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Activities during the Crisis in Portugal

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Overriding Uncertainty in the Companies' Future via the Development of Innovation Activities during the Crisis in Portugal

Ana Ferreira,¹ Centro Interdisciplinar de Ciências Sociais CICS.NOVA - Faculdade de Ciências Sociais e Humanas - Universidade Nova de Lisboa (CICS.NOVA.FCSH/UNL), Portugal

Abstract: The burst of the sovereign debt crisis in 2010 is concomitant to the first decreases of innovation activities in the twenty-first century in Portugal. Understanding innovation as an uncertain future-oriented change process that builds upon scientific and technological knowledge, and is framed by organizational, social, economic, and political contexts, we questioned how innovation development was dependent on these contexts during the crisis in Portugal. For this purpose, we quantitatively characterized the internal and external contexts of Information and Communication Technology firms between 2010 and 2012. Focusing on innovative firms, we further analyzed the evolution of innovation activities; perceptions of the crisis impacts on innovation; and the evolution of uncertainty in the companies' future. Our ordinal regression models revealed that companies with more empowering work environments and increasing assets, present increased probability of having 1) augmented innovation activities; 2) more favorable perceptions of the socio-economic crisis impacts on innovation; and 3) reduced uncertainty in the companies' future. Our study further suggests that while uncertainty is ubiquitous to innovation processes, increases in contextually-framed innovation activities support more favorable perceptions of the crisis impacts on innovation, and additionally override perceptions of uncertainty in the companies' future.

Keywords: Innovation, Uncertainty, ICT Sector, Crisis

Introduction

The international financial crisis in 2007 to 2008 was followed by the burst of the sovereign depth crisis in Europe, in 2010, and by the Troika's² intervention in Portugal, in 2011. These years were characterized by social and economic downturns (OECD 2014) and a changing political arena in Portugal³. This context impacted on firms activities and their economic readouts (INE 2014) and, for the first time in the twenty-first century, the frequency of innovation activities⁴ in firms operating in Portugal, witnessed decreases (European Commission 2014).

Innovation is hereby understood as a complex social change process that builds upon scientific and technological knowledge, is framed by the specific organizational locus where it takes place, and by the broader social, economic, and political contexts where it is embedded (Hekkert et al. 2007, Geels and Schot 2007, Rip 2012). More specifically, previous studies have shown that, at the organizational level, innovation development is associated with companies' general characteristics, structure, and past activities; human, scientific, and financial resources; as well as by companies' culture. At the environmental level, firms' sector of economic activity; location; suppliers, competitors, and clients; participation in networks and internationalization

¹ Email: aferreira@fesh.unl.pt; Postal address: CICS.NOVA, Avenida de Berna, 26 C, 1069-061 Lisboa, Portugal

² The Troika is composed of the International Monetary Fund, the European Central Bank, and the European Commission. It started to intervene in Portugal in 2011 and ended in 2014.

³ The Portuguese prime minister resigned in March 2011 and, 3 months later, elections took place. This resulted in a change in government from a non-majority ruling by Partido Socialista (member of Progressive Alliance of Socialists and Democrats in the European Parliament) to a majority coalition between Partido Social Democrata, and Centro Democrático e Social – Partido Popular (members of the European People's Party (Christian Democrats) in the European Parliament).

⁴ Innovation activities include product; process; organizational; and marketing innovation (OECD and Eurostat 2005).

strategies; public policies and surrounding culture, were also shown to be associated with innovation activities (reviewed in Becheikh, Landry, and Amara 2006; Gupta, Tesluk, and Taylor 2007; van der Panne, van Beers, and Kleinknecht 2003). If this is the case, a characterization of innovation development in firms should entail an integrated characterization of its intra- and extra-organizational contexts. Still, most studies either focused on the impacts of individual parameters on innovation development, or, alternatively, characterized a relatively limited number of variables (de Jong and Vermeulen 2006; Freel 2006; Gupta, Tesluk, and Taylor 2007; Camelo-Ordaz, Fernández-Alles, and Martínez-Fierro 2006). In addition, these studies have, for the most part, addressed non-crisis periods, with few exceptions characterizing the drivers and blockers of innovation activities at the beginning of the global financial crisis (Frey, Iraldo, and Testa 2013; Archibugi, Filippetti, and Frenz 2013). As such, and focusing on the most innovative sector of economic activities in Portugal and Europe, that is, the Information and Communication Technology (ICT) services sector (European Commission 2014), this paper aims to simultaneously characterize the internal and external contexts of innovation development, and identify the critical variables underlying innovation progression under a socio-economic crisis context, more specifically, between 2010 and 2012. This has not been previously addressed. Besides the ICT sector being the most innovative sector in Portugal and Europe (as revealed by the highest investments on innovation and Research and Development (R&D); the fastest rates of innovation; highest outputs and productivity growth (European Commission 2014)), the reasoning for the focus on this sector of economic activities also rests on the rather reduced scientific literature on services' firms (Papadakis, Thanos, and Barwise 2010), and the fact that ICTs have wide economic, and social impacts.

In addition to innovation being a complex social change process that is framed by its intra- and extra-organizational settings, another important characteristic of these processes is that they link the past and present, to the unknown future (reviewed in Ferreira 2014). This is the case since innovation outputs do not exist prior to their development, except as imagined futures or expectations (Tutton 2011, Borup et al. 2006, Pollock and Williams 2010). These imagined futures are historically built, and contextually framed. Noticeably, innovation-associated future projections entail the presence of uncertainty, since, as for the development of any other social action, first, its development alters future's settings, and second, others' behaviors are beyond ones control (Barbalet 2009a, 2009b). In the specific context of innovation, the materialization of returns on investment, as well as the time taken for its accomplishment were, among others, previously associated to innovation' intrinsic uncertainty (reviewed in Galende 2006). If uncertainty is expected to negatively impact or, eventually block innovation development (Barbalet 2001), it is still unknown how the internal and external organizational contexts of innovative ICT services' firms operating in Portugal frame the development of uncertainty in companies' future under a socio-economic crisis context. This specific lacuna will be addressed in this paper.

