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Innovation Intensity: From IT Use and Innovative Culture to Organizational Performance

Completed Research Paper

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Abstract

Drawing from past research on information technology (IT) use, organizational culture, and innovation, the present study tests a model exploring the effects of collaborative and experiential culture as well as internally and externally-focused use of IT on innovation intensity and organizational performance. As the innovation process is complex and uncertain, we try to open the black box of innovation intensity by exploring the roles played by the use of IT and the innovation culture. The research model was tested via a structural equation model using PLS with data collected from 395 top executives. Results indicate that intense use of internally and externally-focused IT positively affect innovation intensity. The results also show that collaborative culture increases innovation intensity. In turn, innovation intensity increases both operational and financial performance.

Keywords: IT Use, Innovation culture, Innovation intensity, Organizational performance

For most organizations, innovation is synonym of growth, competitive advantage, productivity, and survival (Anderson et al. 2014; Tushman and Nadler 1986). To stimulate innovation, managers deploy organizational, financial, commercial, scientific, and/or technological resources and infrastructures to generate product, process, and/or service innovations (Barrett et al. 2015; Lusch and Nambisan 2015; Tanaka et al. 2005). Nevertheless, managers face many challenges while innovating such as balancing efforts between innovation exploitation and exploration (Benner and Tushman 2003). They are under continuous pressure to reduce the cost and time needed, forcing them to look for new ways of innovating (Nambisan 2013). Although there is much talk about open, collaborative, disruptive, and global innovation (Chesbrough 2006; Christensen et al. 2015), innovating is still challenging for most organizations as it can be hampered by external factors, e.g. stifling regulations, as well as by internal factors, e.g. limited tools and resources or working environments non-supportive to innovation (Hamel 2006; Van de Ven 2017).

In the last two decades, the nature of innovations has changed with the reduction of the information processing and communication costs, the network effects, the ability to scale up rapidly because of information technology (IT), as well as with the increased modularity of services and products enabled

by digitization and the Internet (Barrett et al. 2015; Hünermund 2017; Nambisan et al. 2017). Traditionally, innovation has taken place within organizational boundaries, with a focus on structure, hierarchy, control, and partners selection. More recently, technological progress has allowed organizations to engage and exchange with communities outside the organizational boundaries. This forced them to reconsider their innovation culture and how it affects innovation (Benner and Tushman 2015; Ishak 2017; Leavy 2005).

Organizations deploy IT infrastructures to help employees acquire, select, generate, and distribute the knowledge needed to innovate within and outside the organizational boundaries (Lakhani et al. 2013). For this approach to work, employees must work in contexts that embrace change, promote exchanges, encourage different points of view, and accept failures (Büschgens et al. 2013). In short, the context in which employees evolve must foster innovation, as culture is a primary determinant of innovation and lies at the core of innovation (Ahmed 1998; Tushman and O'Reilly 1997). However, there is a dearth of studies which have looked at the relationships between an organization's innovation culture (Dobni 2008) and its use of IT on its organizational performance.

Drawing from past research on IT use, organizational culture, and innovation, the present study tests the effects of collaborative and experiential cultures as well as internally and externally-focused use of IT on innovation intensity and organizational performance. As the innovation process is complex and uncertain, we try to open the black box of innovation intensity by exploring the roles played by the use of IT and the innovation culture. The hypotheses were tested via a structural equation model using PLS with data collected from 395 top executives. Results indicate that intense use of internally and externally-focused IT positively affect innovation intensity. The results also show that collaborative culture increases innovation intensity and, in turn, innovation intensity increases operational and financial organizational performances. The paper's next section highlights the importance of innovation, IT use, and presents an overview of the collaborative and experiential cultures. The research model and hypotheses are developed followed by a description of the data collection. Findings are presented along with their theoretical and practical implications.

Theoretical Background

An innovation is defined as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations” (Tanaka et al. 2005, p.46). Innovating is a continuous, uncertain, dynamic and complex process (Anderson et al. 2014). Most successful innovations do not result from radical innovations but follow from the cumulative effects of smaller and incremental changes (Tushman and Nadler 1986). They stem from the creative combinations, throughout organizations, of existing methods, ideas, and technologies. Innovative organizations create working environment and conditions, which will allow employees to do today's work, “while simultaneously generating tomorrow's innovation” (Tushman and Nadler 1986, p.78). Successful and innovating organizations navigate through this tension by supporting an organizational culture that promotes and stimulates innovation as well as by ensuring that employees have the proper tools to innovate (Anderson et al. 2014; Nambisan et al. 2017).

