this paper we acknowledge the fundamental properties of technological regimes, and their effects on the sectorial patterns of innovation, focusing on the analysis and measurement of technological regimes in a sector, with the aim of integrating their definition and characterisation. In particular, the argument brought forward in this paper is that technological regimes as defined in the literature (i.e. defined by the characteristic of the technology and invariant within the same sector) have to be *interpreted* and *elaborated* by organisations operating in a given sector. This implies that the technology is "adapted" to the firm and this process of adaptation can be affected by substantial cognitive distance between firms and therefore by the absorptive capacity of the organisations involved.

With interpretation we mean "the process of translating [...] events, of developing models for understanding, of bringing out meaning, and of assembling conceptual schemes" (Daft and Weick, 1984:286), giving meaning to information before the organisation starts the learning process or take action. In other words, through the interpretation process, firms try to understand what they have done so far, in terms of technological posture, and figure out what they should do in the future. The issue of interpretation assumes particular importance in relation to the degree of perception of specific technological regimes, since the former can be influenced by different effects such as the characteristics of the environment in which the firm operates, the previous experience of the firm, the way in which the firm gained experience and the type of problem it would like to solve. As a consequence, one could expect that this process of interpretation could vary from firm to firm, thus influencing in different ways and to different extents their perceptions, contributing to create their own perceived technological regimes.[1]

Another fundamental step for the creation of the perceived technological regimes is the elaboration of information. The concept of elaboration used in this context derives from the notion of sensemaking as defined by Weick (1988, 1993, 1995) and Weick at al. (2005). Sensemaking can be defined as the process of giving meaning to experience and creating shared awareness and understanding or as a way of creating a shared understanding that is plausible enough to move toward action (Weick et al., 2005). Interpretation is a component of sensemaking since it refers to the effort of understanding something that already exists, without creating anything new. Some of the fundamental properties of sensemaking, as defined by Weick himself (1995), can be particularly useful in explaining the differences in perceived technological regimes among firms. First, sensemaking is grounded in identity construction; as a consequence, the perception of the sensemaker about who he is and is becoming has a strong influence on his interpretation and action behaviors. In the context of perceived technological regimes, the identity construction principle seems to confirm that different firms, with distinct backgrounds and competencies, will be likely to differently interpret the technological regimes of their sector. In addition, sensemaking is based on plausibility rather than on accuracy. This means that the understanding of a phenomenon and taking action may be based more on intuition and perception than on the discovery of the specific elements of the problem, which is precisely the concept that the perceived technological regimes notion introduces. Finally, sense-making enacts sensible environments, since the particular ways in which organisations interpret the environment lead them to undertake specific actions that in turn will shape their environment. Similarly,

[1] Daft and Weick (1984) highlight two key dimensions that determine the differences in interpretation among organisations: the extent to which each organisation believes that the environment can be analysed and their decision to actively intrude into the environment.

the innovative behaviours of different firms in a sector both reflect their perception of the technological regime and tend to determine and strengthen it. In this respect, the perceived technological regimes tend to have a self-fulfilling effect.

The existence of different perceived technological regimes in one sector can be traced to the existence of a certain degree of cognitive distance (Nooteboom 1999, 2000; Nooteboom et al., 2007) among firms. The diversity in the knowledge and learning behaviors are in turn determined by the paths and the environment in which the organisations have developed and by their different capability to understand, evaluate and interpret the problems and the situations that they have to face. In line with the resource-based view of the firm (Penrose, 1959), which emphasizes the resource heterogeneity as a fundamental source of performance differences among firms, cognitive distance is defined as a difference in "a broad range of mental activity, including proprioception, perception, sense making, categorisation, inference, value judgments, emotions, and feelings, which all build on each other" (Nooteboom et al., 2007:1017). Cognitive distance among firms will be generated as long as they have developed in different technological environments. The final effect of cognitive distance on the firms' innovative dynamics will be determined by the interaction among a series of factors, the most important of which is the absorptive capacity. This concept can be traced back to Cohen and Levinthal (1990), who defined it in terms of R&D accumulated in technological capital; however, the subsequent characterisation of absorptive capacity provided by Zahra and George (2002) can be particularly relevant in this context. The authors, defined the absorptive capacity as "a set of organisational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (Zahara and George, 2002:186) and introduced two main types of absorptive capacities, namely the potential and realised absorptive capacity.