Yet another important feature of the inter-temporality of innovation is that innovation is, at least partly, a cumulative process. This is revealed by the fact that while innovation is framed by present intra- and extra-organizational contexts, it is simultaneously framed by firms' innovation history. This history is translated into specific knowledge and expertise that sets (or not) firms in favorable (or unfavorable) positioning from the go-ahead (e.g., after firms guaranteeing specific knowledge and skills, the efficiency of following investments increases) (reviewed in Galende 2006). If this is the case, then decreasing innovation activities today is expected to impact first, on firms' capabilities to innovate in the future, and subsequently, since previous studies reported an association between the development of innovation and companies' survival (Cefis and Marsili 2006), to broadly impact firms' activities, and, eventually, firms' survival. These issues will be addressed via the characterization of top managers' perceptions regarding the companies' future. This paper further assesses how these perceptions on the companies' future relate to the development of innovation activities in the present.

Having established that innovation is a future-oriented, cumulative and complex change process that is framed by the internal and external organizational contexts, the next section characterizes the ICT services sector in Portugal, as well as goes over the recent progression of innovation activities in this sector. Subsequently, the aims and hypotheses of the present study are outlined. This is followed by the methodological and the results sections. Finally, the results are discussed, the limitations of the study are presented, and future directions are proposed. The paper ends with conclusive remarks.

Contextualizing the Portuguese ICT Services Sector: On Innovation and Beyond

Innovation activities in companies operating in Portugal continuously increased between 2000 and 2010, reaching 60 percent of all firms between 2008 and 2010 (European Commission 2014). However, concomitant to the burst of the sovereign debt crisis in Europe (in 2010), and the beginning of Portugal's bailout by the Troika (in 2011), there is an inversion of this increasing pattern: between 2010 and 2012 only 54 percent of firms developed innovation activities. Concurrently, the ICT services sector that presented 89 percent innovative firms between 2008 and 2010, only had 79 percent between 2010 and 2012 (European Commission 2014). In these years, ICT services firms were characterized by negative economic impacts, with companies showing, since 2008, decreasing annual turnovers. This trend is reproduced, since 2010, in decreasing production values, gross value added, gross operating surplus, assets, liabilities, equity capital, and gross investments in tangible goods between 2010 and 2012 (INE 2014). As such, the socio-economic crisis in Portugal strongly impacted ICT services firms.

During this period, while the most reported strategy that ICT services firms mobilize to attain their companies' goals was to develop innovation activities, the biggest reported obstacles were competition among firms; costs of entering new markets; decline in demand; costs associated with governmental regulations and other legal requisites; and an inadequacy of the available financing mechanisms (European Commission 2014). This data reveals very important hints: while firms understand the critical role of innovation activities, they also recognize that innovation development has major environmental obstacles: competitors; elevated costs in a context of inadequate financing mechanisms and decreased number of clients. Still, it remains to be addressed how these and other indicators, characterizing the internal and external contexts of innovative ICT services firms, specifically frame the development of innovation between 2010 and 2012. This will be addressed in the following sections.

Aims and Hypotheses

The aims of this study are 1) to characterize the internal and external contexts of ICT services firms, between 2010 and 2012, in Portugal. Additionally, this paper aims to characterize whether and how these contexts 2) contribute to the development of innovation; 3) frame the perceived impact of the crisis on innovation development; and 4) contribute to the evolution of uncertainty in the companies' future. These aims will be achieved via the characterization of variables previously associated with organizational activities and innovation (Papadakis, Thanos, and Barwise 2010). These encompass indicators a) characterizing the internal context of ICT services firms (e.g., financial resources; research and development (R&D)); b) in spite of being external to the firms, have a direct impact on firms' activities (e.g., clients; competitors); and c) span the intra- and extra-organizational contexts (e.g., communication). All variables will be quantitatively evaluated through the lens of firms' top managers who, standing at the interface of the internal and external organizational contexts, are ultimately responsible for strategic control and decision-making (Nutt and Wilson 2010).

Based on the above, we will test the following hypotheses:

Hypothesis 1: Innovation activities are dependent on companies' resources (i.e., human, scientific, cooperation partners and networks, and financial), companies' culture, and competition with other firms.

As previously reported, innovation is framed both by the organizational and the environmental contexts where firms are embedded (reviewed in Becheikh, Landry, and Amara 2006; Gupta, Tesluk, and Taylor 2007; van der Panne, van Beers, and Kleinknecht 2003). More specifically, previous studies have shown that the availability of financial resources has significant positive impacts on the development of innovation activities (Beneito 2003). This seems to be the case since financial resources are critical for carrying out investments, developing in-house R&D, and innovation activities. Regarding human resources, it is broadly accepted that their qualifications, experience, and skills are positive determinants of innovation (Romijn and Albaladejo 2002). Additionally, personnel management including the mobilization of strategies targeting employees training or promoting their motivation and autonomy while increasing trust in employees, renders companies to be more prone to R&D development, and innovation (Michie and Sheehan 2003; Brattström, Löfsten, and Richtnér 2012; Brower et al. 2009; Madrid et al. 2014; Beugelsdijk 2008). Moreover, the use of codified S&T knowledge (generally associated with formal education and training systems, R&D and partnerships with the academia), and experience-based knowledge (generally associated with interactions among firms' employees or sectors as well as with other firms, clients or suppliers) (Jensen et al. 2007), were shown to be critical for innovation progression. As such, firms' cooperation partners, and participation in critical networks (Oliveira and Carvalho 2010; Salavisa, Sousa, and Fontes 2012; de Faria, Lima, and Santos 2010), including access to international partnerships and markets (Romijn and Albaladejo 2002), were associated with successful innovation development. Finally, while innovation is ICT services companies' most reported strategy to achieve their goals, several layers of competition are the most reported obstacles for innovation development in Portugal between 2010 and 2012 (European Commission 2014). This could be partly associated with the socio-economic crisis environment in which firms are immersed, an environment where resources are scarcer (INE 2014), and competition is expected to be increased. However, while previous studies addressing the relation between competitors and innovation activities suggested a counterproductive effect of working closely with key competitors or monitoring their activities (Nieto and Santamaría 2007; Souitaris 2001; Lukas and Ferrell; Han, Kim, and Srivastava 1998), others report competitor orientation (i.e., companies that continuously monitor progress against competitors) as critical for innovation development (Augusto and Coelho 2009; Li and Calantone 1998). In fact, a meta-analysis of published literature showed that competitor orientation was dependent on a minimum level of client orientation (Grinstein 2007). In spite of all these inputs, whether and how innovation activities are concomitantly impacted by companies' organizational resources (e.g., financial, human, cooperation partners, networks), companies' culture, and competitors remains to be studied. This paper will address this specific issue.