Innovation in the IS Field

In the IS field, several innovation studies have been guided by the idea that organizations which have greater innovation-related needs and abilities will generate a greater “quantity” of innovation (Fichman 2004). This widely held view has yielded key insights regarding the management, the propagation, and the evaluation of innovations (Anderson et al. 2014; Fichman 2004). This paper contributes to this stream of research in IS by focusing on innovation intensity. The concept of innovation intensity captures the extent of efforts deployed by organizations regarding new or significantly improved: 1) products or services, 2) production or distribution methods, 3) marketing methods, and/or 4) business practices, organizational structures or external relationships (Fichman 2004; Tanaka et al. 2005).

When studying innovation, researchers must remember that “innovation is not just about new technology and spending more money” (Ashurst 2015, p.368). Innovation does not necessarily require entirely new processes or technology because there are “potential innovation to be made in creatively combining (and making use of) inventions that we already have” (Brynjolfsson and Saunders 2009, p.95). These days, organizations and employees have access to a wide variety of technologies which are already in place but which have barely begun to be exploited to generate innovations (Ashurst 2015).

One area for which more research is needed is how IT is used by employees to innovate. As knowledge is a central element of the innovation process (Amabile et al. 1996), it is essential to better understand how employees use the IT available to search, collect, stock, transfer and learn from various knowledge sources (Anderson et al. 2014; Van Wijk et al. 2008). Furthermore, by using IT in novel or unexpected ways, employees can also generate innovations which can be exploited subsequently (Ashurst 2015). Common sense suggests that it is not enough for organizations to develop and implement IT infrastructures to innovate. Employees must use these IT, but they also must evolve in a context which will support them in their innovative efforts (Ishak 2017; Maloney et al. 2016).

Most IT can be considered as intellectual tools because functionalities are not entirely pre-determined and they can be transformed endlessly by individuals using them (Lee 1999). However, for employees to “innovate endlessly” with IT, they must work in a context where the organizational culture value risk taking, creativity, teamwork, freedom, trust and respect (Ahmed 1998; Dobni 2008). Employees must evolve in an organization with a solution-oriented mindset, where principles, processes and practices support the generation, adoption, implementation and incorporation of new ideas, practices and artefacts, i.e. an organization with an innovative culture (Brettel and Cleven 2011; Ishak 2017). An innovation culture can be defined as a: “multi-dimensional context which includes the intention to be innovative, the infrastructure to support innovation, operational level behaviors necessary to influence a market and value orientation, and the environment to implement innovation (Dobni 2008)”. Two key dimensions of an innovation culture which stimulate and support innovating are the collaborative culture (Barczak et al. 2010) and the experiential culture (Hornsby et al. 2002).

Research Model

Consistent with past studies (Trantopoulos et al. 2017), as well as with the idea that creatively combining and using IT, in a collaborative and supportive context, could generate innovation (Ashurst 2015; Brynjolfsson and Saunders 2009), we hypothesize that 1) the use intensity of internally and externally focused IT as well as 2) collaborative and experiential culture will positively influence an organization’s level of innovation intensity. Furthermore, this innovation intensity will positively influence operational and financial performance of an organization.

Internal and External IT¹Use Intensity Effects and Innovation Intensity (H1 and H2)

Innovation usually emerges at the intersection of various specialized domains and effectively managing knowledge exchange across these domains’ boundaries provide organizations with a competitive advantage (Leonard-Barton 1995). These specialized domains can be within and/or outside an organization. Employees can use IT to facilitate, broaden, and accelerate access to knowledge across domains and share each other’s domain specific-knowledge more easily. Thus, when innovation is desired, IT can be used to transfer, translate, and transform knowledge across domains (Carlile 2004).

IT encompasses digital tools which could both trigger and/or enable innovation by, for instance, initiating the deployment of new innovative business routines, enabling the development of new products, generating new affordances, or collecting useful knowledge (Nambisan 2013). Nambisan et

¹Any IT can be used to realize a multitude of actions as it offers different affordances to its users (Majchrzak and Markus, 2013). As the knowledge needed to innovate can be found within or outside an organization’s boundary, a list of IT, commonly used in organizations, have been identified and separated based on whether that are used to mainly support internally-focused, i.e. within an organization’s boundary, or externally-focused, i.e. outside an organization boundary, activities.

al. (2017) argue that innovation outcomes, which do not need to be digital, are made possible through the use of IT. For instance, Dougherty and Dunne (2012) showed how the use of new digital tools by scientists working on drug discovery created new forms of knowledge that generated insights for complex innovations which, otherwise, could not have existed. The use of such IT led to creation and reorganization of innovation activities amongst scientists.

