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# Factors Influencing Adoption of Open Source Software – An Exploratory Study

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## ABSTRACT

Open Source Software (OSS), an example of an IS innovation, provides an alternative to proprietary software for organizations. Despite its free availability, OSS has not been universally adopted. While IS innovation has been extensively studied, there is a dearth of research literature on the adoption of OSS. Using a multi-site case study research method and a well known framework on the adoption of IS innovations, we explore this novel phenomenon and uncover critical factors that influence the adoption of OSS in organizations.

## Keywords

Open Source Software, IS Adoption, IS Innovation, Case Study.

## INTRODUCTION

The term Open Source Software (OSS) generically applies to any collaboratively produced software when the source code is freely available to the public for review and modification, provided the modification is also freely redistributed (Fitzgerald 2006). The OSS Movement is currently gaining prominence in the IT industry. Organizations that have been ardent proponents of Intellectual property rights have begun to embrace OSS. IBM released the source code for its Eclipse suite and framework in 2001, and continues to support open source projects (Samuelson 2006, Capek et al. 2005). Increasingly, OSS seems to co-exist and compete with proprietary software. This is evident from the widespread adoption of OSS products such as the Linux operating system, the Apache web server, and the Mozilla Browser (Fitzgerald 2006, Lerner and Triole 2002). Such organizational adoption of OSS increases the choices available to IT managers in making software adoption decisions. However, factors that influence OSS adoption decisions are likely to be different from those impacting adoption of proprietary software due to several critical differences between these two groups of software products.

Firstly, OSS is mostly free compared to proprietary software for which companies have to pay an upfront purchase price. Thus, it makes economic sense to choose OSS over proprietary software. In fact, benefit from cost reduction is considered one of the driving forces behind organizational adoption of OSS (Landry 2000). Secondly, OSS users have to rely on the Open Source Community or a third party vendor for technical support. This is different from the traditional model of vendor supported after-sales service in case of proprietary software. Finally, users of OSS have access to the source code, and are free to modify it to suit their specific requirements. This enables them greater flexibility in using OSS compared to proprietary software (Krishnamurthy, 2003).

While adoption of IS innovations has been extensively studied (Basole 2008, Venkatesh et al. 2003), very few research studies have investigated the adoption of OSS. This is primarily due to the novelty of the OSS phenomenon. The objective of this research is to gain a deeper understanding of OSS adoption by organizations. Specifically, we investigate various factors that influence the adoption of MySQL, an OSS, in an enterprise computing environment. The remainder of the paper is organized as follows. In the following section we review related research. Next we describe the research methodology and the data collection process. Our findings are then presented. Finally, the paper is concluded with a discussion of the limitations of this study.

## LITERATURE REVIEW

OSS can be categorized as an IS innovation (Verma et al. 2005). In this section we summarize the extant research on OSS adoption, and selectively review relevant research on IS innovation to develop a research framework to guide our investigation.

Viewed from a pure economic perspective, the total cost of ownership (TCO) of software provides a valuable insight into adoption decisions. Calculation of TCO, however, is a complex task and must be computed over the lifetime of the project. Wide variation in labor costs can significantly impact the outcome of such an analysis, and thus influences adoption decisions (Varian and Shapiro, 2003). OSS adoption studies involving public sector enterprises in Europe found cost savings to be a major factor in adoption decisions (Fitzgerald and Kenny, 2003; Waring and Maddocks, 2005; Ven et al., 2007). While the zero acquisition cost of OSS (free software) makes it an attractive alternative to proprietary software, potential adopters often consider additional factors, including, technological attributes, network externalities, organizational capabilities, vendor lock-in, and influence of the user community, when making OSS adoption decisions (Miralles et al. 2005). Free downloads and freedom from licensing restrictions enhances the trialability of OSS, which was found to enhance its adoption in embedded systems (Lundell et al. 2008). On the other hand, a perception of less reliable technical support available from third party vendors and/or the OSS community was considered a critical barrier to OSS adoption (Goode 2005, West and Dedrick 2006). The influence of technical support in OSS adoption is further corroborated by the fact that it, along with software quality, significantly impacts the satisfaction of individual OSS users (Lee et al., 2009). Verma et al. (2005) contend that working with source code, and the absence of documentation, which make OSS more difficult to use vis-à-vis proprietary software, are actually looked upon favorably by technologically sophisticated users, such as developers. This is because the technically skilled users value the flexibility afforded by working with the source code (Lerner and Triole 2002). Thus, the perception of ease-of-use (Hasan 2007, Lippert and Forman 2005), a key factor in the adoption of IS innovation, depends on the level of technical skill of the OSS user. The availability of human capital (knowledge, skill, abilities, and experience) within the organization and access to human capital outside the organization have been found to influence an organization's intention to adopt OSS (Li et al., 2005). While these studies inform us about factors that influence OSS adoption decisions, the current body of literature on this topic is quite sparse. Our study seeks to further our understanding of OSS adoption by providing a comprehensive and in-depth analysis of OSS adoption decisions by two Fortune 500 companies located in the USA.