Hypothesis 2: Among innovative companies, perceptions on the impacts of the socio-economic crisis on innovation are dependent on companies' resources (i.e., human, scientific, cooperation partners and networks, and financial), companies' culture, and competitors.

ICT services companies operating in Portugal have suffered strong economic impacts during the socio-economic crisis (INE 2014) and presented decreases in the frequency of innovation activities (European Commission 2014). Additionally, it was previously reported that the majority of economically dynamic innovative firms operating in Portugal—that is, with annual turnovers above 1 million € in 2008 with an increase over 5 percent between 2007 and 2008—perceive that the socio-economic crisis has negative impacts on their activities with the most

dynamic firms perceiving less negative impacts of the socio-economic crisis (Nunes 2012)⁵. In spite of the relevance of this study, the analyzed population excludes almost 90 percent of ICT services firms operating in Portugal (that, in fact, present annual turnovers below this value (INE 2014)). As such, these results remain to be confirmed or negated in a sample that replicates the distribution of ICT firms operating in Portugal. Additionally, and as previously said, the development of innovation activities is companies' most reported strategy to obtain their goals, with competition being the most reported obstacle to innovation between 2010 and 2012 (European Commission 2014). However, the relation between perceptions of the impacts of the socio-economic crisis on innovation, and the evolution of companies' resources, companies' culture, and competition with other firms remains to be studied. It is our expectation that most companies perceive that the socio-economic crisis is unfavorable for innovation development, and that these perceptions are dependent on companies' resources, culture, and competitors. This will be addressed in this study.

Hypothesis 3: Among innovative companies, increasing innovation activities decreased uncertainty in the companies' future

As previously stated, innovation is a cumulative process connecting non-linearly the past, present, and the unknown future (Galende 2006; Dosi, Orsenigo, and Labini 2005; Ferreira 2014). It is an inherently uncertain process in which uncertainty levels decrease along the development of innovation trajectories. Also, innovation has been associated with firms' performance, and survival (Cefis and Marsili 2006; Savona, Cainelli, and Evangelista 2004; Mansury and Love 2008; Rosenbusch, Brinckmann, and Bausch 2011; Akgün et al. 2007; García-Morales, Lloréns-Montes, and Verdú-Jover 2007). If this is the case, then it is to be expected that companies that are presently developing innovation present more favorable perceptions of their companies' future than the ones that are not developing innovation activities. As such, the evolution of innovation in the present is expected to be negatively correlated with uncertainty in the companies' future. To the best of our knowledge this hypothesis was not previously tested.

Methods

This paper presents and discusses data that is part of a broader research project on innovation development in companies of the ICT services sector⁶ operating in Portugal. More specifically, we will characterize the internal and external contexts in which innovation activities are developed at ICT services firms. For this purpose, we carried out an online survey⁷ that was applied to 309 firms chosen according to a quota sampling methodology. This sample is representative of the ICT services sector in terms of the development of innovation activities (95% confidence interval; 5% maximum error of estimate) (European Commission 2014), and has a proportional distribution to the universe of ICT services firms operating in Portugal in terms of classes of number of employees and annual turnovers (INE 2011).⁸ This sample was not stratified by firms' date of incorporation.⁹

⁵ The sample used in this study was based on a reference population obtained from a private company dataset and encompassed only companies developing innovation activities.

⁶ The ICT services sector refers to companies identified as belonging to Section J, divisions 61 to 63 of the statistical classification of economic activities in the European Communities NACE-Rev. 2 (European Commission 2008)

⁷ A phone call initiated the contact with ICT services' firms. One to three reminder emails followed the initial phone call, and resulted in an 8.9 percent response rate.

⁸ The analyzed sample is mainly composed of micro companies (86.8%). Additionally, 10.2 percent of the analyzed companies are small; 2.3 percent are medium, and 0.7 percent are large (European Commission 2003).

⁹ The sample presented 48.2 percent of firms founded between 2007 and 2012; 33.9 percent between 2000 and 2006; and 17.9 percent between 1980 and 1999.

The questionnaire was answered by ICT services firms' top managers during 2013,¹⁰ and addressed the period between 2010 and 2012. It encompassed different groups of questions concerning 1) the development of innovation activities; 2) the evolution of variables characterizing the internal and/or external contexts of the firms;¹¹ 3) perceptions of the impact of the crisis on innovation development.¹² The development of innovation activities was assessed with a nominal scale (Yes/No). The evolution of variables characterizing the internal and external contexts of ICT services firms was evaluated with a five-point ordinal scale in which "1" corresponded to "strong decrease," and "5" to "strong increase." Perceptions of the crisis impacts on innovation development were measured with a five-point ordinal scale in which "1" corresponded to "very unfavorable," and "5" to "very favorable."

Spearman's rho correlation coefficients were used to analyze the direction and strength of correlations between ordinal variables. Subsequently, Principal Component Analysis (PCA) was carried out to simplify the large number of intercorrelated measures into fewer dimensions (Carifio and Perla 2008, Ho 2006). Finally, and considering the factor scores of the new variables defined by the resulting components of the PCA, we performed ordinal regression analyses (Marôco 2010). This last analytical procedure was carried in order to identify the dependence between 1) the evolution of innovation development; 2) perceptions of the crisis impacts on innovation development; and 3) the evolution of uncertainty in the companies' future and the summary components resultant from the PCA analysis.

IBM SPSS Statistics version 20 statistical package was used for statistical analysis.

Results

Characterizing ICT Firms Operating in Portugal between 2010 and 2012

Between 2010 and 2012, 71.2 percent of ICT services companies developed innovation activities.¹³ Focusing on companies developing innovation activities, we assessed top managers' perceptions on the evolution of both internal and external organizational contexts between 2010 and 2012 (Figure 1). Aiming to simplify the analysis without losing relevant information, the data is presented on a 3-point ordinal scale.¹⁴

¹⁰ Statistics Portugal lists a total of 4310 ICT services firms (INE 2011).