First, cognitive distance can be considered as the direct consequence of the potential absorptive capacity (Zahra and George, 2002) of each firm in the considered sector. The potential absorptive capacity refers to the ability of firms of both acquiring and assimilating external knowledge and, for this reason, it directly builds on the Cohen and Levinthal's (1990) definition of absorptive capability. In particular the term acquisition deals with identifying and absorbing the knowledge that has been developed externally, which is crucial to the firm's operations, while assimilation refers to the presence and the adaptation of routines that allow the firm to understand and process the knowledge obtained from external sources. As a consequence, cognitive distance is related to the fact that in some cases the external R&D is the main source of knowledge needed to acquire or develop a technology. Since in such contexts firms are highly dependent on external dynamics and not all of them have access to the same sources and to the same extent, it is reasonable to infer that each of these firms will develop its own cognitive and learning processes, and that they will not necessarily be the same across these organisations.

Second, the cognitive distance may be the result of the existence of different realised absorptive capacities (Zahra and George, 2002) among the firms operating in a sector. The realised absorptive capacity derives from firms' capability to both transform and exploit the knowledge that they have acquired. In this respect, the word transformation refers to the creation and refinement of routines that can allow the firm to combine and integrate both current and newly assimilated knowledge. The term exploitation alludes to the routines that help the firm to leverage the existing competencies or to create new competencies that let it exploit knowledge. Therefore, firms can show a different ability to create and adjust their routines in order to combine new and assimilated knowledge and to apply it. A certain degree of cognitive distance could derive from these processes, since the various firms of a sector tend to learn differently and to develop new abilities while performing their own activities.

At the basis of the arguments in favour of the notion of perceived technological regimes, there are the reflections that technological regimes basically refer on the one hand to the characteristics of the technology in a sector and, on the other hand, to the way in which firms learn and build their own knowledge base. Now, if it is possible to admit that these cognitive processes can vary across firms, the logical consequence will be that they will also differentially affect the manner in which firms interpret the technology of their sector, since they indeed know and use different pieces of technology in their activities.

In other words, if we asked two different firms about the level of opportunity, appropriability, cumulativeness and the characteristics of the knowledge base linked to the technologies of a specific sector, it would be reasonable to expect different answers from the two firms, or at least not necessarily the same answers, because each of the two firms has a different perception of characteristics and the potential of the technologies of that sector. Similarly, there is the possibility that the two firms perceive the technological regime of their sector in a different way since, for example, they have different competences and knowledge about the possible application and the future development of the technologies. These examples respectively deal with the two possible cases of cognitive distance described above. In fact, in the first example the considered firms have developed distinct sets of knowledge, which could either derive from external R&D or internal R&D and learning processes, and which are linked to the different technologies they employ in their activities; in the second case the firms' activity is instead based on the same technologies, but these organisations are characterised by differential capabilities, which are linked to the way in which they apply their knowledge and build on it. On these grounds, we make the research hypothesis:

Hypothesis 1 – Firms show different perception relatively to the dimensions of technological regimes.

Hypothesis 2 – Perception is related to absorptive capacity variables, structural and market side variables of firms.

Those hypotheses allow the definition of a general model for the empirical application:

$$P_{i,d} = f_d\,(AC_i,\ Str_i,\ MS_i) \qquad \text{Eq. 1}$$

Where P expresses the level of perception; $i = 1,\dots, N$ indicates the dimensions of the technological regimes, respectively: opportunity, appropriability, cumulativeness and knowledge basis; $d = 1, \dots, D$ refers to each firm; the function f refers to a system of seemingly unrelated equations including the same set of independent variables and the various dimensions of technological regimes; *AC* refers to the descriptors of the absorptive capacity of the human resources of the firm; *Str* indicates the set of structural variables of the firm, such as economic performance, dimension, number of employees, etc.; *MS* refers to the market side variables, which could potentially include price of the final products, distance to the markets and extension of the market.

In our view, the definition of perceived technological regimes completes the technological regimes notion, making it more justifiable and comprehensible on empirical grounds, which often show a remarkable degree of heterogeneity in the innovative activity of firms belonging to the same sector. In addition, the specification of the effects of the cognitive distance at the basis of the differences in the perceived technological regimes makes it easier not only to verify the existence of different perceived technological regimes in an industry, but also to determine the firms‘ characteristics that determine them, as the next chapters will show.

