Critical factors affecting the adoption of open source software in public organizations

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ABSTRACT: Context: The way public organizations produce, acquire, use, and commercialize software is changing as a result of open source software (OSS). Because of the numerous benefits provided by open source software, public organizations began to use it to meet their demands. As a result, governments implement various measures to encourage and facilitate OSS use. A variety of factors continue to influence the choice to implement OSS, which can have a positive or negative impact on the adoption process.

Objective: The study's purpose is to explore the most critical factors that may influence the open source software adoption process, which are drawn from chosen case studies from various domains in public organizations. Based on their findings, the authors produced a guideline to tell prospective adopters about the most crucial factors that they may confront during the adoption process.

Method: Authors chose a handful of publications that address three public domains: healthcare, municipal government, and higher learning institutions. We looked for articles based on various criteria, beginning with their relevance to open source software adoption in general and, more specifically, in the public sector. We also screened the papers based on whether they were written in simple English or if they were written in another language.

Results: According to the findings, government and top management support, reliability, security, availability, and cost ownership are the most influential elements that contributed to the adoption process's success. Lacking of in-house development, connectivity, quality, computing resources, and expertise were identified as barriers to the adoption of open source software in specific sectors.

Keywords: open source software; public organization; OSS adoption; local government; e-health; higher education

1. INTRODUCTION

Open Source Software (OSS) is becoming more widely recognized as a viable replacement to proprietary goods, bringing greater software reliability and cost savings to enterprises of all sizes [1]. As a result, OSS has found wide acceptance from government institutions worldwide. As a result, numerous public sector organizations are engaging in open source research, including determining the availability and potential of open source solutions in government institutions [2]. Government institutions in Malaysia are likewise taking substantial steps to encourage OSS adoption [3]. It would be good to gain a better understanding of the characteristics that facilitate OSS adoption, particularly in the setting of public organizations.

There are numerous benefits to citizens from the adoption of Open Source Software (OSS) by public entities. Among these, the most frequently claimed benefits include a more open and privacy-enhancing process, less vendor dependence, and the impediment of digital-dividing boundaries. The adoption of OSS is increasing at a rapid pace in public organizations throughout the world; numerous case studies of migrations to OSS within those organizations will be discussed later in this paper. However, implementing OSS is a difficult process that necessitates a significant shift in the

organizational structure. This is a phenomenon that has been noticed with regard to disruptive technologies, of which OSS has been identified as one. In the public sector, government regulations can have a significant impact on the successful implementation of OSS. Additionally, the assessment noticed an increased government push. This impulse cannot be relied upon to steer the entire adoption process. Numerous individual, technological, and organizational elements can all have an effect on the ultimate success.

This review aims to identify the most essential elements affecting the open source software adoption process. The following is the organization of the paper. It begins with a discussion of the implications of open source adoption in public sector organizations. Following that, the article discusses the current trend of open source adoption in developing and developed countries. Following that, a review of critical factors will take place, followed by a discussion. Finally, the review expressed an opinion and concluded with a conclusion.

2. OPEN SOURCE ADOPTION

2.1 *Why public sector should adopt OSS*

Numerous benefits of open source software could be leveraged to business users, developers, and societies. The next section will outline some of the benefits to many stakeholders, followed by a discussion of the benefits to business users, especially governmental organizations.

2.1.1. *Little cost*

According to Gonzalez-Barahona and Daddara [4], the most compelling feature of OSS is its availability for free or at a low cost, and even the most well-known OSS products are free to download from the world wide web. According to Titterton [5], 70 percent of corporate stakeholders are motivated to embrace OSS by cost savings. [6] Believe that the availability of free or low-cost open source software has a significant influence on its broad adoption.

2.1.2. *Reliability*

According to researchers, one of the most significant benefits of OSS is its reliability. In the context of software, reliability is described as the lack of errors or defects that might result in faulty operations, data loss, or system failure. The dependability of OSS is derived from programmers' frequent enhancements based on the availability of source code [7, 8].

2.1.3. *Customizability*

Customizability is a concern associated with reliability. [9] Argues that because the program's source code is freely available to anyone, individuals or groups can alter it to meet their own needs. This is particularly critical for firms operating in specific industries, such as healthcare or other government agencies. At a fraction of the expense of customizing closed-source systems, the customized software can be re-distributed into the open-source community, tested, and enhanced, and then returned to these organizations.