¹¹ An example of a question is "Between 2010–2012, how did your firm's human resources progress?" (List of variables: evolution of financial resources; human resources; internal bureaucratic structures and procedures; and external bureaucracy (e.g., government regulations; legislation); management of human resources; employees' motivation; employees' autonomy; trust in employees; innovation; knowledge-management (activities that ease and regulate access to knowledge, e.g., identifying and organizing companies' information and knowledge, supporting the learning of new skills); planning and monitoring of projects; R&D; creativity stimuli (including brainstorming sessions; team work; rotation of employees between companies' departments; multidisciplinary teams and financial and/or non-financial incentives); discussion of strategic decision-making; pressure on strategic decision-making; clients; networks, internationalization (globally addressing exports; internationalization of human resources; partners, clients, among others); number of suppliers; number of competitors; formal internal and external communication (e.g., newsletters, meetings); and uncertainty in the firms' future.

¹² The specific question is "Between 2010–2012, how did the socio-economic crisis contribute to innovation development in your firm?"

¹³ This data (i.e., frequency of innovation activities) has been previously reported by our research group in a paper that is currently in press (Ferreira and Teixeira 2016). No other data reported in this paper was previously reported or discussed. A disaggregated analysis of the different types of innovation activities (product; process; organizational; and marketing) as well as a discussion on the role of non-technological innovation activities (i.e. organizational and or marketing) on technological innovation outputs (i.e. goods and services) can be found on the following reference (Ferreira, Teixeira, and Roque Dantas 2015).

¹⁴ The 3-point ordinal scale combines high increases (or high decreases) with increases (or decreases).

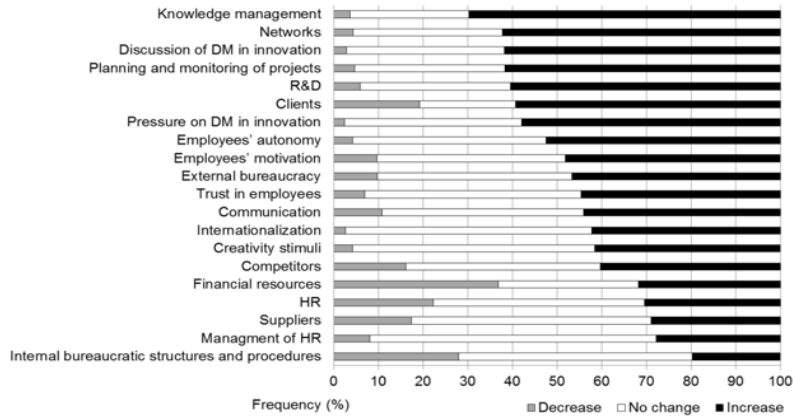


Figure 1: Evolution of the contexts of innovative ICT services' firms in Portugal (2010–2012). DM: Strategic Decision-making; HR: Human Resources; R&D: Research and Development.

The data depicted in Figure 1 reveals that innovative firms strongly invested in S&T-related activities between 2010 and 2012. This is shown, for instance, by the fact that more than 60 percent of the firms increased their activities of knowledge management; planning and monitoring of innovation projects; discussion of decision-making regarding innovation progression, and R&D, while 41.5 percent increased the stimuli to creativity. These patterns suggest the presence of innovation-prone organizational contexts (Jensen et al. 2007).

Along the same lines, and even though the evolution of number of human resources was either stable or decreased in almost 70 percent of the analyzed cases, ICT services' firms invested in empowering their employees. This is reflected in increases in their autonomy (53.6%), and motivation (48.1%), also with 44.6 percent of firms increasing “trust in employees.” These variables have been previously associated with job performance and/or innovation (Brower et al. 2009; Lau, Lam, and Wen 2014; Madrid et al. 2014; Salamon and Robinson 2008; Choi 2007).

Moreover, the evolution of networks, clients, internal and external formal communication, and internationalization, increased in more than 40 percent of the cases. The increases in internationalization mirror the general pattern of Portuguese companies, and particular that of the Information and communication sector between 2010 and 2012, that is revealed, for instance, on increased total import/export coverage rates (INE 2013). These results point to a broadening communication flows, networks, pool of customers and internationalization routes. These data indicate an increased perception of the relevance of knowledge and information flows via intra- and extra-organizational networks as revealed by the increased internal formal communication, and networks.

In spite of all the efforts that innovative ICT services' firms made to promote an innovation-prone organizational behavior (all previously mentioned variables plus the presented decreases in internal bureaucracy in 28% of our sample) a more negative scenario is revealed by companies' financial resources. In this particular case, 36.8 percent of firms present decreases. Additionally, with the number of competitors increasing in 40.3 percent and with external bureaucracy increasing in 46.7 percent of firms under of context of socio-economic crisis, ICT services' firms perceive increases on pressure on strategic decisions regarding innovation progression in 57.9 percent of the cases.

In summary, ICT services' companies operating in Portugal between 2010 and 2012 face an adverse external environment that is reflected on a challenging financial scenario, and on a high level of pressure on strategic decision-making regarding innovation. This is being

counterbalanced by promoting an innovation-prone organizational environment (with S&T related activities, and empowering of employees), and widening of networks, clients, and internationalization routes.

Next, we assessed the significance and strength of the relations among these variables (Spearman σ). As can be easily attested from Table 1, a very wide number of significant relations ($n=152$) was found, with some being very strong ($\sigma>0.500$; $n=10$).¹⁵ However, since this large number of correlations is difficult to analyze in-depth, our next analytical step was to simplify our data via the application of a principal component analysis (PCA). This analysis is presented in the following section.