3 Empirical Analysis

In order to prove the validity of the perceived technological regime notion, we set up an empirical experiment focused on the Apulian wine industry. This industry is particularly suitable to the analysis of firms’ perceptions as Apulian wine producers are typically small in size, hardly interact with other firms and depend on external R&D and technological progress to introduce major technological innovations.

In order to set up the experiment, a preliminary process of identification and analysis of the most valuable and promising technologies of the sector has been conducted. This was based on the review of relevant publications and journals that specialise in the food sector.

In addition, thanks to the advice and indications received from industry and academic experts, I have discussed and selected the most appropriate technologies to be tested in the experiment, on the basis of their use and their potential and future applications. Table 1 shows the selected technologies and includes a brief description of each of them.

Table 1 Technologies considered for the empirical analysis

TECHNOLOGY	DESCRIPTION
Innovative Wine Machines	High level of automatism. Reduction of energy consumption and optimization of specific phases of the wine making process such as: submerged cover fermentation, heated and refrigerated maceration, white-like red wine making, deferred maceration.
Biotechnologies applied to yeasts	Adding selected yeasts that empathize *terroir*, so local wine characteristics
Biosensors	Monitoring wine quality parameters on machineries during the wine making
Alternative wine making techniques	E.g. pre-fermentative chill maceration, through different chilling agents to increase the anthocyanin rate

In order to gather information on wineries’ perception of those technologies, we prepared a database of the Apulian wineries, consisting of a population of 205 enterprises, and we conducted a questionnaire survey of telephone interviews with firms between December 2011 and February 2012.

The questionnaire enquired about the respondents' perception about the benefits deriving from the implementation of each of the aforementioned technologies, about firms' collaboration with external agents and their major sources of information for the purpose of innovation. The questionnaire also collected some general information about the firms (employment, turnover, etc.) and their principal market of destination.

Table 2 gives a synthetic idea of the questionnaire and the corresponding variables for the analysis.

Table 2.
Variables considered for the analysis

Variables		Type	Information
Tech. Regimes Dimensions	Technological opportunity 1 (OPP1)	Level of agreement on a 5 point scale	Convenient for my firm to invest in this direction
	Technological opportunity 1 (OPP2)	Level of agreement on a 5 point scale	Investing in this direction opens up new possibilities to improve my product
	Appropriability conditions (APP)	Level of agreement on a 5 point scale	By investing in this direction my firm could reach a position that is hardly imitable by my competitors
	Cumulativeness conditions (CUM)	Level of agreement on a 5 point scale	This technology is consistent with the capacities, the knowledge and the tooling that are already available in my firm
	Basic knowledge (KBA)	Level of agreement on a 5 point scale	I think that my firm has the scientific knowledge which constitutes the foundation of this technology
	Applied knowledge (KAP)	Level of agreement on a 5 point scale	I think that my firm has the experience and the practical capabilities to correct apply this technology
Structural characteristics of the firm	Importance of the source of innovation	Level of agreement on a 5 point scale	University, other firms, consortiums, suppliers customers, wine makers
	Journals and Magazines as source of information	Frequency of consultation	Scientific journals, food and agriculture magazines, market specific magazines, wine specific magazines
	Years of the firm	Years	
	Involvement into a cooperative, producers association	Yes/No	
	Number of employees with college degree		Number of food technologists and agronomists Number of business administration staff
	Number of firms for which the winemaker works		
	Region where the wine maker comes from		
	R&D regularly conducted by the enterprise	Yes/No	
	% of revenues invested into R&D		

	Type of research activities		
	Does your firm collaborates with a consulting firm		
	Economic size of firm	Sales volume	Classes: 0-1 Mil. Euro, 1-3 Mil. Euro; 3-5 Mil. Euro; 5-10 Mil. Euro; 10-30 Mil. Euro; More than 30 Mil. Euro
	Hectoliters wine produced		
Market side variables	% of bulk wine		
	% of bottled wine		
	Price of the wine sold the most		
	Price of the most expensive wine		
	Presence of one or more wine into the wine guides	Yes/No	Veronelli, Gambero Rosso, Parker, Gazzetta del Mezzogiorno, etc.

Questionnaires were completed and sent back via email after a telephone contact. After a first round, other two telephone rounds for stimulating wineries to the survey participation has been conducted. The interviewer introduced the general scope of the research and encouraged company management representatives to fill in the questionnaire by presenting the opportunity to be part of a research with relevant implications relative to the innovation process and financing[2]. A first explorative analysis has been conducted. Descriptive statistics are presented in table 3.