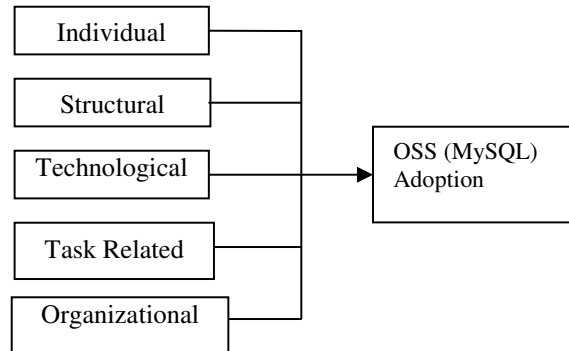
Adoption of IS innovation forms a major research stream within IS research (Venkatesh et al. 2007). Drawing on this corpus of research, OSS adoption can be investigated using many different theoretical lenses. Agency theory and Transaction cost economics provide explanations from an economic perspective, while Adaptive Structuration theory, Diffusion theory, Institutional Theory, and Social Network theory may be used to understand OSS adoption from a sociological perspective (Rogers 1983, Niederman et al. 2006a).

The Technology Acceptance Model (TAM) (Venkatesh et al. 2003, Davis et al. 1989) holds a preeminent place in the IS adoption literature because of its simplicity and explanatory power to explain individual user's adoption behavior. A meta-analysis of TAM suggests that user type and usage type play significant roles in IS adoption (King and He 2006). Several perceived characteristics such as, relative advantage, ease of use, compatibility, trialability, result demonstrability, voluntariness, and image, have been identified as driving factors of adoption behavior of the individual (Agarwal and Prasad 2000, Compeau et al. 2007). DeLone and McLean (1992) proposed the model of IS success both at individual and organizational levels based on Information Quality, System Quality, Use, User Satisfaction, Individual impact and Organizational impact. This model was later updated to include Service Quality (DeLone and McLean, 2003).

Several frameworks have been suggested in the extant literature to study IS innovation. Preeminent among these is Swanson's Tri core model, which offers an integrative framework to study IS innovation and adoption (Grover et al. 1997). As per Tornatzky and Fleischer's contextual framework, technology, organization, and environment are the key elements in adoption of innovation (Tornatzky and Fleischer 1990). Using Adaptive Structuration Theory as a framework, researchers have examined the influence of organizational structure and technological structure on each other (DeSanctis and Poole 1994). Niederman et al. (2006b) suggested a multi-level framework to study OSS. Five discrete levels of analysis recommended by this study are: (1) artifact, (2) individual, (3) team, project, and community, (4) organization, and (5) society. Our study investigates the adoption of MySQL (an IT artifact at the infrastructure level) by organizations. Thus, our analysis will include both individual and organizational levels of adoption.

Kown and Zmud (1987) identifies five critical factors that influence the diffusion of IS innovation (See Figure 1). These are individual, structural, technological, task related, and organizational factors. Technology users often play a critical role in the successful adoption of IS innovations (Jeyaraj and Sabherwal 2008). In a bottom-up decision process, users have a major voice in vetting new technologies. Even in a top-down decision process, where changes are mandated by top management,

users still play an important role during the post adoption phase of adaptation and acceptance. Cosmopolitanism, education level, and job tenure, are some of the factors that affect an individual user's disposition towards new technology (Venkatesh et al. 2003). Technological factors, such as, compatibility with existing technology, availability, relative advantage, etc., play an important role in influencing technology adoption decisions (Deishin and Mendelson 2007). Task-technology fit (Shaft and Vessey 2006) is another important dimension that influences new technology adoption. Organizational culture, structure, and the decision making process (top-down vs. bottom-up) regarding new technologies are additional factors that may influence adoption of innovations. We used the framework depicted in Figure 1 to guide our investigation.



