Barriers to Mission-Critical Open Source Software Adoption by Organizations: A Provider Perspective

Completed Research Paper

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ABSTRACT

While open source has long been increasing in the infrastructure software domain, few organizations have adopted open source for mission-critical software application. We use the Delphi method to investigate barriers to mission-critical OSS adoption as perceived by two panels of experienced providers in France (n= 18) and in Canada (Quebec) (n= 11). On average, panelists have 15 years of experience in the software industry including 9 years with open source software. By comparing the barriers selected by each group, zones of concordance and discordance are identified. We complement the open source adoption literature by adding new insights to the existing body of knowledge dominated by client perspective alone. We also anchor our findings in the extant literature by comparing our results with those of previous studies.

Keywords

Mission-critical application, open source software, adoption, barriers, international Delphi.

INTRODUCTION

The information and communication technology (ICT) sector is playing an increasing role in the economy of most developed countries and the information economy market is now in the range of 10% of GDP, and accounts for more than half of their economic growth (UNU-MERIT 2006). The software industry is one of the key elements driving ICTs' role in the economy (op cit, 2006) and "Software is becoming critical for almost every company's performance" (McKinsey, 2013). In fact, the global trade in intellectual property (IP) licenses alone is worth more than 900 billion US dollar a year that is about 5% of world trade and rising (Hargreaves, 2011). At the same time, the structure, competitiveness, and performance of the ICT industry has potential to be strongly affected by Open Source Software (OSS) (Merrill Lynch, 2001) which has emerged as one of the most important IT trends in the 21st century (Forrester, 2007). For instance, the contribution of open source to Europe's economy is estimated to be 450 billion euro per year (Daffara, 2012). Thus, it comes at no surprise that OSS has emerged as a phenomenon that simultaneously presents cultural, economic, societal, technological, legal, ethical, moral, and political implications.

As more and more organizations adopt OSS (Niederman, Davis, Greiner, Wynn and York, 2006), this phenomenon has grown beyond infrastructure software in horizontal domains to IS applications in vertical domains (Fitzgerald, 2006), and has now reached the domain of mission-critical software such as enterprise system software like ERP (Olson and Stanley, 2012), and Electronic Medical Record (EMR) (Webster, 2011). Mission-critical software are defined as: "Business applications, excluding email, that would bring a company to a stop if they were not running" (IDC, 2009, p. 3). In other words it directly impacts on the organization ability to achieve its mission and goals.

Two different trends can be observed currently. On the one hand, OSS market is substantial and increasing for some software segment such as Web server (for instance Apache), and operating system (for instance Linux Server). On the other hand, OSS is staying behind proprietary software in other segment such as client operating systems (for instance Linux Workstation), office productivity software (for instance OpenOffice), and mission-critical software such as ERP and EMR (Wheeler, 2011). Given that 1) a number of OSS characteristics make them particularly attractive to organizations (Bradbury, 2006), including the potential for reducing the total cost of ownership and vendor lock-ins when compared with other alternatives (Nagy, Yassin, and Bhattacherjee, 2010), 2) several governments around the world have set up initiatives or even legislate in favor of OSS adoption (CSIS, 2010); based on Paré, Wybo and Delannoy (2009) we maintain that the apparently slow movement of organizations toward mission-critical OSS has increased both the relevance and importance of understanding the main barriers or constraints preventing organizations from adopting these software applications. In fact, a report commissioned by EU revealed that, in Europe the majority (70%) of firms use OSS for non-mission-critical applications (UNU-MERIT 2006). In the same vein, a survey conducted in the United Sates, France, the UK and Germany revealed that only 10% of the

companies surveyed reported using OSS for mission-critical applications (IDC, 2009). Within the research community, the acknowledgement of the importance of this contemporary phenomenon is attested by the advent of special tracks for OSS in conferences and special issues of journals in the information systems domain[1] (Jin, Robey and Boudreau, 2007). Despite calls for researchers of all disciplines to study this important contemporary phenomenon without any theoretical or methodological restrictions (von Krogh and von Hippel, 2006), "the present open source adoption research is very preliminary and narrow" (Aksulu and Wade, 2010, p. 598) and the issue of open source adoption from a business perspective has received little attention (Morgan and Finnegan, 2010). In addition, acknowledging that external consultants play an important role in the broad process of innovating with information technology (Swanson, 2010), the domination of client-centric perspective in the current literature create opportunities for researchers to broaden our understanding of OSS adoption by investigating the perspective of other major stakeholders such as integration partners (integrators). And, the importance of investigating the provider perspective has been recognized in the information systems literature (Levina and Ross, 2003). Lastly, this variation of perspective will complement existing literature, and strengthen our theory building efforts.