2.1.4. *Licensing*

When the 'Open Source Definition' was written in 1997, criteria for what characterized OSS or what did not were also created. It featured laws that regulate software licensing. There are four distinct components that clearly differentiate licenses: whether they permit the combination of OSS and proprietary software; whether modifications can be made privately but not returned to the author; whether the software can be re-licensed by anyone; and whether the software includes special rights for the original copyright Holder [9]. Due to the licensing advantage over proprietary software providers, large enterprises, governments, and schools that cannot afford high license prices may choose for less expensive OSS alternatives.

2.1.5. *Greater choice and control for end-users*

OSS involves establishing an alternative competitively to proprietary software and giving end users a broader selection of ever-improving software solutions. These bundles are competitive with the numerous commercial offerings. Due to the open-source nature of the product, programmers can alter it or correct issues. It will prevent consumers from becoming reliant on a single vendor who owns the source code and can dictate the hardware platform [10].

2.1.6. *Support from major companies*

Historically, many firms have been hesitant to invest in OSS due to a lack of available support and training. It starts to change now that major IT corporations are beginning to support OSS. IBM, Hewlett-Packard, and Oracle have all vowed

to promote Linux and are doing so via Red Hat and SuSE [11]. This approach benefits suppliers whose business models revenue expanded to include support for OSS and users reassured that users would provide support.

3. OPEN SOURCE MOVEMENT WITHIN PUBLIC SECTOR ORGANIZATIONS AROUND THE WORLD

3.1 Policies on OSS

Government interest in OSS is growing significantly throughout the world, reflected by studies on OSS policies and standards, although OSS is a relatively young concept [12–14]. The South African government's policy requires ministries to use OSS [15]. Singapore provides tax advantages to businesses that run on Open Source Linux rather than Microsoft Windows [13, 16, 17]. Germany has secured an arrangement with IBM to offer discounted prices on IBM servers pre-installed with Linux [13]. A practical example of an open standards policy is the Commonwealth of Massachusetts' decision in 2007 to enforce available formats for office documents [18]. The Vietnamese government promotes OSS adoption via the Open Source Software Master Plan [2004–2008]. [16]. Because of their cost-effectiveness, interoperability, vendor independence, security, and return on capital, the UK Government's strategy considered both OSS and proprietary software. Brazil is a significant user of open-source software. In 2003, the Brazilian government set up the government-led FOSS (Free and Open Source Software) program to urge federal and state governments to adopt OSS. In 2005, Brazil's president issued a policy mandating the adoption of OSS by all government agencies. The Brazilian government's Open Source strategy motivated by three reasons that inextricably linked: economics, development, and ideology [19, 20]. In Australia, the federal government's ICT procurement policy advised that organizations embrace OSS when procuring ICT to maximize value and meet business requirements.

3.2 Adoption of OSS in Hospitals: An Empirical Model:

Strauss and Corbin's (1998) paradigm was used to build an empirical model characterizing OSS adoption in hospitals, based on data from a study case of OSS implementation at the Beaumont hospital in Ireland. This empirical model enables us to create and suggest relationships between the components identified throughout the research. The empirical model presented in Figure 1 details the study of the factors that emerge from the findings and their relationships. The empirical model identifies temporal and inferential correlations between the factors influencing OSS adoption in hospitals instead of causal relationships. For instance, the mix of causal conditions. In a certain hospital at a particular point in time (as measured by the degree of in-house development, the presence of IT specialists, and so forth). establishes the stage. It determines what follows when a core category event occurs (e.g., when a software vendor offers an open-source solution to the hospital). This main category then directly influences the strategic choices (i.e., adoption or non-adoption of OSS) that result in the implications. Contextual factors and intervening conditions operate as a moderator and mediator of the strategic activities to achieve desired outcomes [21].

FIGURE 1. Empirical model for the adoption of OSS in hospitals

3.2.1. Causal Conditions:

The phrase "causal conditions," as employed in our empirical approach, refers to factors found as affecting the core category. The data indicate that each of these causal conditions affects whether or not the hospital is receptive to a proposal of OSS via a service provider.

3.2.2. Core Category:

The combination of causal conditions present in a given hospital environment provides the scope for the "core category," or hospital service provider.

3.2.3. Contextual Factors:

Contextual factors are a specific subset of conditions (patterns of conditions) that overlap dimensionally at this time and place to form a series of events or difficulties to which participants react through actions/interactions [22].