[2] Therefore, participation to the survey could also be intended as the winery openness to innovation and collaborations to be developed in this sense. For this reason, sample selection approach following Heckman (1979) or Shonkwiler and Yen (1999) approach.

Table 3.
Descriptive statistics

	Variable	Mean	St. Dev	Min	Max
Innovative wine machines	OPP1	4.07	1.22	1.0	5.0
	OPP2	3.00	1.20	1.0	5.0
	APP	4.13	1.25	1.0	5.0
	CUM	4.33	0.82	2.0	5.0
	KBA	4.20	1.08	1.0	5.0
	KAP	3.53	1.19	1.0	5.0
Biotechnologies	OPP1	3.93	0.96	2.0	5.0
	OPP2	3.87	1.19	2.0	5.0
	APP	3.93	0.96	2.0	5.0
	CUM	4.40	0.74	3.0	5.0
	KBA	4.07	1.22	1.0	5.0
	KAP	3.47	1.30	1.0	5.0
Biosensors	OPP1	2.93	0.96	1.0	5.0
	OPP2	2.67	1.18	1.0	5.0
	APP	3.00	1.25	1.0	5.0
	CUM	3.40	1.35	1.0	5.0
	KBA	3.53	1.46	1.0	5.0
	KAP	2.87	1.19	1.0	5.0
Alternative techniques	OPP1	3.93	0.88	3.0	5.0
	OPP2	3.33	1.05	2.0	5.0
	APP	3.93	1.10	1.0	5.0
	CUM	4.13	0.99	2.0	5.0
	KBA	4.20	1.08	1.0	5.0
	KAP	3.60	0.91	2.0	5.0
Autonomous development	Innovative wine machines	0.47	0.52	0.0	1.0
	Biotechnologies	0.27	0.46	0.0	1.0
	Biosensors	0.53	0.52	0.0	1.0
	Alternative techniques	0.67	0.49	0.0	1.0
	Other technologies	0.20	0.41	0.0	1.0
Development through	Innovative wine machines	0.20	0.41	0.0	1.0

collaborations	Biotechnologies	0.27	0.46	0.0	1.0
	Biosensors	0.33	0.49	0.0	1.0
	Alternative techniques	0.20	0.41	0.0	1.0
	Other technologies	0.13	0.35	0.0	1.0
Major sources of innovation	University	2.54	1.45	1.0	5.0
	Other firms	2.23	1.01	1.0	4.0
	Consortium	1.31	0.63	1.0	3.0
	Suppliers	3.00	1.22	1.0	5.0
	Customers	2.08	1.16	1.0	4.0
	Wine makers	4.31	0.75	3.0	5.0
Documentation about innovation	Scientific journals	0.33	0.49	0.0	1.0
	Food & agriculture magazines	0.67	0.49	0.0	1.0
	Wine magazines	0.93	0.26	0.0	1.0
	Market magazines	0.33	0.49	0.0	1.0
Years of the enterprise		32.33	29.71	1.0	92.0
Firm as part of associations or consortiums		0.27	0.46	0.0	1.0
Full time employees no.		7.79	9.75	0.0	35.0
Employees with a college degree		2.80	3.53	0.0	14.0
	Food tech./agron.	1.40	1.40	0.0	5.0
	Business admin. staff	1.53	1.46	0.0	5.0
Wine maker works with other firms		0.60	0.51	0.0	1.0
	No. Firms the wine maker works with	6.40	12.45	0.0	50.0
Presence of R&D activities		0.40	0.51	0.0	1.0
% of revenues spent into R&D		0.19	0.27	0.0	0.8
The firm collaborates with a consulting group/firm		0.36	0.50	0.0	1.0
Sales volume (classes from 1 to 6)		1.87	1.13	1.0	4.0
Hectoliters of wine produced		14043.5	27985.9	40.0	100000
	% bulk wine	0.35	0.33	0.0	1.0
	% bottled wine	0.61	0.35	0.0	1.0
Price	Most sold bottle	4.70	2.70	1.5	12.0
	Most expensive bottle	14.82	18.52	3.5	75.0
Own wines into wine guides		0.87	0.35	0.0	1.0