Table 1: Linking the Contexts of Innovative Firms of the Portuguese ICT Sector

	HR	Know. Man.	HR Man.	R&D	P&M	Int. Bur.	Ext. Bur.	Comm.	Comp.	Suppl.	Clients	Internat.	Creat. Stimuli	Emp. Mot.	Emp. Aut.	Trust Emp.	Netw.	Disc. DM	Press. DM	
FR	0.586**	0.262**	0.366**	0.287**	0.220**	0.203**	0.077	0.311**	-0.003	0.262**	0.537**	0.260**	0.180**	0.236**	0.194**	0.198**	0.189**	0.166*	-0.093	
HR		0.383**	0.574**	0.377**	0.362**	0.245**	0.101	0.403**	0.076	0.300**	0.537**	0.256**	0.259**	0.302**	0.177**	0.217**	0.217**	0.233**	0.015	
Know. Man.			0.358**	0.511**	0.474**	0.126	0.078	0.171*	0.187**	0.227**	0.379**	0.266**	0.391**	0.351**	0.279**	0.350**	0.200**	0.224**	0.016	
HR Man.				0.316**	0.406**	0.190**	0.074	0.345**	0.056	0.318**	0.440**	0.277**	0.297**	0.397**	0.289**	0.317**	0.314**	0.247**	0.060	
R&D					0.488**	0.003	0.088	0.197**	0.064	0.286**	0.350**	0.263**	0.396**	0.409**	0.342**	0.310**	0.146*	0.186**	0.022	
P&M						0.185**	0.025	0.371**	0.043	0.311**	0.354**	0.332**	0.331**	0.449**	0.402**	0.378**	0.313**	0.262**	0.094	
Int. Bur.							0.422**	0.287**	0.086	0.232**	0.175*	0.024	0.122	0.077	0.050	0.048	0.092	0.166*	0.017	
Ext. Bur.								0.214**	0.042	0.124	0.032	0.042	0.055	-0.044	-0.016	0.043	0.066	0.133	0.110	
Comm.									-0.059	0.355**	0.337**	0.281**	0.189**	0.158*	0.097	0.089	0.196**	0.321**	0.177*	
Comp.										0.201**	0.053	0.105	0.080	0.103	0.104	0.087	0.066	0.165*	0.148*	
Suppl.											0.394**	0.125	0.310**	0.285**	0.310**	0.296**	0.315**	0.220**	0.149*	
Clients												0.343**	0.316**	0.420**	0.313**	0.373**	0.238**	0.164*	-0.088	
Internat.													0.104	0.172*	0.201**	0.240**	0.192**	0.095	0.002	
Creat. Stimuli														0.579**	0.510**	0.451**	0.280**	0.310**	0.160*	
Emp. Mot.															0.674**	0.631**	0.243**	0.190**	0.020	
Emp. Aut.																	0.661**	0.271**	0.248**	0.149*
Trust Emp.																		0.311**	0.246**	0.101
Netw.																			0.065	0.036
Disc. DM																				0.565**

This table reports Spearman correlation coefficients among ordinal variables.

* $p<0.05$

** $p<0.01$.

Bold indicates strong direct relation: $\sigma>0.500$.

FR: Financial Resources; HR: Human resources; Man.: Management; R&D: Research and Development; P&M: Planning and monitoring; Int. Bur.: Internal bureaucratic structures and procedures; Ext. Bur.: External Bureaucracy; Comm.: Internal and external formal communication; Comp.: Competitors; Suppl.: Suppliers; Internat.: Internationalization; Creat. Stimuli: Creativity stimuli; Emp. Mot.: Employees' motivation; Emp. Aut.: Employees' autonomy; Trust Emp.: Trust in employees; Netw.: Networks; Disc. DM: Discussion of strategic decision-making; Press. DM: Pressure on strategic decision-making.

¹⁵ Among these strong direct relations we can find the ones between financial resources and human resources; between human resources and its management; knowledge management and R&D; between creativity stimuli and both employees' motivation and autonomy; between employees' motivation and both their autonomy and trust in employees; between employees' autonomy and trust in employees; and, finally, between discussion of strategic decision-making and pressure on strategic decision-making.

The Contexts of Innovative ICT Services Firms: Reducing Data Complexity

We performed a PCA (Carifio and Perla 2008; Ho 2006) with the evolution variables depicted in Figure 1 and Table 1 and expressed in a 5-point ordinal scale (1—strong decreases; 2—decreases; 3—no decreases or increases; 4—increases; 5—strong increases) (KMO = 0.843; Bartlett’s test of sphericity: $\chi^2_{(190)} = 1181.1$, $p < 0.001$). According to the Kaiser criterion, five components were extracted. These components account for 61.8 percent of the variance. Table 2 presents the factor loadings resulting from a Varimax rotation. The % of variance explained is also presented.

Table 2: ICT Services Firms’ Activities are described by Empowerment, Assets, Contexts of Decision-making, Bureaucracy, and Competitors

	<i>Factor Loadings</i>	<i>% of Variance Explained</i>
Factor 1 – Empowerment (E)		19.008
Employees’ Motivation	0.850	
Employees’ Autonomy	0.843	
Trust in Employees	0.819	
Creativity Stimuli	0.713	
Suppliers	0.334	
Factor 2 – Assets (A)		18.698
Human Resources	0.769	
Financial Resources	0.704	
Management of Human Resources	0.668	
Clients	0.664	
Communication	0.567	
Internationalization	0.556	
Planning and Monitoring	0.539	
R&D	0.454	
Management of Knowledge	0.444	
Networks	0.365	
Factor 3 – Contexts of Decision-Making (cDM)		8.868
Pressure on strategic decision-making	0.884	
Discussion of strategic decision-making	0.772	
Factor 4 – Bureaucracy (B)		8.167
Internal bureaucratic structures and procedures	0.811	
External bureaucracy	0.794	
Factor 5– Competitors (C)		7.014
Competitors	0.872	

The first component is “Empowerment” (E). It combines variables that evaluate differential paths of empowering companies’ employees: the first variables focus on employees’ autonomy, motivation and trust in employees, and the last one addresses the application of creativity stimuli. This component, that reflects firms’ cultural dimension, fits very nicely with the strong direct bivariate correlations earlier presented (see Table 1). “Assets” (A) groups internal organizational resources (financial, human, scientific, and managerial) with external resources (clients), and reaching in/out activities like internationalization activities; internal and external formal communication. “Contexts of decision-making” (cDM) aggregates the two variables that in this study describe the contexts of strategic decision-making (pressure and discussion of strategic decision-making). As for the variables underlying the component “Empowerment,” these two decision-making variables were strongly correlated with each other (see Table 1). “Bureaucracy”

(B) groups the evolution of internal, and external bureaucracy. The final factor only includes the contribution of the variable “Competitors” (C).¹⁶

The data presented in Table 2 indicates that the reported five components summarize the twenty variables that the study started with, and thus fulfil our goal of reducing data complexity. Having established these five components, we can now directly assess whether the 1) evolution of innovation activities; 2) impacts of the crisis on innovation development; and the 3) evolution of uncertainty in the companies’ future are dependent on these components.