3.2.4. Intervening Conditions:

Intervening conditions are those conditions that "mitigate or otherwise impact causal conditions".

3.2.5. Strategic Actions:

Strategic actions are defined as "clearly intentional or premeditated measures taken to address a particular problem." Combining the core category (hospital software suppliers) with contextual factors and intervening conditions may result in hospitals deciding to fully utilize particular technology—in this scenario, OSS—as a plausible or implausible substitute to proprietary or commercial software solutions.

3.2.6. Consequences:

Consequences are the outcomes of the interaction of the core category with the contextual factors, intervening conditions and the strategic actions

Table 1. Successes and Failure Factors

	Healthcare	Institution of Higher Learning	Local Government
Successes Factors	- Clear objectives	- Customizability	- Top management support
	- Government support	- Reliability	- Independency
	- Adapt user friendly interface	- Flexibility	- Integration
	- Determine accessibility	- Security	- Customization
	- Implement standards	- Cost ownership	- Time
	- Cost effectiveness and user satisfaction	- Free to make copies and distribute without being worried of software	- Cost reduction
	- Limited financial resources	- legality	- Open standard
	- Top management support	- Availability	- Reliability
	- Software functionality	- Performance	- Trialability
	- User's past experience	- Eliminate software license fees	- Usability
	- OSS-literate IT personnel	- Reducing vendor lock-in	- Security
	- Limited financial resources		- Interoperability
	- User's past experience		- Frequent updates
	- Reduction of bugs in medical systems		- Compatible with legacy system, skills and task
	- Reduction of software ownership and development cost		- Flexibility and freedom
	- Public policy encouraging that all software developed by the government must be released under an OSS license		- Centrality of IT
	- OSS can reduce EMR ownership and development cost		
	- Disappearance of the vendor lock-in		
	- OSS adherence to standards for compatibility and data interchange		
	- Network externalities		
	- The OSS champion example		

Continued on next page

Table 1 continued

Failure	<ul style="list-style-type: none"> - Connectivity - Skills and information - Computing - Lack of support from vendors - Perception that OSS would threaten local proprietary software companies - Fear by users to become de-skilled - Lack of reliable procurement models - Legal (licenses) - Technical (functionality, security, usability) - Corporate and business policy (vendor, customer support, and software alliances) - High level of technical expertise required for OSS - Proprietary mindset of the medical community - Technology complexity of the medical domain - Lack of OSS-IT personnel support, specifically for medical software applications - Leadership and top management in healthcare is risk adverse - Elimination of in-house personnel due to outsourcing - Technology complexity of the medical domain - Having to change operating model to OSS - Lack of OSS champion example 	<ul style="list-style-type: none"> - Compatibility - Version control - Market demand - Lack Support - Applying strategies for developed countries 	<ul style="list-style-type: none"> - Lack of functionality - Lack of commitment from technical personnel - Maintenance costs - Lack of training - Difficulty in training - Unpleasant routine - Lack of consultant - Lack of support services

4. CRITICAL FACTORS FROM CASE STUDIES IN DIFFERENT PUBLIC ORGANIZATIONS

As seen in Table 1, the common factors that influence the adoption positively or negatively of open source in three different public sectors are listed below. The following part will describe the most critical factors discovered based on the authors' views and in other studies, which the authors believed were the primary concern for adopting open-source software.

4.1 Institution of higher learning

The increasing prominence of Open Source software adoption is one of the several trends in Higher Education. Acceptance and spreading of OSS in HEIs started in the 1960s. OSS has many benefits, one of which is that it may aid, enrich, and augment education by offering tools for promoting teaching and learning activities. As a result, the number of institutions and colleges transitioning to OSS is increasing. The migration process to adopt OSS is driven by a variety of factors that can affect the adoption process positively or negatively. We will discuss the main aspects which could work as a driver for higher education institutions to use open-source software.

A case study was conducted in Zanzibar by (20), in which they identified the most influential factors that contributed to the adoption of OSS in Tanzanian higher education institutions. They demonstrate that the primary drivers of the OSS adoption approach were total cost ownership, the freedom to copy and distribute software without fear of legal consequences, reliability, availability, and performance, and finally, security problems. The review established that the authors prioritize cost savings by arguing that open source software offers cost savings, which prompted them to build the cost-cutting methodology. Additionally, hindrances such as support persisted, which researchers identified as the primary obstacle to the adoption process. They conclude that developed-country OSS adoption strategies do not fit the Zanzibar experiment and make several recommendations, including amending education curriculum to incorporate open standards,

establishing an OSS team to provide consultations and integrate with open standards, and finally, establishing an OSS Research Center to conduct various FOSS projects to support ICT strategy in education.