Nambisan et al. (2017) also argue that technology use could be considered as “sets of affordances and constraints for particular innovating actors (p.230)” and can help better understand why existing IT can be repurposed by different actors, in different contexts, to generate solutions to innovation problems (Zammuto et al. 2007). For example, Saldanha et al. (2017) described a case where CRMs provided organizations with relational information processing capabilities which helped increase the probability of eliciting innovations from their clients.

Based on an information processing perspective (Galbraith 1974), the use of IT can support employees’ sharing and accessing knowledge across internal organizational boundaries. IT can also be used to help create a shared understanding between employees with different specialized knowledge domains and thus facilitate sharing and using knowledge across boundaries (Bittner and Leimeister 2014). For example, videoconferencing and collaborative platforms can help knowledge transfer between employees from different areas. Business intelligence applications or data exploration tools can also be used to transform data into knowledge and generating insights extracted from data. Thus, the more IT are used to gather knowledge and ideas to generate innovations, the greater should be the “quantity” of innovations generated (Carlile 2004; Fichman 2004). Hence :

H1: Internal IT use intensity² will positively influence the level of innovation intensity.

Several researchers argue that innovation development requires the creation, assimilation, and integration of knowledge (Benner and Tushman 2015). This required knowledge exists, not only within one individual, team, or organization, but within a knowledge network which cross the increasingly porous organizational boundaries (Anderson et al. 2014). Also, to seek and identify innovative opportunities, employees need to engage with external partners and resources (Brettel and Cleven 2011). As such, the use of IT can facilitate the development and maintenance of external collaborations. Sarantopoulos et al. (2017) showed that organizational IT infrastructures could be used to absorb external knowledge and improve the innovation process performance.

Lyytinen et al. (2016) argue that IT “increase innovation network connectivity by 1) reducing communication costs and increasing its reach and scope and 2) increase the speed and scope of digital convergence, which increases network knowledge heterogeneity and need for integration (p.47)”. Thus, an increased use of externally-focused IT can help employees access, more rapidly, a broader and deeper pool of knowledge which could potentially trigger innovations. Some internally-focused IT can be used to work on both exploitative and exploratory innovations within an organization (Benner and Tushman 2003) and were considered in the development of H1. However, since “the digital revolution push the locus of innovation beyond the boundaries of firm” (Benner and Tushman 2015, p. 498), more externally-focused IT could be used to stimulate innovation by searching, collecting, transferring and learning from external knowledge sources. Hence:

H2: External IT use intensity will positively influence the level of innovation intensity.

Collaborative Culture and Innovation Intensity (H3)

Innovation usually requires collaboration among a collection of actors. Collaboration improves knowledge sharing and organizational effectiveness (Nambisan et al. 2017; Pérez López et al. 2004). Innovation benefits from knowledge sharing between employees but also with external actors by using various IT and digital platforms (Nambisan et al. 2017). To stimulate innovation, an organization must

² Internal IS use intensity represents the intensity level to which, an organization had used its IT to support its internally-focused processes and activities whereas external IS use intensity represents the intensity level to which, an organization had used its IT to support its externally-focused processes and activities. The focus here is on the use intensity rather than on the nature of UT used (Ke et al. 2012).

develop an open and collaborative environment which inspires employees and incentivizes cycles of innovation (Lacity and Willcocks 2013). Thus, it must develop a collaborative culture which includes support for adaptability, open communication, respect, teamwork, and diversity (Barczak et al. 2010).

Several researchers (Ahmed 1998; Brettel and Cleven 2011; Pérez López et al. 2004) argue that organizations which create and support collaborative contexts will generate more innovations. In a collaborative culture, employees are encouraged to learn from each other since it is through learning that an organization can innovate and improve its performance (Pérez López et al. 2004). Martin and Terblanche (2003) also argue the cooperative teams influence innovation as they allow diversity and individual talents to complement one another and favor the exchange of technical and social knowledge. In addition, in a collaborative culture, employees' knowledge and skills are more likely to be up to date and known by the other employees. Thus, a collaborative culture favors progress and stimulates innovation as it is a mean "to leverage knowledge through organizational learning" (Pérez López et al. 2004, p.101).