To address the above mentioned gap in our understanding, we conducted a Delphi study to answer the following research question : *What are the barriers that prevent organization from adopting mission-critical open source software* ? The study was carried out in two different countries namely France and Canada to lessen socio-economic context bias (Pudelko, 2006). The focus, that is, the identification of barriers to the adoption of mission-critical OSS software by organizations, from integrator' (as a provider) perspective and the investigation of two different socio-economic contexts constitute the original contribution of the study. Even though the two countries were selected at first for pragmatic reasons, we retrospectively investigated similarities and variations (Seawright and Gerring, 2008). For example, the two countries are comparable as far as economic development level is concerned (they are both members of the G8); they are, however, far apart in the open source index: France is ranked 1st (out of 75) whereas Canada is ranked 28 (cf Table 1).

The remainder of this study is organized as follows. We first present the contexts of the study and the research methods. Next we present our findings, then we discuss potential explanations for our results, and conclude with implications for research and practice.

RESEARCH CONTEXTS AND METHODS

Research Contexts

	France	Canada
General context		
GDP\capita (US$)	42,377	50,345
International Telecommunication Union's Digital Access Index (ITU-DAI)	0.72	0.78
ICT Development Index (IDI)	18	22
OSS specific context		
Open source Index Ranks (out of 75 countries)		
Activity Rank	1	28
Government Activity Rank	1	34
Industry Activity Rank	25	17
Community Education Activity Rank	3	16
Environment Rank	15	10
Government Environment Rank	18	11
Industry Environment Rank	18	15
Community Education Environment Rank	17	5
Governmental policies on the use of Open Source	A/P/M	A
M=Mandates (where the use of open source software is required), P=Preferences (where the use of open source software is given preference, but not mandated), and A=Advisory (where the use of open source software is permitted)		
Sources: UN (2012); ITU (2012); Open Source Index Ranks (2009); HDI (2011); Center for Strategic and International Studies (2010)		

Table 1. Key Characteristics of OSS Socioeconomic context in France and Canada

[1] e.g., *Management Science* in 2006, *DATABASE for Advances in Information Systems* in 2008, and the *Journal of the Association for Information Systems* in 2010.

Canada has a population of about 32 million; Quebec is the second largest province of Canada, after Ontario with a population of about 8 million (Institut de la statistique du Québec, 2012). It is important to realize that the OSS professional activity is in its infancy in Quebec but is likely to become more significant over time. The first OSS integration firm was created in 1999, and currently, there are about thirty enterprises specialized in OSS related services[2] (including system integration activities) and about ten OSS vendors (Appell, 2011). Most of these organizations are of small and medium size employing less than 30 persons and offer services related to more than 100 OSS (op. cit, 2011). In contrast, France is the largest country in EU, in terms of land area, with a population of over 65 millions people in 2012 (Insee, 2013). As in Quebec, the professional activity related to OSS in France is very young but rising at an estimated rate of 20 to 30% per year and most companies were created after year 2000 (Cnll, 2010). There are about 300 firms specialized in OSS and the large majority of them (95%) employ not more than 60 persons (Cnll, 2013). About 55% of these firms have system integration activities.

When contrasting France and Canada with regard to the socio-economic contexts using the economic and ICT indicators presented in Table 1, the facts indicate that the majory of indicators are similar for both countries except four : OSS activity rank, OSS government activity rank, OSS environment rank and community education environment rank. For instance, France is ranked first overal out of 75 countries for both OSS activity rank and OSS government rank whereas Canada is ranked 28 and 34 respectively for the same indicators. In addition, France is one of the six countries[3] around the world with a higher level of OSS adoption as well as a high level of development in all parts of the OSS ecosystem : the Government, Universities, Companies, and the Communities of developers (Cenatic, 2010). Hence, overall, France OSS socio-economic context can be considered to be more mature than that of Quebec.