	% on total	0.27	0.23	0.0	0.8
	Grocery	0.14	0.30	0.0	0.8
Regional sales	Ho.Re.Ca.	0.30	0.30	0.0	0.9
	Wine shop	0.20	0.23	0.0	0.5
	Direct sales	0.38	0.38	0.0	1.0
	% on total	0.22	0.19	0.0	0.6
	Grocery	0.18	0.32	0.0	1.0
National sales	Ho.Re.Ca.	0.17	0.22	0.0	0.7
	Wine shop	0.15	0.17	0.0	0.5
	Direct sales	0.17	0.23	0.0	0.6
	% on total	0.48	0.32	0.0	1.0
	Grocery	0.15	0.33	0.0	1.0
Export	Ho.Re.Ca.	0.17	0.21	0.0	0.5
	Wine shop	0.15	0.21	0.0	0.7
	Direct sales	0.12	0.24	0.0	0.8

We estimated the average and the standard deviation of the score wineries assigned to the dimensions of technological regimes. The results presented in Table 3 highlight the inhomogeneous perception of the dimensions and represent a first confirmation of our research hypothesis.

Secondly, an important outcome of the results concerns the development of innovation, which results autonomous more frequently than from collaborations. Moreover, the main sources of innovation are the winemakers for most of the wineries, then suppliers, university, and other firms. A relevant aspect is that the winemaker, in 60% of the cases works for other wineries.

The main source of information is wine magazines and more general food and agriculture magazines. Only the 27% of the sample is part of a consortium or a producers association. About 40% of employees have college degree and they occupy both administration and technical sections of the wineries. 40% of the firms carries out R&D activities with an average spending of 20% of their total revenues. A similar percentage concerns firms collaborating with a consulting company.

Most of the wine produced is bottled and its price ranges from 1.5 to 75 Euros per bottle. About 90% of the firms count the presence of their products into wine guides. Their wine is sold mainly to foreign countries to the Ho.Re.Ca., secondly within the region, in this case mainly through direct sale.

Although the sample presents a number of hypothetically virtuous firms, high variability in size and market specific characteristics (price, markets of destination, distribution channel) might be sufficient for testing our hypotheses. Given the consideration that homogeneous answers to the importance of the dimensions of technological regimes means having deviation from the average score not significantly different from zero, the hypothesis of observing an actual perception of those can be tested through a t-test and a F-test. While, the t-test investigates whether the answers relative to each dimension in each technology is significantly different from zero, the F-test verifies whether the whole set of answers is significantly different from zero. Table 4 and 5 presents respectively the t-test and the F-test.

Table 4.
T-test

	OPP1	OPP2	APP	CUM	KBA	KAP
Innovative wine machines	4.085 (0.001)	5.137 (0.000)	4.487 (0.000)	4.802 (0.000)	3.817 (0.001)	5.723 (0.000)
Biotechnologies	5.237 (0.000)	6.102 (0.000)	5.237 (0.000)	7.686 (0.000)	5.858 (0.000)	5.495 (0.000)
Biosensors	3.466 (0.002)	5.403 (0.000)	4.525 (0.000)	6.231 (0.000)	5.376 (0.000)	5.390 (0.000)
Alternative techniques	6.749 (0.000)	5.683 (0.000)	3.876 (0.001)	5.921 (0.000)	3.817 (0.001)	6.014 (0.000)

Table 5.
ANOVA testing whether deviation from mean perception is generally significant

Source of variation	df	SS	MS	F	P-value
Among groups	23.000	150.459	6.542	5.604	0.000
Within groups	360.000	420.267	1.167		
Total	383.000	570.726			

Finally, the statistical tests confirm that there is a perception of technological regimes with no exception of technology. Our first hypothesis, thus, cannot be falsified.

In order to complete the empirical analysis, the cause-effect model presented in eq.1 needs to be estimated. To the scope of exploring the most suitable econometric specification, in detail whether there is the need to estimate a set of seemingly unrelated equation or a single equation model, correlation among dependent variables need to be explored (Table 6).