Barczak et al. (2010) showed that collaborative culture is a strong predictor of creativity and innovation. Svahn et al. (2017) noticed that, to embrace digital innovation, organizations must develop their employees' relationship skills and competencies to collaborate both internally and externally. Finally, Pérez López et al. (2004) indicated that collaborative culture positively impact organizational performance as well as organizational learning. Hence:

H3: *An organization's collaborative culture will positively influence the level of innovation intensity.*

Experiential Culture and Innovation Intensity (H4)

Innovating is often associated with entrepreneurship as it "is the managerial process for creating and managing innovation" (Drucker 2014, p. xiii). Innovative organizations are those who create an experiential culture that encourages initiatives and support innovation momentum (Ikeda et al. 2016). They are also conscious that innovation requires "continuous injections of news ideas and initiatives" (Ikeda et al. 2016, p.17) and that to stay ahead of the competition, they have to innovate constantly and intensively. Such organizations give their employees the time and space to innovate. They support and encourage employees to try new things in order to generate new ideas and artefacts. They also provide incentives, visibility, and recognize the efforts made by employees to tryout things.

In an organization with an experiential culture, Dobni (2008) argues that uncertainty is view as an opportunity, and not as a risk. In such context, employees are empowered to experiment. They have the possibility to "improvise and enact at will" (Dobni 2008, p.551). Further, they are given the time/opportunity to develop their creative potential and they are encouraged to do things differently. In an experiential culture, employees must also feel emotionally safe to freely debate issues, express their viewpoints and let new ideas surface easily (Ahmed 1998). Employees must also have the freedom to define and execute their own work, to challenge the status quo, to try things and fail, to experiment and not to be punished for failure (Ahmed 1998; Hornsby et al. 2002).

In addition, experiential culture supports innovation by: rejecting or at least limiting practices and behaviors that hinder innovation such as control, predictability, rigidity and stability (Dobni 2008; Martins and Terblanche 2003). Hence:

H4: *An organization's experiential culture will positively influence the level of innovation intensity.*

Innovation Intensity and Organizational Performance (H5)

The link between innovation and organizational performance goes back to Schumpeter's creative destruction (Schumpeter 1942). Innovation has been linked with increased firm performance through studies in economics and management (Abernathy and Utterback 1978; Anderson et al. 2014; Geroski et al. 1993; Rosenbusch et al. 2011; Uzkurt et al. 2013). Organizations innovate to generate growth, gain competitive advantage, increase productivity or simply to survive. Innovation is linked to different performance facets and seems to contribute to both internal and external performance (Anderson et al. 2014). Some authors assessed the linkages between innovation and internal performance or efficiency

measures (Damanpour et al. 1989) while others linked innovation with external performance, comparing innovators with non-innovators (Geroski et al. 1993).

Internally-focused performance measures are usually related to operations and processes efficiency while externally-focused measures are usually related to broader economic considerations such as, for instance, financial valuation by shareholders or market share (Kaplan and Norton 1996; Richard et al. 2009). To reflect the influence of innovation on these two facets of performance, several studies assessing the impact of innovation on performance measured both types of performance in their research design (Bowen et al. 2010; Damanpour et al. 2009; Subramanian and Nilakanta 1996). Fichman (2004) argues that “the quantity of innovation directly determines performance impacts (p.344)”. Hence:

H5a: Organizational innovation intensity will positively influence the level of operational performance.

H5b: Organizational innovation intensity will positively influence the level of financial performance.

Methodology and Data Collection

To test the hypotheses, a data collection was conducted using a web questionnaire and conducted in collaboration with the CEFRIO³, an important IT research center in Canada. Invitations to complete the survey were sent to 1800 IT managers who subscribe to the CEFRIO’s newsletter. Respondents were promised personalized feedback if they agreed to complete the questionnaire. After completion of the questionnaire, the respondents received a summary of their scores on the various dimensions.

Most of the measures used to test the research model were adapted from existing ones and are presented in Appendix. As several organizational-related contextual elements can affect innovation, three control variables were included to capture these influences: perceived IT self-efficacy, customer sensing capability, and customer responding capability (Compeau and Higgins 1995; Roberts and Grover 2012). Perceived IT self-efficacy is defined as the individual's beliefs about their capabilities to use IT to conduct their organizational tasks. The wording of each item was assessed by researchers and practitioners to ensure clarity in the context of innovation. A web questionnaire company built the survey instrument and extensive tests were conducted to ensure respondents had an easy time filling it.

In total, 395 usable responses were received for a response rate of about 22%. The respondents were part of senior management. They were owners or president (39,9%), Vice President (5.3%), COO (9.2%), CIO or Director of IT (17.6%), Director of another function (27.9%). Respondents had been in their current function for an average of three and a half years. Sixty five percent were male; 35 percent were female. They came from a wide variety of industries, which strengthen the confidence we can have in the representativeness of the data.