Research Methods

Considering the fact that academic literature is relatively young and limited in comparison with the vast experience accumulated by practitioners in adopting, implementing or maintaining OSS and mission-critical open source software in particular, we believe that Delphi is an appropriate method to answer our research question as it enables the elicitation of experts' judgment. This is consistent with Dalkey (2002) emphasis on the fact that one of the assumptions upon which the Delphi method is based is that expert judgment can be used as a surrogate for direct knowledge in situations of incomplete information. For the purpose of this research we used the "ranking-type" variant of Delphi method (Schmidt, 1997) which is the most used in IS (Paré, Cameron, Poba-Nzaou and Templier, 2013), followed by individual semi-structured interviews[4] with experts for further investigation on our findings, in accordance with Dalkey and Helmer (1963).

Profile of Panels Members

The selection of "available and qualified" experts on the subject under study is one of the most critical tasks when conducting a Delphi study (Delbecq et al., 1975). An expert can be defined as someone who possesses the knowledge and experience of a particular topic, necessary to participate in a Delphi study (Clayton, 1997). In this study, experts were selected based on the position they occupy within an OSS provider firm in France or in Quebec (Delbecq et al., 1977). And more specifically a firm specialized in the consultancy niche of "system integration"[5] (Swanson, 2010). "For their clients, systems integrators provide know-how for specification and implementation of systems solutions. [...] They provide [required expertise] for integration with other systems." (op. cit, p. 23).

We initially identified potential respondents in France (67) and in Quebec (28) from companies' web site and open source professional association directories. To form the two panels, a formal invitation to participate in the study was sent by email to 67 candidates in France and 28 in Quebec, along with a brief description of the research project and the expected commitment. A total of 8 emails did not reach the candidates in France due to invalid addresses and 59 invitation letters were

[2] The main activities of OSS firms include some or all of the following: software development, system integration, software publishing, consulting and training (Cnll, 2013)

[3] The other five countries are: The Unites States, Germany, Australia, Spain and Brazil.

[4] More than half of our Delphi panel members agreed to be interviewed. The interviews are in progress.

[5] Swanson (2010) distinguishes five consultancy niches in which consultants assist their clients when innovating with IT: Business strategy, Technology assessment, Business process improvement, System integration, and Business support services.

effectively delivered. Among those who were reached, 22 agreed to participate, one was unable to commit to our study due to time constraints, and the rest did not reply to our request. In the end, the participation rate to our initial call in France was 37%, which is quite satisfactory. As for Quebec all potential candidates were reached. Among them 16 agreed to participate and two candidates were unable to commit to our study due to time constraints, and the rest did not reply to our request. Finally, the participation rate to our initial call in Quebec was 57%. The first survey was thus sent out to all experts from both panels who agreed to participate. After two weeks, we received 18 and 11 responses from the French and the Quebec panels respectively, representing a response rate of 82% and 69%. Hence, the final samples sizes satisfy the requirements suggested by Delphi methodologists (Linstone and Turrof, 2002). As indicated in Table 2, over 80% were men and the majority were under forty years in both panels. On average, they had over ten years of professional experience in the IT industry including eight to nine years in the OSS domain.

		France (n=18)		Quebec (n=11)	
Gender	Male	16 (89%)		10 (91%)	
	Female	2 (11%)		1 (9%)	
Age (years)	< 30	2 (11%)		-	
	30-39	6 (33%)		6 (55%)	
	40-49	3 (17%)		2 (18%)	
	50-59	1 (5%)		-	
	> 59	-		3 (27%)	
Highest education degree	Engineer	6 (33%)		-	
	Bachelor	1 (5%)		5 (46%)	
	M.S/MBA	4 (22%)		2 (18%)	
	Ph. D. or equiv.	1 (5%)		-	
	Other	-		4 (36%)	
OSS expertise	ERP	7 (39%)		6 (55%)	
	CRM	6 (33%)		8 (73%)	
	Database software	6 (33%)		5 (45%)	
	Communication	6 (33%)		10 (91%)	
	Operating system	5 (28%)		7 (63%)	
	Software development	5 (28%)		5 (45%)	
	Business intelligence	3 (17%)		4 (36%)	
	Network management	2 (11%)		2 (18%)	
	Other	6 (33%)		-	
		Average	Median	Average	Median
Number of years of experience in the information technology industry		13	16	15	15
Number of years of experience in the open source software industry		8	12.5	9	9