Table 6.
Correlation matrix among tech. regime dimensions

Technologies	Tech. Reg. Dimensions	OPP1	OPP2	APP	CUM	KBA	KAP
Innovative wine machines	OPP1	**1.00**	-	-	-	-	-
	OPP2	**0.72**	**1.00**	-	-	-	-
	APP	*0.57*	0.36	**1.00**	-	-	-
	CUM	0.10	0.35	*0.62*	**1.00**	-	-
	KBA	0.06	0.21	*0.66*	**0.93**	**1.00**	-
	KAP	**0.92**	*0.69*	*0.58*	0.18	0.21	**1.00**
Biotechnologies	OPP1	**1.00**	-	-	-	-	-
	OPP2	**0.74**	**1.00**	-	-	-	-
	APP	*0.59*	0.38	**1.00**	-	-	-
	CUM	*0.53*	0.22	**0.73**	**1.00**	-	-
	KBA	0.26	0.08	**0.78**	**0.80**	**1.00**	-
	KAP	*0.58*	0.46	**0.71**	*0.63*	*0.58*	**1.00**
Biosensors	OPP1	**1.00**	-	-	-	-	-
	OPP2	*0.66*	**1.00**	-	-	-	-
	APP	0.48	0.10	**1.00**	-	-	-
	CUM	0.14	-0.33	*0.55*	**1.00**	-	-
	KBA	0.13	-0.21	**0.72**	**0.89**	**1.00**	-
	KAP	0.27	0.02	*0.61*	*0.59*	*0.64*	**1.00**
Alternative techniques	OPP1	**1.00**	-	-	-	-	-
	OPP2	*0.57*	**1.00**	-	-	-	-
	APP	*0.61*	*0.61*	**1.00**	-	-	-
	CUM	0.31	0.06	0.37	**1.00**	-	-
	KBA	0.47	0.35	*0.61*	**0.86**	**1.00**	-
	KAP	0.44	*0.60*	**0.74**	0.23	0.47	**1.00**

Bold face is high correlation, italic is medium correlation

The presence, in some cases of a high correlation among the dimensions of technological regime let us conclude the need to estimate regressions as a system of seemingly unrelated equations, or a multivariate ordered probit as in the analysis of Adams (2006).

Table 7 gives an overview of the variables, showing high correlation (>60%) with the dimensions of the technological regime.

Table 7.
Correlation matrix among tech. Regimes dimensions, absorbtive capacity, structural and market side variables

Technologies	Tech. Reg. Dimensions	Sign of Correlation	Correlated Variables
Innovative wine machines	OPP1	-	Agro-Food specific Magazines as source of information
		-	Number of employees with college degree
	OPP2	-	autonomous development of biosensors
		-	suppliers as source of innovation
		+	conducting R&D activities
	APP	-	Agro-Food specific Magazines as source of information
		-	Market & distribution Magazines as source of information
	CUM	-	autonomous development of biosensors
		-	customers as source of innovation
		-	Market & distribution Magazines as source of information
	KBA	-	Agro-Food specific Magazines as source of information
	KAP	-	Agro-Food specific Magazines as source of information
Biotechnologies	OPP1	-	autonomous development of innovative wine machines
		-	development of innovative wine machines through collaborations
		-	customers as source of innovation
	OPP2	-	Wine specific magazines
	APP	-	autonomous development of innovative wine machines
		-	customers as source of innovation
		-	Market & distribution Magazines as source of information
	CUM	-	autonomous development of innovative wine machines
		-	percentage of bulk wine on total production
		+	percentage of bottled wine on total production
	KBA	-	autonomous development of biosensors
		-	customers as source of innovation
		-	percentage of bulk wine on total production
	KAP	+	university as source of innovation
		-	customers as source of innovation
		-	wine maker with college degree
		+	percentage of bulk wine on total production

		+	development of innovative wine machines through collaborations
		+	development of other technologies through collaborations
	OPP1	-	wine specific magazines
		-	employee with college degree
		+	wine maker working for other firms
	OPP2	-	Number of employees with college degree
		-	number of employees food technologists/agronomists
	APP	-	customers as source of innovation
Biosensors	CUM	+	development of biosensors through collaborations
		+	development of alternative techniques through collaborations
		-	percentage of revenues invested into R&D
		-	percentage of bulk wine on total production
		+	percentage of bottled wine on total production
	KBA	-	percentage of bulk wine on total production
		+	percentage of bottled wine on total production
	KAP	-	percentage of bulk wine on total production
		+	percentage of bottled wine on total production
Alternative techniques	OPP1	-	Agro-Food specific Magazines as source of information
		-	percentage of revenues invested into R&D
	OPP2	-	Agro-Food specific Magazines as source of information
	APP	-	Market & distribution specific magazines as source of information
	CUM	-	Market & distribution specific magazines as source of information
	KBA	-	autonomous development of innovative wine machines
		-	autonomous development of biosensors
		-	customers as source of innovation
		+	number of employees food technologists/agronomists
		+	collaboration with consulting firms
	KAP	-	autonomous development of biosensors
		-	customers as source of innovation

The results presented in the table show the sign of the correlations between variables and deviations from the mean. Although correlation does not tell anything about causality or significance among variables, some relevant information come to light in order to form expectations on results of econometric analysis.