Table 1 includes key indicators for reliability, convergent and discriminant validity. The rho coefficients are all above the 0.7 threshold. The average variance extracted generally follows the desirable 50% minimum, except for two measures comprising a lot of items. The minimum extracted is 43%, which remain acceptable. The comparison of the square root of the AVE with the correlation coefficient reflects the expected pattern (Geffen, Straub, and Boudreau, 2000). Two correlations are very high: the correlation between the use of IT for internal purposes and for external purposes, and the one between collaborative culture and experiential culture. The first one is above the square root of the AVE of a corresponding measure. Interestingly, this reflects the grouping of the variables (IT use intensity and innovation culture) in the development of the hypotheses. Internal use and external use of IT do not vary totally independently. Also, collaborative culture and experiential culture are not completely independent constructs.

When assessing individual item loadings, items that did not reach the .5 threshold were dropped. These were very few. Email and office-like software was dropped from the list of technologies (basically because it did not vary; every firm had it for everyone). Intranet and ERP/CRM were also dropped from

³ <https://cefrio.qc.ca/en/>

the list of internal technologies. One of the 10 item in IT self-efficacy had a loading of .46 and was dropped.

Table 1. Reliability indicators, correlation, and AVE

Variable	Rho	AVE	1	2	3	4	5	6	7	8	9	10
1. Innovation intensity	.84	.57	.75									
2. Operational Performance	.86	.55	.41	.74								
3. Financial Performance	.90	.63	.28	.55	.79							
4. Internal IT Use Intensity	.91	.43	.45	.43	.36	.66						
5. External IT Use Intensity	.84	.56	.44	.45	.29	.74	.75					
6. Collaborative Culture	.93	.63	.40	.55	.25	.45	.44	.79				
7. Experiential Culture	.89	.55	.37	.53	.27	.43	.45	.73	.74			
8. Perceived IT self-efficacy	.89	.48	.26	.26	.15	.39	.34	.44	.42	.69		
9. Customer Responding Cap.	.95	.79	.34	.57	.28	.39	.36	.63	.61	.36	.89	
10. Customer Sensing Cap.	.93	.74	.36	.53	.27	.46	.47	.60	.62	.31	.68	.86

Results

PLS-Graph was used to test the model proposed (version 3.0, build 1130). Four of the five hypotheses are supported (See Figure 1). IT use intensity, both internal and external (H1 and H2) had a positive and significant influence on innovation intensity. Collaborative culture was also found to have a positive and significant influence on innovation intensity (H3). Innovation intensity had a positive and significant influence on operational performance (H5a) and financial performance (H5b). The only hypothesis that was not supported was the one linking IT experiential culture with innovation intensity (H4). There was no observable link between the two variables. None of the control variables were significant⁴.

Considering the correlation between collaborative culture and experiential culture, the model was also tested removing collaborative culture to see if experiential culture would be significant when used as the only component of innovation culture. The resulting coefficient was weak (only 0.109, with a T-value of 1.79 (reaching the 5% significance threshold for a one-tailed test). Conversely, just including collaborative culture leads to a path of 0.172 with a T-value of 3.17. This reinforces the confidence in the results showing that collaborative culture is the component of innovation culture having the strongest influence on innovation intensity.

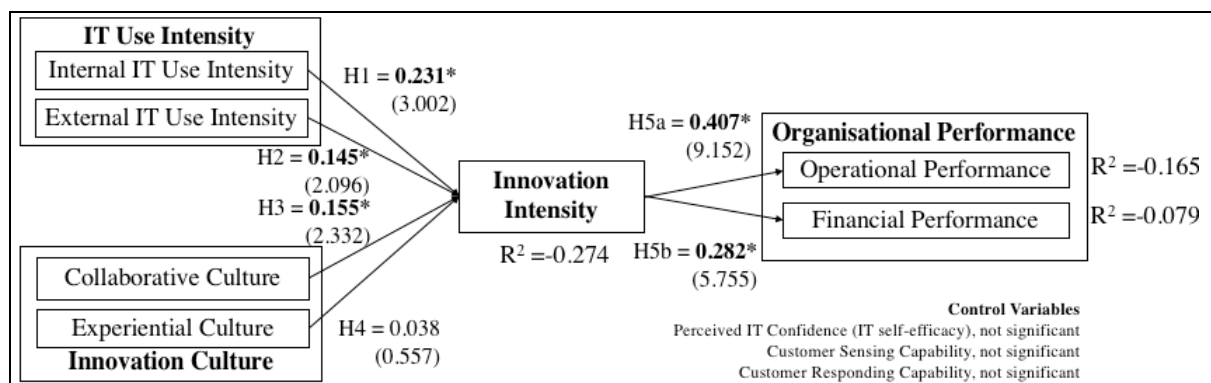


Figure 1. Results

⁴ Additional tests were conducted to evaluate the possible interactions effects between IT use intensity and innovaton culture but the results were non significant.