**Figure 1. Factors affecting OSS adoption (based on Kwon and Zmud 1987)**

## RESEARCH METHODOLOGY

Adoption of OSS is a relatively new phenomenon, and research in this area is in formative stage. We, therefore, decided to use the case study research methodology to explore this phenomenon. Case study provides an appropriate research methodology to explore a situation in its natural setting (Yin 1994). It allows the researcher to get a deeper understanding of the situation, and answer “why” and “how” questions. It is very helpful in theory building research.

We conducted a multi-site case study. Two organizations were selected for this research. We will call them Airco and Telco. Both organizations are multinationals with their headquarters located in the USA. Airco is a major software solution provider for airlines and travel related businesses. Its customers include private organizations and governmental agencies located in many countries. It also offers consulting services in operational and strategic areas to the airline industry. Telco is a major telecommunication services provider. It offers landline, wireless, and broadband services to individuals and businesses. It has made significant investment in its IT infrastructure, which is a critical component of its business strategy. Unlike Airco, which depends on an outsourcing partner for its IT infrastructure management, Telco relies on its in-house IT organization for this purpose.

The technology artifact of interest in this study is MySQL, an open source database management system available from Sun Microsystems. According to the company website ([www.mysql.com](http://www.mysql.com)), “MySQL was originally founded and developed in Sweden by two Swedes and a Finn: David Axmark, Allan Larsson and Michael “Monty” Widenius, who had worked together since the 1980’s.” Currently it is owned and operated by Sun Microsystems. Major organizations, such as Yahoo!, Alcatel-Lucent, Google, Nokia, YouTube, Wikipedia, and Booking.com, are claimed to be users of MySQL, as per its website. Airco adopted MySQL in 2002 and has been using it since then. Telco was in the process of finalizing the adoption of MySQL at the time of our data collection, and subsequently made a limited adoption decision.

Key executives in both organizations were contacted to facilitate the data collection process. They identified critical informants in their respective companies, provided introduction to our research team, and helped set up interviews. In-depth, open-ended interviews were conducted with these informants. This provided the primary source of data for our analysis. These data were supplemented with publicly available information about the two companies and internal reports obtained from the informants, wherever necessary. We interviewed a total of 12 informants at both sites. They included four decision makers (DMs), four opinion makers (OMs) and four technology users (TUs). Decision makers are senior level employees in the organization who assess new technologies and have the final authority to decide whether a new technology will be adopted by the organization. Opinion makers, on the other hand, are technical experts at staff level or senior project managers who assess new technologies and make recommendations regarding technology adoption. Technology users are employees who use technology to perform their jobs. Thus, their daily work lives are affected by new technology adoption. Since MySQL, our target technology, is a database management system, the technology users included software developers

and database administrators (DBAs).

OSS adoption is not yet well understood. To explore the factors that influence the adoption process we created two sets of open-ended questions to guide our interviews. The first set was used for interviewing DM and OM informants, and the second set was used for interviewing TUs. The questions were based on prior literature on technology adoption. The framework presented in Figure 1 guided the formulation of these questions.

Face-to-face interviews were conducted at the case sites. Each interview lasted for approximately one hour. Prior to beginning an interview, the interviewee was assured that his/her identity will be kept confidential, so as to encourage him/her to speak freely. All conversations were recorded with the permission of the interviewees. Table 1 provides a summary of the informants' profiles.

Informant Category	Roles and Responsibilities	Average tenure in the company (in years)	
		Telco	Airco
Decision Maker (DM)	IT executive, Responsible for IT infrastructure and operations decisions, and standard setting	5	4
Opinion Maker (OM)	IT Manager / Lead, executioner and architect of IT projects	7	3
Technology Users (TU)	Database developer, implementer, DBA	8	6

**Table 1. Informant Profile**

**DATA ANALYSIS AND RESULTS**

The recorded interviews were transcribed. These transcripts formed the primary source of data. These were augmented by published and unpublished reports about the companies, and their technology usage pattern. The data were analyzed iteratively to find common themes across the two sites, and contrasts among them with regard to their decisions regarding adoption of MySQL. Here we share some of the early key findings from our analysis.