Innovation opportunity conditions are linked to the development of already in place technologies, to the number of college degree employees and winemakers working for other firms, as a consequence also to the R&D activities and corresponding investments. This result confirms that absorptive capacity plays a major role towards the understanding of the convenience for the firm, so the economic opportunity, of investing into innovation. The ability to foresee how innovation could change the economic performance in the future is fundamental.

Innovation appropriability conditions are negatively linked to the source of information, the highest correlated type of source is food and agriculture magazines and information from customers for most of the technologies. Again, absorptive capacity measured in term of right sources of information selected is strictly connected to the mental projection of how the innovative technology could actually have influence on the final product.

Instead innovation cumulativeness seems to be related to structural and market characteristics of the firm. High correlation, in fact, has been found with variables such as the share of bulk wine on total production or the share of bottled wine on total production. Previous development of innovation or R&D investments also influences innovation cumulativeness. Being cumulativeness the coherence of the new technology with the others already in place, absorptive capacity plays a less relevant role.

The basic knowledge for the understanding of the technology, differently to other dimensions, has different set of correlated variables per each technology. More specifically, innovative wine machines basic knowledge is negatively related to the use of Market and Distribution magazines; biotechnologies and biosensors are negatively related to the share of bulk wine on total production; alternative wine production techniques, on the other hand, are related to the autonomous development of the other technologies, to the number of employees with food technology degree or agronomists and to the cooperation with consulting firms.

Applied knowledge results positively related to collaboration with university, especially in the case of biotechnologies; perception of the applied knowledge for developing the biosensors is positively related to the share of bottled wine on total production.

4 Concluding Remarks

In order to verify the validity of the Perceived Technological Regime Notion an empirical experiment focused on the Apulian wine sector has been set up. Wine firms result particularly suitable for the analysis of firms' perception because of the strong dependency to external sources of innovation for the introduction of technological and organisational progress.

Results confirmed the existence of different perceptions of technological regime dimensions among wine producers. As a consequence, on the basis of the relationship between technological regimes and patterns of innovation demonstrated by Breschi *et al.* (2000), it is plausible to expect that each of them will follow innovative paradigms that are largely independent from the ones followed by the other firms of the sector. In addition, the results of the F-test, performed for each of the considered fundamental dimensions of the technological regime, showed that for each technological regime dimension the firms' responses tend to vary uniformly across the four considered technologies.

Moreover, the correlation analysis has highlighted the link between perception of technological regimes and absorptive capacity, especially for the dimension regarding the firms' view of the technological opportunities and appropriability. Structural and market characteristics result important for the implementation of the analysed new technologies. Overall, the results of the analysis determine a set of policy implications, which have the potential to reduce or eliminate some of the most evident problems hindering the innovative dynamics of the Apulian wine sector. First of all, the Government, and more in general the decision makers, should take into account that strong and remarkable differences exist in the way firms interpret their technological regime. Another important suggestion deriving from this analysis deals with the necessity to improve the technological knowledge of firms in order to allow them to be more independent in taking innovation initiatives. In our opinion, this objective could be reached in two fundamental and complementary ways. On the one hand, policy makers should set up systematic ways for wine producers to meet and interact in order to increase their capability to exchange knowledge. This is particularly crucial in the Apulian wine sector where firms are highly heterogeneous and isolated. On the other hand, the Government should spur industry professionals, academic experts and in general wine producers to collaborate in order to create an organisation having the aim to diffuse the technological and innovative knowledge among the industry stakeholders. This is another important step to take in order to improve the knowledge base and the learning dynamics of the sector.

However, the work in progress presented needs major improvements. A wider dataset is desirable in order to carry out the econometric analysis and give more validity to the results and better support to the implications. In addition, further testing on other technologies and other sector is needed in order to further validate the notion of perceived technological regime.

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