Discussion

Innovative initiatives are constantly facing resource pressures and can be hampered by external and internal factors (Hamel 2006). Moreover, the drop in search and transaction costs, the network effects and the ability to scale up rapidly with IT have changed the ways in which organizations innovate (Benner and Tushman 2015; Nambisan et al. 2017).

As little research examined how IT use and innovation culture affect innovation intensity, the present study explores the effects of internal/external IT use as well as the effects of the collaborative and the experiential cultures on innovation intensity. Since the “ultimate outcomes or benefits of innovation with IT are rarely considered in studies within the dominant paradigm” (Fichman 2004, p. 317), the study assesses the effects of innovation intensity on operational and financial performance.

Implications

The results support the idea that IT use intensity and collaborative culture positively affect innovation intensity which, in turns, improves organizational performance. Indeed, we observed significant direct and positive effects of both internal IT use intensity (H1) and external IT use intensity (H2) on innovation intensity. The results support Nambisan’s et al. (2017) argument that innovation is made possible through the use of IT and digital technologies.

A possible explanation for this result can be that, as a wider variety of IT is used by a larger group of employees (measured here by IT use intensity), the greater are the probabilities that employees will discover new features and/or will experiment with IT in creative ways (Liang et al. 2015). By exploring and identifying new affordances (Majchrzak and Markus 2013), employees become better at integrating IT into their work and using them to collect and share knowledge and ideas. Thus, employees might use the IT infrastructure more effectively, develop new ways of working and generate IT or non-IT innovations. This suggests that the breadth of IT use provided by the variety of available technologies can help generate innovations in addition to and above the depth of IT use assessed in previous studies (Burton-Jones and Grange 2013; Liang et al. 2015). Thus, intensively using a wider variety of IT can generate possible affordances to innovate (Majchrzak and Markus 2013; Zammuto et al. 2007).

Another possible explanation for the positive effects of IT use intensity on innovation intensity can be that, as a wider variety of IT is used by employees, the employees become more competent at transferring, translating and/or transforming of knowledge to generate innovations (Carlile 2004). Since innovation emerges at the intersections of various specialized domains (Leonard-Barton 1995) and that innovation requires knowledge exchange, assimilation, and integration between various domains (Benner and Tushman 2015; Tushman and Nadler 1986), the more intensively IT is used, the higher are the chances that knowledge will cross boundaries, internal or external. It has a higher chance to support internal and external collaborations (Svahn et al. 2017; Trantopoulos et al. 2017). Thus, organizations who want to stimulate innovation could implement incentives to use IT more intensively.

One interesting observation as to do with the high correlation observed between the use of IT for internal and external purposes. Separating the two types of uses can be interesting from a conceptual perspective and helpful in refining our understanding of the different types of possible uses. However, from a practitioner point of view, little distinction seems to be made between the internal and external boundaries when it comes to IT use (Levina and Vaast 2008). This suggests that that IT use intensity could probably be investigated as a single construct in future studies.

Some technologies may be used for both internal and external purposes, so it may be the distinction itself that is not very meaningful. Or it may be that some components are repurposed from one intended usage to another. It could also be that using one type of technology increases the IT skills of employees who reuse the skills to use other technologies. Further studies could analyze common skills enabling the use of different IT tools.

As far as collaborative and experiential culture are concerned, we found a significant direct effect of collaborative culture on the innovation intensity (H3) but no significant effect of the experiential culture (H4) on motivation intensity. One possible explanation for these results can be that, to innovate, it is

not so much the extent to which employees feel safe to take risk, to challenge the status quo, to try things, to experiment, or not to be punished for failure, but rather the impression they have regarding the support they receive from the organization and their colleagues to openly communicate, to socially interact, to share knowledge, to cherish diversity, to foster teamwork as well as to support and respect one another.

Whereas collaborative culture as more to do with the values and beliefs underlying the nature of social interactions (Pérez López et al. 2004), the experiential culture as more to do with the values and beliefs related to the tolerance and freedom to perform innovative behaviors (Ahmed 1998). Thus, when focusing on innovation initiatives, collaborative culture is related to the “*with who*”, i.e. the individuals with whom an employee will interact to share knowledge, to exchange insights and to serve as a sounding board for its ideas, whereas the experiential culture is related to the “*where*”, the space created, in terms of structure, policies and practices, to allow the exploration and the experimentation of new ways of working or new artefact. Based on the study’s results, it seems that the knowledge accumulated and the idea generated by interacting with other individuals is more germane to intensively innovate than the tolerance and freedom atmosphere created within an organization. Thus, it seems that, when innovating, humans are more than ever social animals.