Table 2. Profile of the Delphi participants (n=29)

Data Collection and Analysis

As stated before, our approach was based on the ranking-type variant of the Delphi method suggested by Schmidt (1997) and divided into three phases: brainstorming, narrowing-down and ranking. In the first phase, a brainstorming round was conducted to elicit as many barriers as possible from the two panels of experts. Each panelist was asked to provide at least six (6) barriers to mission-critical OSS adoption by organizations along with short descriptions of barriers, so as to help researchers in their endeavor to consolidate the responses. In the second phase, a combined list was distributed to members of both panels for validation, and eventually, for amendment and additions. We also provided them with a list of definitions for each barrier so as to subsequently guide them. In order to make the ranking exercise straightforward, we sought to narrow the initial list of barriers. The experts were asked to select at least 10 barriers they considered to be the most important. Only factors that had been identified by at least 25% of the panelists were included in the following phase. All 29 experts participated in the second phase. In phase 3, the experts ranked the selected barriers in order of priority. We measured the degree of consensus among the experts on the ranking of the barriers, using the Kendall rank correlation coefficient (W) (Schmidt, 1997). All participants ranked the barriers in the first ranking round. The three phases were conducted over a 4-month period.

FINDINGS AND DISCUSSION

Categories	Barriers to mission-critical open source software adoption	Mean Rank			
		French experts		Quebec experts	
		1st round	2nd round	1st round	2nd round
Environmental	External political pressure*	6.27	6.67	7.11	6.78
	Insufficient dissemination of knowledge related to OSS in higher education institutions*	9.37	9.60	11.44	11.33
	Lack of guide lines from public authorities	NA	NA	8.44	8.67
	Disadvantageous tender/procurement processes vis-à-vis OSS Mission-critical solution	NA	NA	10.89	9.22
	Lack of reliable information about mission-critical OSS products*	8.60	8.00	11.44	10.00
	Shortage of a qualified workforce with a combination of technical and functional skills*	9.43	9.40	9.00	10.00
	Lack of homologation by government bodies	9.37	6.40	NA	NA
Organizational	Conservative nature of CIOs and CEOs attitudes and practices*	6.23	6.20	5.33	7.00
	Lack of internal IT resources and expertise*	8.13	9.20	9.67	9.11
	Internal political pressure*	7.67	7.07	6.56	9.00
	Fear, Uncertainty and Doubt (FUD) with regard to Mission-Critical OSS service providers reliability*	7.47	7.87	7.22	6.67
	Fear, Uncertainty and Doubt (FUD) with regard to Mission-Critical OSS product reliability	NA	NA	8.56	7.33
	Misunderstanding of OSS products and business models	NA	NA	4.44	6.89
	Mission-critical open source software product stereotype and prejudice*	6.17	4.07	6.33	4.22
OSS specific	Lack of responsible third-party engagement*	7.77	7.47	10.44	10.56
	OSS industry and business model stereotype and prejudice	8.37	8.33	NA	NA
	Insufficient market visibility and lack of marketing actions*	6.50	6.87	9.00	9.00
	Lack of required business knowledge and functional skills from OSS providers	7.80	8.80	NA	NA
	Complexity of open source ecosystem*	10.87	7.00	10.00	10.44