Characterizing the Evolution of Innovation Activities between 2010 and 2012

Between 2010 and 2012, 79.2 percent of ICT services firms developing innovation increased innovation activities, while 17.6 percent did not increase or decrease, and only 3.1 percent decreased. With this highly innovative context in mind (not only the ICT service sector presents very high frequencies of innovation activities, but, among innovative firms, three quarters of these firms are increasing their innovation efforts), the first question this paper addresses is whether the evolution of innovation activities, expressed on a 3-point ordinal scale (decrease; no change; increase),¹⁷ is dependent on the previously established components. For this purpose we applied an ordinal regression model (Model 1) that is shown in Table 3. This model is statistically significant¹⁸ with McFadden R^2 statistics ($R^2_{MF} = 0.272$) showing an excellent model fit.¹⁹ More specifically, what this model tells us is that companies with an increased probability of a more positive evolution of innovation activities are the companies that increased both the empowerment of their employees, and their assets between 2010 and 2012. Also, these are the firms that felt increased pressure on strategic decision-making while increasing the discussion of decision-making. The model further tells us that the evolution of bureaucracy, and competitors, do not significantly contribute to the evolution of innovation activities (Table 3).

As such, this data negates *Hypothesis 1*—that the evolution of innovation activities is simultaneously dependent on the evolution of companies’ resources, culture, and competitors. In fact, the dependence relation is established with the evolution of companies’ internal and external assets (integrating several layers of companies resources), employees’ empowerment (encompassing the companies’ cultural dimension), and contexts of decision-making. This data is consistent with studies that, mostly focusing on individual parameters, underlie the proposed *Hypothesis 1* in what concerns companies’ assets and employees’ empowerment (Michie and Sheehan 2003; Brattström, Löfsten, and Richtnéř 2012; Brower et al. 2009; Madrid et al. 2014; Beugelsdijk 2008; Beneito 2003; Jensen et al. 2007; Oliveira and Carvalho 2010; Salavisa, Sousa, and Fontes 2012; de Faria, Lima, and Santos 2010; Romijn and Albaladejo 2002). Additionally, in firms in which the probability of increasing innovation is dependent on a culture favoring among others, motivation and autonomy of employees, as well as trust in employees, it is to be expected that discussion of strategic decisions is favored over a model of centralized decision-making (even in the presence of increased pressure in strategic decision-making). Finally, the evolution of the number of competitors does not impact the evolution of innovation

¹⁶ Input variables “networks” and “suppliers,” having a much smaller contribution for the corresponding component (factor loadings below 0.50), could be disregarded in the analysis.

¹⁷ We mobilized a 3-point ordinal scale to simplify the analysis without losing relevant information. This scale combines strong increases (or strong decreases), with increases (or decreases).

¹⁸ The best statistical significance (as evaluated by the smaller value of 2LL) was achieved with negative log-log Link function. Logit, cauchit, and probit Link functions also achieved statistical significance. The presumption of slopes’ homogeneity was validated ($\chi^2(5)=4.904$; $p=0.428$) by the test of parallel lines. Additionally, the chosen model correctly predicted the behavior of the dependent variable in 78.6 percent of the cases (observed versus expected).

¹⁹ For logistic regressions, the interpretation of the R^2 is different from the one in linear regressions. Usually named as pseudo- R^2 , it measures the information gain between the fitted and the null model (Maróco 2010). Pseudo- R^2 tend to be lower than linear regression’s R^2 , and values between 0.2 and 0.4 can be considered as representing an excellent fit (McFadden 1979).

activities. As such, in a context in which 40 percent of all ICT services innovative firms report increased number of competitors (see Figure 1), and during the same period of time (i.e., 2010–2012) in which ICT services firms perceived competitors as a prime obstacle to innovation (data from the Community Innovation Study of the corresponding period of time, i.e., 2010–2012 (European Commission 2014)), the evolution of innovation activities are independent of the evolution of the number of competitors. The potential discrepancies can be partly explained by methodological differences between the studies (while this study addresses the integrated impacts of the above mentioned variables, including the evolution of the number of competitors, on innovation development, the Community Innovation Survey directly addresses perceptions of competitors as obstacles for innovation progression). Additionally, and as previously stated (see *Hypothesis 1*), the literature reports contradictory results regarding the impacts of competitors on innovation activities, with a meta-analysis of previous scientific literature suggesting that the positive impacts of competitor orientation in innovation were dependent on the presence of client orientation (Grinstein 2007). Again, the variables at stake are different. Future studies should address the fine contours of these relations by assessing, not only a broader range of specific indicators of competitors (e.g., number of competitors, competitor orientation), but also, the environmental context in which these relations take place. This is particularly important since it was also shown that market orientation—combining client and competitor orientation with interfuncional coordination²⁰—significantly favored innovation activities in large companies, at the services sector, in highly competitive environments, in contexts characterized by low technological turbulence, and in cultures where individualism and high power distance prevail (Grinstein 2007). While our sample matches some of these characteristics (e.g., services sector, competitive environment), that is not the case for some of the other mentioned variables (e.g., large companies, low technological turbulence).

²⁰ Interfuncional coordination refers to interaction and communication within a specific organization.

Table 3: Estimates and Significance of the Adjusted Ordinal Model; Evolution of Innovation between 2010 and 2012 (*Model 1*)

<i>Model 1</i>	
<i>Evolution of Innovation</i>	
Dependent Variable	Estimates (St. dev) Sig.
Innovation	
Threshold 1	-2.018 (0.254)***
Threshold 2	-0.591 (0.199)***
Independent Variables	Estimates (St. dev) Sig.
Empowerment	0.570 (0.133)***
Assets	0.563 (0.127)***
cDM	0.315 (0.115)**
Bureaucracy	0.188 (0.125)ns
Competitors	0.012 (0.113)ns
Link Function	Negative log-log [#]
Model Statistics	
Model Fit	p=0.000 or ***
G ² (5)	51.890
R ² _N	0.399
R ² _{MF}	0.272
R ² _{CS}	0.278
Correctly Predicted	78.6%

Note: St. dev.: standard deviation; Sig.: significance; ns: non-significant;

*: $p < 0.05$;

** : $p < 0.01$;

***: $p < 0.001$;

cDM: contexts of strategic decision-making;

[#]Negative log log link function has the form: $-\ln(-\ln(x))$ in which

x represents the cumulative probability that the event occurs;

R²_N: R² Nagelkerke; R²_{MF}: R² McFadden and R²_{CS}: R² Cox and Snell.