Regarding organizational performance (H5), the results support Fichman’s (2004) claim who argues that “the quantity of innovation directly determines performance impacts (p.344)” as well as previous studies in economics and management (Abernathy and Utterback 1978; Geroski et al. 1993; Rosenbusch et al. 2011). Indeed, the results also show that innovation intensity positively influence both operational and financial performance measures. Operational performance, which is assessing internal processes, is easier to observe for respondents. It may explain why the effect of innovation on operational performance is very strong (a coefficient of 0.407) and the variance explained is approximately 17%. Financial performance, on the other hand, is more subject to be influenced by other factors (notably actions from competitors) so while the coefficient is still strong, the variance explained is lower. It would be interesting to conduct a longitudinal study to analyze the progression of performance over time. It is reasonable to think that the effect of innovation on operational performance may be more immediate (thus more observable), and that the effect of innovation over financial performance happens over a longer period.

As organizations seek to increase their performance, the results reinforce the importance of innovating for practitioners. Innovation is an important driver of performance, both for internal efficiency and for competitiveness. The role of IT in the innovation process is not trivial. It allows information, knowledge, and idea sharing. Managers should ensure that their employees have a wide array of tools to increase both internal and external information exchanges. Results also indicate that managers should develop and nurture an organizational context that promotes and stimulates innovation as well as collaborative teamwork.

Limitations

Some limitations of the present study need to be acknowledged. First, the cross-sectional nature of our data limits our ability to explore how the interactions between IT use intensity, collaborative culture, and experiential culture might have changed the organizational innovation intensity levels (Burton-Jones 2009). We can only observe the variance patterns. Furthermore, we can only assume causality of the relationships studied (Antonakis et al. 2014). There is a possibility that these relationships may occur in reverse order. High performing organizations may spend excess cash flows on IT. Second, even if perceptual measures of performance have been used in previous studies (Ramamurthy et al. 1999; Subramanian and Nilakanta 1996), using such measures can be affected by two methodological problems: the pro-innovation bias (e.g. the assumptions that innovation are beneficial) or the fact that respondent might have participate or be in charge of the innovative efforts (Fichman 2004). To minimize the possible undesirable effects of these problems, the survey was completed by top executives who, generally, are not the key responsible of bringing innovation into the organization. Furthermore, to limit the possible effects of the pro-innovation bias and the social desirability, the performance measures questions were framed in a way that operational and financial performances are

established in relative terms, i.e. by comparing with the main competitor rather than evaluating it in the absolute. Nevertheless, it has been shown that, using perceptual measures to capture performance was an appropriate and useful way as perceptual measures satisfy the requirements of reliability and validity (Ketokivi and Schroeder 2004). Thirdly, in terms of IT use, not distinction was made between IT exploration activities and other activities using IT to simply complete tasks (Liang et al. 2015). Such distinction might have helped better discriminate between the IT types mostly used to explore and those used to execute tasks. Such, distinction could be studied in future research.

Conclusion

The present study is one of the few to examine the influence of IT use intensity and innovation culture on innovation intensity. Examining the influence of IT use intensity and innovation culture, we found that both internal and external IT use intensity positively influence innovation intensity. Further, we also observed that collaborative culture positively influences innovation intensity. Finally, organizational performance seems to be positively affected by the level of innovation intensity. These findings provide, to the IT and innovation literature, a novel and complementary perspective by underlying the central role played by IT use intensity and collaborative culture in the innovation process. The results show that, by deploying a variety of IT for staff who evolve in an organizational context that promotes innovation and collaboration, organizations should increase their level of innovation intensity and ultimately their organizational performance. We hope that these findings can provide a useful step towards a better understanding of the role played by IT use and collaborative culture in the organizations' quest for innovation.

Appendix – Measures⁵

Internal IT Use Intensity (developed for the study)

For each category, what use did your company made regarding the following technologies to support internally-focused processes and actions in the past 12 months (proportion of employees using it)?

1. "No use" means that the technology has not been implemented within your organization.
2. "Not at all Intensive" means that <10% of your employees use it.
3. "Low Intensive Use" means that between 10% and 25% of your employees use it.
4. "Intensive use" means that between 25% and 50% of your employees use it.
5. "Very intensive use" means that 50% or more of your employees use it.