*: barriers common to France and Quebec

Table 3. Results of the Delphi Ranking Rounds

In the first stage, we received a total of 128 and 100 barriers from the French and Quebec panels respectively. The number of barriers presented by each respondent was comprised between 4 and 16, out of which many overlapped or were associated to the same barrier. After the consolidation, we identified 30 barriers. During the second phase, participants indicated that the first consolidated list was a good portrayal of their opinions. For consistency and clarity, we organized our list of barriers according to four dimensions by combining particulars barriers into more general categories (Miles and Huberman, 1984) that are based on the technology–organization–environment (TOE) framework of Tornatzky and Fleischer (1990) (cf Table 3). The three categories of barriers are: environment-related, organisation-related, and OSS specific. During the ranking phase, the first attempt to arrange the barriers in order of priority provided inconclusive results, with a relatively low Kendall W rank-order correlation coefficient in both panels that is comprised between .1 and .3 (Schmidt, 1995). More exactly, the coefficient where .10 and .20 for the French and Quebec panels respectively. We informed the experts that the first round did not produce a high-level agreement among the panel members on the relative rankings. Therefore, we pursued our efforts with a second round of rankings. In order to facilitate the development of consensus, the revised list was ordered according to the mean ranks obtained in the first round (Schmidt et al., 2001). Notwithstanding, the second round produced a low level of agreement with a Kendall coefficient comprised between .1 and .3 again (Schmidt, 1997). At this stage it was decided that further ranking rounds would not be required because of a levelling off of W revealed by a lack of progress between the two

rounds (Schmidt, 1997). Since the validity of the prioritization is evidenced by the level of consensus (Mitroff and Turoff, 2002), our finding may appear disappointing at first. In this regard, it is important to remind that consensus is not always the goal of a Delphi study (Mitroff and Turoff, 2002) and that having little or no agreement can be as important as agreement (Scheibe et al., 1975). It is for this reason that Delphi studies with low level of agreement between panels experts concerning the ranking of a list of issues have been reported in academic journals and conferences (e.g. Keil et al., 2002). Like in the latter studies, the panels had agreed on the most important barriers, and the lack of strong consensus was on the priority, or ranking, of these barriers.

Compared to the initial list of OSS barriers derived from the literature, overall, the expert panels provided nineteen additional barriers, more precisely fourteen related to the OSS product and ecosystem, one related to the adopting organization and three related to the environment in which the integrator and the adopting organization operate (Due to space constraints, the initial list is not included in this article).

Common barriers

Our findings indicate that 12 out of 19 (63%) barriers are perceived to be the most important by both panels (cf Table 3). Interestingly, 4 out of 12 were not reported in the literature, namely, "Mission-critical open source software product stereotype and prejudice", "Complexity of open source ecosystem", "Insufficient dissemination of knowledge related to OSS in higher education institutions", and "Shortage of a qualified workforce with a combination of technical and functional skills" (see Table 4).

Common barriers to mission-critical OSS adoption from France and Quebec Experts	Support in the extant literature
Conservative nature of CIOs and CEOs attitudes and practices	Paré et al. (2009)
External political pressure	Paré et al. (2009)
Lack of reliable information about mission-critical OSS products	Morgan and Finnegan (2007); Paré et al. (2009); Leigh, Sameer, and Wen (2012)
Insufficient market visibility and lack of marketing actions	Morgan and Finnegan (2010)
Lack of internal IT resources and expertise	Morgan and Finnegan (2010); Nagy et al. (2010); Paré et al. (2009); Leigh et al (2012)
Lack of responsible third-party engagement	Morgan and Finnegan (2010); Paré et al. (2009); Leigh et al. (2012)
Fear, Uncertainty and Doubt (FUD) with regard to Mission-Critical OSS service providers reliability	Feller and Fitzgerald (2001)
Internal political pressure	Paré et al. (2009)
Specific barriers mission-critical OSS adoption from Quebec Experts only	Support in the extant literature
Fear, Uncertainty and Doubt (FUD) with regard to Mission-Critical OSS product reliability	Fuller and Fitzgerald (2000)

Table 4. Common and specific barriers with support in the literature

First, in the extant literature on OSS adoption, stereotype and prejudice is reported in relation to OSS developers only, and not related to OSS products. "A stereotype is an exaggerated belief associated with a category. Its function is to justify (rationalize) our conduct in relation to that category" (Allport, 1954, p. 191). "Prejudice refers simply to a judgment about something before fact (a prejudgment)" (Gardner, 1994, p1-2). Stereotype and prejudice are closely related. Prejudice is usually based on a negative stereotype (Stroebe and Insko, 1989 in Gardner, 1994). Our results reveal that it is most likely that the stereotype and prejudice towards OSS developers may be extended to OSS products or vice versa. Nonetheless, this result highlights a notable difference between client and provider perspectives when compared to the result reported from a field study by Morgan and Finnegan (2010, p. 91): "For example, the majority of managers believed that quality, security, flexibility of use and escape from vendor lock-in were significant benefits of OSS". In addition, our finding is surprising given that "High-profile organizations like Amazon, Google, and Salesforce.com take advantage of the reliability and low cost of open source to create a platform on which they can offer value-added services in their own business domains." (Fitzgerald, 2006, p. 591). Second, drawing on Collier and Cumming (2011, p. 209) we define an ecosystem as "a network of