Since OSS is freely available, there is a general perception that low total cost of ownership (TCO) is a major driver of OSS adoption (Landry 2000). Our results, however, suggest that low cost is a motivator to consider OSS adoption but is not a deciding factor in the final adoption decision.

At Telco, low cost was not considered motivating enough for implementing OSS based solutions. As remarked by an OM at Telco, *“For large companies like ours, where our operations run into millions of dollars, saving some money in software would not be a good option while risking crisis time support and an outage of a few hours”*.

Though the license is free, that does not mean that there is no cost to the organization in adopting OSS. MySQL offers basic support services at a cost.

The OM at Airco explained, *“... I guess I can well explain a little bit about the pricing model for MySQL to you. What you do today is that you buy a MySQL network agreement. What you are buying really is one of four levels of support. When you buy one of two highest levels of support, you get a certain level of indemnification provided you articulate that during your negotiation with MySQL. But if you buy one of the lower two levels, then you don't get any level of indemnification offered to you, ...”*

Airco, which has been using MySQL for several years, relies on support service from MySQL. In their experience, support cost added significantly to the TCO, thus making the adoption of MySQL financially somewhat less attractive. They were, however, satisfied with the quality of support offered by MySQL.

Lack of premium support for MySQL was found to be a major concern for Telco, which requires very high availability of its operational infrastructure. They had a low perception of support quality for MySQL vis-à-vis its proprietary alternatives, such as Oracle and Microsoft SQL Server. A DM at Telco mentioned, *“I am not comfortable with Open Source for something strategic, mission critical, or of large scale as the OSS is not matured enough. We don’t have the flexibility with OSS even though some vendors do support it but we don’t have things like premier level support that we get for proprietary software, as in case of Microsoft products. You can open a ticket with Microsoft and you can get people right away on the bridge<sup>1</sup>. There is no such thing in OSS unless you do a contract with a company that supports the OSS.”*

Among technical factors, scalability and high availability architecture were considered to be major considerations. Some user groups within Airco were planning to migrate from MySQL because it was unable to efficiently handle their growing transaction volume. They would need to make additional investment in hardware upgrades in order to continue with MySQL, thus adding to the TCO. A DM at Airco remarked, *“Yes, though MySQL maybe perfect for other non updatable environments, it is just that in our environment it has to continuously scale up. So we are having a scalability issue, and not functionality issue, as we are using it for read-only purposes. Right now, we are projected to have 200 MySQL Servers by the end of the year. ....We have just run a proof of concept with Oracle and that will reduce the 200 servers to just 16. ... So, from a database point of view it makes a strong case for migration from MySQL.”* The DM at Telco was equally apprehensive - *“There is no assurance that it (MySQL) will scale up for an enterprise level system for a large corporation like ours.”*

High availability architecture was a major consideration for Telco because it needs 24/7 trouble free operation of its applications. System unavailability outside the prescribed maintenance window at Telco is prohibitively expensive, primarily because of the nature of their operations. As per the OM at Telco, *“The other thing I am not sure about MySQL is its high availability feature, which is critical for our 24/7 trouble free operations”*

Both Telco and Airco felt that OSS in general, and MySQL in particular, may not be appropriate for mission critical applications. Lack of accountability on the part of the vendor, in case of critical failure, was considered as one of the reasons for not deploying MySQL in mission critical applications. Airco is using MySQL in a read-only environment. A DBA at Airco said, *“We replicate data from Oracle for pricing, shopping, and fare quotes but these are all read-only. All updates are being done in Oracle.”*

Even though the ability to modify the source code is considered to be a distinct advantage of using OSS, Airco does not plan to use this option. The OM at Airco was categorical, *“We do not want to incur any cost of code modification, and have any liabilities related to that.”* The DM at Airco added, *“Code modification requires hiring of specialized resources and that can add to our cost.”*

Airco is in the business of creating customized solutions for its clients. Therefore, it deploys new technologies as required by its clients. As remarked by an OM, *“The decision about using a specific technology depends on what the client wants.”* Needless to say, this drives Airco to constantly innovate, and hone its skills on the latest tools and technologies. On the other hand, Telco, a much larger organization than Airco, creates and maintains its own IT infrastructure that supports its day-to-day business operations. IT infrastructure decisions at Telco emphasize standardization with a view to lower the costs of operations and maintenance. Thus, diversity in technology is not favored. As pointed out by a DM, *“We are really more into consolidation rather than expansion in terms of technologies.”* But that does not mean that Telco is not looking for new tools. However, they take a more conservative stance in adopting new technologies. As reiterated by another DM, *“We aim for adopting the latest and greatest technologies, but we do it gradually...Definitely we are not early adopters. We do it slowly and gradually.”*