Impacts of the Crisis on Innovation Development

Next, we addressed whether perceptions of the socio-economic crisis impacts on innovation, expressed on a 3-point ordinal scale (unfavorable, not unfavorable or favorable, favorable),²¹ were dependent on the variables empowerment, assets, contexts of strategic decision-making, bureaucracy, and competitors. For this purpose we applied an ordinal regression model (Model 2, Table 4) that achieved statistical significance²² and presented a reasonable model fit (R²_{MF} = 0.116). As such, companies that have increased probability of presenting more favorable perceptions of the socio-economic crisis impacts on innovation development, on the one hand, present increased empowerment strategies and assets, and, on the other, perceive decreased pressure and discussion of strategic decision-making during innovation projects. Additionally, more favorable perceptions of the socio-economic crisis impacts on innovation are present in firms with decreased internal bureaucratic structures and procedures, and that also perceive a reduction in external bureaucracy. The model further tells us that, as for the evolution of innovation activities, the evolution of the number of competitors does not significantly contribute to perceptions of the socio-economic crisis impacts on innovation development (Table 4).

²¹ The impact of the socio-economic crisis on innovation development was perceived to be favorable in 7.8 percent; not favorable or unfavorable in 21.3 percent, and unfavorable in 70.9 percent of firms.

²² Logit Link function achieved the best statistical significance (as evaluated by the smaller value of 2LL). Cauchit, complementary log-log; negative log-log, and probit link functions also achieved statistical significance. The presumption of slopes' homogeneity was validated by the test of parallel lines ($\chi^2(5)=2.642$; $p=0.755$). Additionally, the chosen model correctly predicted the behavior of the dependent variable in 70.9 percent of the cases (observed *versus* expected).

Table 4: Estimates and Significance of the Adjusted Ordinal Model; Impacts of the Socio-economic Crisis on Innovation Development between 2010 and 2012 (*Model 2*)

<i>Model 2</i>	
<i>Impacts of the Crisis on Innovation</i>	
Dependent Variable	Estimates (St. dev) Sig.
Impacts of the crisis on Innovation	
Threshold 1	1.112 (0.223)***
Threshold 2	2.916 (0.363)***
Independent Variables	Estimates (St. dev) Sig.
Empowerment	0.558 (0.220)*
Assets	0.642 (0.223)**
cDM	-0.573 (0.223)*
Bureaucracy	-0.548 (0.203)**
Competitors	-0.009 (0.205)ns
Link Function	Logit [#]
Model Statistics	
Model Fit	p=0.000 or ***
G ² (5)	25.147
R ² _N	0.208
R ² _{MF}	0.116
R ² _{CS}	0.163
Correctly predicted	70.9%

Note: St. dev.: standard deviation; Sig.: significance; ns: non-significant;

*: $p < 0.05$;

**: $p < 0.01$;

***: $p < 0.001$;

cDM: contexts of strategic decision-making;

[#] Logit link function has the form: $\ln(\gamma/(1-\gamma))$ in which γ represents the cumulative probability that the event occurs; R²_N: R² Nagelkerke; R²_{MF}: R² McFadden and R²_{CS}: R² Cox and Snell.

Once again our hypothesis that “among innovative companies, perceptions on the impacts of the socio-economic crisis on innovation are dependent on companies’ resources (i.e., human, scientific, access to networks and financial), companies’ culture, and competitors” (Hypothesis 2), was shown to be incorrect. In fact, out of the five addressed variables, only “competitors” did not impact top managers’ perceptions of the socio-economic crisis impacts on innovation.

In addition, a comparison of the data reported in Tables 3 and 4 shows that while an increased probability of more favorable perceptions of the crisis impacts on innovation are present in firms with growing assets, and increasingly mobilizing empowerment strategies (as for the dependency relation of innovation activities on assets and empowerment strategies), these are also the firms that, in spite of the socio-economic crisis, perceive decreasing pressure in strategic decisions and present a more centralized model of strategic decision-making (in opposition with the dependency relation of innovation activities on the contexts of decision-making). Future studies should address more closely the relations between the development of innovation activities, perceptions of the socio-economic crisis impacts on innovation, the structure of firms (including the presence or absence of a centralized structure of decision-making), and firms’ cultural layer. In what regards competitors, once again, they don’t significantly frame top managers’ perceptions of the socio-economic crisis impacts on innovation.

From Present Innovation Development to the Evolution of Uncertainty in The Companies' Future

The evolution of uncertainty in the companies' future expressed on a 3-point ordinal scale shows that while only 13.1 percent of the analyzed firms decreased the levels of uncertainty; 38.8 percent witnessed no changes, and almost half of the firms (48.1%) increased their uncertainty levels. This data reveals a worrisome scenario, in which even though 78.1 percent of companies are increasing their innovation activities, 48.1 percent express uncertainty regarding their companies' future.

Our subsequent analytical procedure evaluated whether combinations of the variables empowerment; assets; contexts of decision-making; bureaucracy, and competitors could explain the evolution of perceptions of uncertainty in the companies' future. Once again, an ordinal regression was used, and statistical significance was achieved.²³ Table 5 depicts the coefficients and the significance of the adjusted ordinal model with the analysis revealing that companies with decreasing empowerment strategies, and assets, as well as with increasing discussion and pressure on strategic decision-making processes, and increasing bureaucracy, have increased probability of having experienced no changes or increases in uncertainty in the companies' future.

²³ Cauchit Link function achieved the best statistical significance (as evaluated by the smallest 2LL). Complementary log log Link function also achieved statistical significance. The assumption of slopes' homogeneity was validated by the test of parallel lines ($\chi^2(5)=6.969; p=0.223$). Additionally, the chosen model correctly predicted the behavior of the dependent variable in 64.4 percent of the cases.