components connected by various relations". Based on Cenatic (2010), we identify four main components of OSS ecosystem: the Government, the private business sector, universities and the community of developers. We propose to considerer that this structural complexity is accentuated by OSS license proliferation. "Proliferation refers to the scores of open source licenses that are now in use, with more being created all the time" (Gomulkiewicz, 2009, p. 263). Indeed, there are 68 OSS licenses approved by the Open Source Initiative (OSI, 2012). The two remaining barriers are interrelated. One can maintain that the "shortage of a qualified workforce with a combination of technical and functional skills" required for the integration of mission-critical OSS is related to the "insufficient dissemination of knowledge related to OSS in higher education institutions".

Barriers specific to each country

Our results reveal barriers that are perceived to be the most important by one of the panels only. Three barriers were considered important by French panel only. Of these, one is specific to OSS (Lack of required business knowledge and functional skills from OSS providers), one is related to the adopting organization (OSS industry and business model stereotype and prejudice), and one another is related to the environment (Lack of homologation by government bodies). To our knowledge, none of these barriers have been reported in the literature. First, Lack of required business knowledge and functional skills from OSS providers. The effectiveness of this barrier seems to be attributable to the facts that OSS has its roots in infrastructure applications and mission-critical OSS is a recent phenomenon. In fact, a survey conducting in France indicates that 74% of firms specialized in OSS face difficulties in recruiting qualified personnel. Third, Lack of certification and homologation by government bodies. Drawing on Morgan and Finnegan (2010) we argue that such barrier emanates from the community-based peer-production processes that generally drive OSS development, and thus such concerns may prevail longer than previous concerns. In fact, "a standard approach to reduce the risks in deploying" mission-critical software is to establish an independent certification process (Shaikh and Cerone, 2009, p. 11). The latter authors stressed that today we lack standards and methods to assess the quality of open source software; and indicate that the lack of central management in open source software projects makes it difficult to establish certification processes. We suggest that the presence of all but one (organization related) barriers in France only could be explain by the highest level of maturity of the open source socio-economic-context when compared to Quebec.

In the same manner, our findings revealed four barriers perceived as important by Quebec panel only. Two are related to the environment (Lack of guide lines from public authorities; Disadvantageous tender/procurement processes vis-à-vis mission-critical OSS) and the other two are related to the adopting organization (Misunderstanding of OSS products and business models; FUD with regard to mission-critical OSS product reliability). None of these barriers were reported in the scientific literature. Similarly to France, the presence of all the four barriers in Quebec only could be explained by the low level of maturity of the open source socio-economic context.

CONCLUSIONS AND IMPLICATIONS

Recalling that Open Source Software (OSS) is one of the most debated phenomena in the software industry, both theoretically and empirically (Comino and Manenti, 2003), our study contributes to the literature in several ways. First this study contributes to the literature by being one of just a few studies to examine the barriers to mission-critical OSS adoption. Second, the taxonomy of mission-critical OSS barriers outlined in this section is a useful framework for organizing such findings and provides a solid baseline from which to proceed with the research domain of OSS adoption. Third, by investigating integrator perspective, we have added new insight in OSS adoption literature dominated by client perspective alone. From a practice perspective, the present study provides managers and policy makers with an exhaustive, yet validated set of mission-critical OSS barriers and it demonstrates the influence of socio-economic context and the maturity of the field on the relative importance of these barriers.

To conclude, we must recognize the main limitations of our findings. As with any Delphi study, our results are based on a limited number of respondents. While participants were chosen for their vast experience as OSS experts, we can make no claim about the representativeness of our sample. Our panelists were not chosen randomly, and they came from two countries only. Clearly, additional Delphi studies must be conducted with OSS experts from other parts of the world to allow more generalizability of the findings.

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