IT Categories

1) Mobile applications such as applications for iPhone, Android or Blackberry, or iPad; **2)** Office suites such as Microsoft Office, Apple iWork, Linux OpenText (dropped); **3)** Management software packages such as ERP, CRM, SCM (dropped); **4)** Electronic Document Management (EDM); **5)** Intranet (dropped); **6)** Web conferencing tools (e.g., webEx, Skype, Google Hangout) or videoconferencing system (e.g. Cisco); **7)** Collaboration platform such as SharePoint, Oracle Collaboration Suite or Alfresco; **8)** Project management software such as Microsoft Project, MacProject or Project-Open; **9)** Collaborative FAQs; **10)** Instant messaging; **11)** Wiki, discussion forums or social networks for internal collaboration; **12)** "Big Data" storage; **13)** Data exploration (Data Mining); **14)** Applications such as 'Web', 'Social', 'Predictive' or 'Video Content' Analytics; **15)** Business Intelligence applications; **16)** Cloud computing for data storage; **17)** Computing for applications (e.g. SaaS)

External IT Use Intensity (Developed for the study)

In its relationships with customers, partners and suppliers, how does your company have used the following technologies, for each category, in the past 12 months? (proportion of employees using it)?

1. "No use" means that IT has not been implemented in your exchanges with your customers, partners and suppliers.
2. "Not at all intensive" means that <10% of your trade with your customers, partners and suppliers is through this IT.
3. "Low intensive use" means that between 10% and 25% [idem as above].
4. "Intensive use" means that between 25% and 50% [idem as above].
5. "Very intensive use" means that 50% or more [idem as above].

⁵ Due to space limitation, the control variables' measures are not presented here but could be provided on request.

IT Categories

1) E-mail (dropped – there was no variance, almost all employees had email); **2)** Websites; **3)** Mobile Applications such as applications for iPhone, Android or Blackberry, or iPad; **4)** Social networks for external collaboration; **5)** Web conferencing tools (e.g., WebEx, Skype, Google Hangout) or videoconferencing system (e.g. Cisco)

Collaborative Culture (Pérez López et al. 2004)

In your organization, ... (1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Strongly agree)

1. ... Employees consider change to be natural and necessary.
2. ... The management team considers employees as an asset and tries to appreciate them continuously.
3. ... Employees who experiment and take reasonable risks are well-considered even if they should be mistaken.
4. ... The preservation of different points of view is encouraged.
5. ... The opinions and contributions of all are respected and appreciated.
6. ... Problems are discussed openly, to avoid finding culprits.
7. ... Collaboration and cooperation among the different duties and departments is encouraged.
8. ... All employees know the expectations of management team.

Experiential Culture (Hornsby et al. 2002)

In your organization, ... (1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Strongly agree)

1. ... Employees are allowed to make decisions about projects without elaborate justification or approval procedures.
2. ... Funding is often available to start new project ideas.
3. ... Employees with innovative and successful projects receive recognition and benefits for their ideas and efforts, beyond the reward system already in place.
4. ... There are several options available for employees within the organization to obtain financial support for their innovative projects and innovative ideas.
5. ... An employee who has a good idea is often given time to develop this idea.
6. ... The development of ideas is encouraged for the improvement of the company.

Innovation intensity (Tanaka et al. 2005)

The following questions identify the changes your company / organization has made in the past 12 months. Over the past year, ... (1 = Not at all, 2 = Limited, 3 = Extensively, 4 = Extensively)

1. ... have you introduced new or significantly improved products or services in terms of their characteristics or the intended use? This includes significant improvements in technical specifications, components and materials, embedded software, usability, or other functional features (Product innovation).
2. ... have you implemented a new or significantly improved production or distribution methods? This includes significant changes in techniques, hardware and / or software (Process innovation).
3. ... have you implemented a new marketing methods involving significant changes in the design or packaging, placement, promotion or pricing of your products (Marketing innovation)?
4. ... have you implemented new business practices, a new workplace organization, a new organizational structure, or new external relationships (Organizational innovation)?

Operational Performance (adapted from Hudson et al. 2001)

Please indicate your perception of your organization's performance. Compared to your main competitors, ... (1 = Very lower / poorer / ineffective / longer; 2 = Fairly lower / poorer / longer, 3 = Similar, 4 = Pretty higher / ... / shorter, 5 = Very Higher / ... / shorter)

1. ... the quality of our products and services is...
2. ... the quality of our processes is...
3. ... the quality of the inputs provided by our suppliers and our collaborators is...
4. ... our work in progress is progressing...
5. ... our production / service time is...
6. ... our delivery times...

Financial Performance (adapted from Venkatraman 1989)

Please indicate your perception of your organization's performance. Compared to your main competitors, ... (1 = Very lower 2 = Fairly lower, 3 = Similar, 4 = Pretty higher, 5 = Very Higher)

1. ... the growth of our organizational sales is...
2. ... our return on investment is...
3. ... our market share gains are...
4. ... our net profit is...
5. ... our financial liquidity is...

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