Table 5: Estimates and Significance of the Adjusted Ordinal Model; Evolution of Uncertainty in the Companies' Future between 2010 and 2012 (*Model 3*)

<i>Model 3</i>	
<i>Evolution of Uncertainty in the Companies' Future</i>	
Dependent Variable	Estimates (St. dev) Sig.
Uncertainty in the companies' future	
Threshold 1	-2.855 (0.523)***
Threshold 2	0.070 (0.181)ns
Independent Variables	Estimates (St. dev) Sig.
Empowerment	-0.611 (0.212)**
Assets	-1.022 (0.256)***
cDM	1.095 (0.263)***
Bureaucracy	0.377 (0.185)*
Competitors	-0.071 (0.170)ns
Link Function	Cauchit [#]
Model Statistics	
Model Fit	p=0.000 or ***
G ² (5)	48.740
R ² _N	0.305
R ² _{MF}	0.154
R ² _{CS}	0.263
Correctly predicted	64.4%

Note: St. dev.: standard deviation; Sig.: significance; ns: non-significant;

*: $p < 0.05$;

**: $p < 0.01$;

***: $p < 0.001$;

cDM: contexts of strategic decision-making;

[#]: Cauchit link function has the form: $\tan(\pi(\tau - 0.5))$ in which τ represents the cumulative probability that the event occurs; R²_N: R² Nagelkerke; R²_{MF}: R² McFadden and R²_{CS}: R² Cox and Snell.

This data shows that even among innovative firms, if your company presents decreased assets, and empowerment strategies, firms' still perceive increased uncertainty in their future. Additionally, concomitant increases in pressure, and discussion of strategic decision-making, as well as increases in the bureaucratic processes negatively affect the perceptions of uncertainty in the companies' future. Altogether our data (Tables 3 to 5) suggest that increasing assets, and empowering strategies impact on companies' activities today (innovation), on companies' present perceptions (socio-economic crisis impacts on innovation), as well as on the ones regarding their future (uncertainty).

Finally, we assessed whether the development of innovation activities was correlated with perceptions of uncertainty in the companies' future, and with perceptions of the impacts of the socio-economic crisis on innovation development (Table 6). Indeed, our data confirms that the evolution of innovation activities is positively correlated with the impacts of the socio-economic crisis on innovation development, and negatively correlated with the evolution of uncertainty in the companies' future.

Table 6: Linking Innovation Activities with Perceptions on the Companies’ Present and Future

	Impacts of the Crisis on Innovation	Uncertainty in Companies’ Future
Evolution of Innovation Activities	0.141*	-0.121*
Impacts of the Crisis on Innovation		-0.214**

Note: * $p < 0.05$

** $p < 0.01$.

This data confirms our *Hypothesis 3* (i.e., among innovative companies, increasing innovation activities, decreases uncertainty in the companies’ future). What this data reveals is that present innovation development has impacts that transcend the specific innovation process at stake and that extend into the future.

Discussion

In summary, this paper shows that between 2010 and 2012 1) 71.2 percent of ICT services firms operating in Portugal developed innovation activities. Additionally, it is shown that companies with more empowering work environments, and increasing assets, present increased probability of having 2) augmented innovation activities; 3) more favorable perceptions of the socio-economic crisis impacts on innovation; and 4) reduced uncertainty in the companies’ future. Finally, 5) increasing innovation activities is correlated with more favorable perceptions on the socio-economic crisis impacts on innovation, and decreasing uncertainty in the companies’ future (Figure 2).

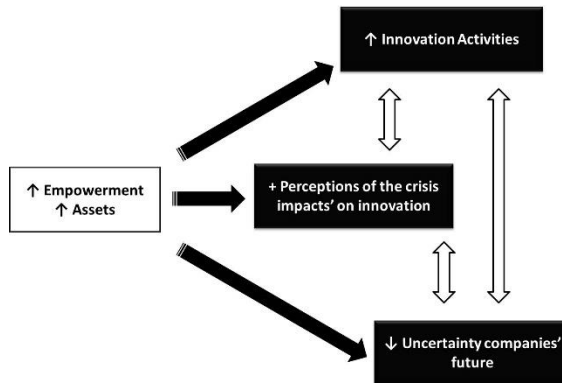


Figure 2: The present and future of innovative ICT services firms. ↑: Increasing; ↓: Decreasing; +: Favorable. One-sided black block arrows indicate that variables in the black boxes are dependent on variables in the white box. Two-sided white block arrows indicate significant correlations between variables in the black boxes.

The data gathered in this study reveals that firms operating at the most innovative sector of economic activities in Portugal are highly dependent on their access to internal and external resources, as well as on the mobilization of empowering strategies under a socio-economic crisis context. Importantly, the impacts of these variables are not only felt in present activities but extend into the future. This reveals the critical relevance of stopping this unfavorable cycle as soon as possible.

Limitations and Future Studies

This study focused on one specific sector of economic activities characterizing its internal and external contexts, and their impacts on innovation development. A follow-up study should assess in other knowledge intensive sectors that, being characterized, just like the ICT services sector,

by 1) very high frequencies of innovation activities (above 70%), and 2) in which firms were also submitted to turndowns in their economic outputs and decreases in the frequencies of innovation activities (e.g., Edition, video, radio and television; Architecture, engineering, R&D and publicity) (European Commission 2014; INE 2014), whether the contexts of innovation in these firms present similar patterns to the one just exposed. This would allow us to evaluate if the data presented hereby can be extrapolated to other organizational settings.

Another question that remains open is whether the dependence relations that were established hereby are specific of the socio-economic crisis context, or whether they can be generalized to other socio-economic settings. This is of major relevance since the organizational and political measures to be taken should consider if diverse external conditions impact the development of innovation activities.

Also, our extensive methodology did not separate the different overlapping stages of innovation progression (i.e., knowledge production, knowledge translation into artefacts, and matching of artefacts to markets needs and demands) (Pavitt 2006), in which the weight of the analyzed variables is expected to differ (e.g., R&D is expected to be highly relevant in the first stages of innovation progression, but less so, when the firms are matching the products to the markets (Oliveira 2008)). As such, a comprehensive methodology that follows innovation trajectories would also be an important avenue for future research.

Conclusion

Going beyond data showing that innovation is the prime strategy for the attainment of companies' goals, this study suggests that under a socio-economic crisis context with a still elusive end, present innovation development impacts on companies' future.

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ABOUT THE AUTHOR

Ana Ferreira: Post-doctoral Fellow, Centro Interdisciplinar de Ciências Sociais CICS.NOVA - Faculdade de Ciências Sociais e Humanas - Universidade Nova de Lisboa (CICS.NOVA.FCSH/UNL) Avenida de Berna, 26 C, 1069-061, Lisboa, Portugal.

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