Airco and Telco use different organizational mechanisms to finalize technology adoption decisions. Airco uses a top down approach – critical new technology adoption decisions, including that of adoption of MySQL, are made by top management in consultation with key senior employees. Technology users have a limited role in this decision process. Telco, in contrast, uses a bottom-up approach in finalizing new technology decisions. Proposals for such decisions are first scrutinized by a Technology Review Team, which gathers inputs from experienced technology users and managers in various operational units. These are then screened by a Technology Certification Team before being submitted to the Architecture Review Board, comprising of senior executives from different units, for its final approval. Telco’s new technology decision process gives technology users, such as, DBAs and Developers in case of MySQL, a significant voice in new technology adoption decisions. Technology users at Telco, during our interview, opined that MySQL is capable of handling small to medium

<sup>1</sup> A bridge is the communication link for crisis intervention to resolve operational crises caused by information system failure.

sized databases. They were, however, concerned about the level of technical support offered by MySQL vis-à-vis that offered by vendors of proprietary software.

To summarize, our findings suggest the importance of technological, organizational, and task related factors in the adoption decision of MySQL. Since MySQL is an IT artifact at the infrastructure level, technological factors, such as, scalability and high availability are critical in its adoption decision. Lack of quality support service is a deterrent in deploying MySQL in mission critical applications. Technical support is especially critical when organizations deploy MySQL as part of their operational infrastructure. Thus, the type of deployment environment, i.e., production vis-à-vis development, can influence such adoption decisions. While OSS may be available for free download, it is not strictly “zero-cost” software when deployed in an enterprise IT environment. Organizations must factor in extra cost of buying support service. In some situations, additional hardware costs may be incurred due to technological limitations imposed by the OSS, as was the experience of Airco. Thus, IT managers considering OSS adoption for their enterprise IT environment must conduct detailed analysis of the TCO before making a final adoption decision. Organizations that thrive on technological innovation and rely on the latest IT tools and technologies to drive their business strategy are likely to be early adopters of OSS. Such organizations foster a culture of innovation that encourages experimentation with new technology. On the other hand, enterprises that rely on a stable IT infrastructure to conduct their day-to-day business operations are likely to be late adopters of OSS. Table 2 summarizes the views of informants at the two sites.

Factors influencing adoption	Views regarding MySQL	
	Telco	Airco
Individual	Technology users apprehensive of functionality	Technology users comfortable with functionality
Structural	Deployment has enterprise wide effects generally	Deployment affects individual implementation
Technological	High availability concerns	Scalability concerns
Task Related	Suitable for low end applications	Suitable for non-updatable environment
Organizational	Focus on In-house infrastructure development. Low cost was not a motivating factor in adoption decision.	Focus on client needs. Low cost was a motivating factor in adoption decision.

**Table 2. Comparison of Telco with Airco**

**CONCLUSIONS AND LIMITATIONS**

Adoption of IS innovation has been extensively studied in IS research. However, adoption of OSS is a relatively new and less understood phenomenon. This study contributes to the research stream on OSS adoption by unraveling factors that influence adoption of MySQL, an open source database management system. Preliminary results show that technological factors, including, quality of technical support, scalability, and high-availability are important factors influencing the adoption decision. TCO is a motivator in considering MySQL adoption, but is not a deciding factor. Organizations are less likely to deploy MySQL in mission critical applications. Also, an organization’s operational environment and business strategy influence its disposition towards OSS adoption. Our findings shed new light on OSS adoption decision, and can help IT managers make informed decisions. These results can also help software vendors develop new product offerings based on OSS. One interesting implication is the urgent demand for third party technical support service to facilitate OSS adoption. The need for such service is articulated as part of the OSS 2.0 phenomenon (Fitzgerald 2007).

Our results must be interpreted keeping in mind the limitations of this study. We used a case research method, which is very appropriate for this situation because of the novelty of the phenomenon being studied. This method allowed us to get insights into OSS adoption decisions at two organizations, and develop conclusions by comparing and contrasting the two situations. One of the limitations of this research method is that readers must use caution in generalizing the results. Additional empirical studies are needed to develop more generalizable results.

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