Another study performed in the United States [23] demonstrates how higher education institutions in the United States are attempting to reconcile limited funds with escalating technology expenses. According to the author, only a slight effort has been made toward developing policies and procedures for open source regulatory compliance and security. The author identified critical factors that drive OSS adoption in higher education institutions in the United States, including the desire to decrease or eliminate software license fees and vendor lock-in. Numerous other factors were identified as barriers to OSS adoption, including a lack of influence from administrative and academic technology services integration, a lack of ability to use open source as a recruitment and retention tool for IT personnel, and a lack of pressure from agencies to adopt open-source software.

Table 2. most critical factors extracted from case studies.

Higher Learning	Local Government	Healthcare
Cost ownership, Eliminate software license fees	cost reduction, top management support	Lack of in-house development, Lack of security

4.2 Local Government

Today, as technology advances at a breakneck pace, citizens' lives require more efficient use of their time for business and government-related operations. Cities and municipalities increasingly make it more difficult for municipalities to coordinate their operations and provide services to their population. To address these issues, cities and municipalities must update their structures and implement e-government solutions. As noted in a case study of open source software usage in Turkey's largest municipality [24], the relevance of open source software OSS in the city resides in cost savings and reduced technical support requirements. Additionally, integration, customization, independence, time, and open standards contribute to the success factors for OSS adoption in municipal government.

It gives an integrated framework in the case study of a Malaysian City Council (2008) that enables the researcher to perceive the different viewpoints that impact OSS appropriation at each stage of the process. This knowledge will aid in making sound implementation decisions and will result in more efficient usage of OSS. Additionally, this case study demonstrates that the most crucial success factor would be top management support. Additionally, this case study illustrates the various perspective requirements for OSS appropriation, which include three perspectives: technological, organizational, and personal.

The disadvantages of utilizing OSS can be summarized in a variety of ways. The absence of consultant and support services and a shortage of software compatible with OSS in comparison to Microsoft Windows are the limitations that have emerged [24]. Additionally, there are numerous disadvantages to utilizing OSS in the City Council of Malaysia (2008), including a lack of functionality, a loss of technical employee commitment, increased maintenance expenses, poor usability, a lack of training, an unpleasant routine and difficulties in learning.

4.3 Healthcare

Open-source software appears to be a promising path for rapidly and inexpensively implementing health information systems suitable for developing countries. The author discussed some features of open source e-health software that are especially pertinent to developing countries. As an example, consider the first case study. Pal, Mbarika, Cobb-Payton, Datta, and McCoy (2005) identified six important success characteristics for telemedicine initiatives in India. According to the author, connectivity, computing resources, and expertise are the primary challenges to e-health projects and the adoption of open-source software in the developing world. Less developed countries often lack the infrastructure necessary to provide telephone connections in rural regions.

Additionally, particular geographical, economic, and governmental issues frequently conspire to prevent appropriate internet access. Wireless communication, on the other hand, resolves these concerns. It is critical to note that not every country's infrastructure develops similarly, and many nations may jump to wireless solutions without using landline-based solutions.

Second, the author believes that computers are a terrible concept. Along with cost, the capacity to withstand rigorous handling, temperature, and humidity extremes, and long battery life are more crucial in developing countries than in OECD member countries because the cost of parts and transportation can make computer repair exceedingly expensive. Finally, consumer e-health is of limited utility in developing countries. Literacy and information literacy deficiencies contribute to challenges. However, because the vast majority of Web resources are written in English and are oriented around the United States regarding healthcare organization, drug and medical device availability, and naming, even materials designed for

health consumers in OECD countries are less useful for those in other countries. In their second case study of OSS adoption in hospitals, the authors discovered that software vendors are crucial in supporting OSS adoption. On the other hand, a lack of in-house development and a presumed lack of security, quality, and accountability in OSS products were impediments to adoption.

5. DISCUSSION

The adoption of open-source software is influenced by various factors that vary according to the present condition and environment of each organization. Prior study has demonstrated how organizations are concerned about implementing OSS within their environment, and academics have categorized these concerns as facilitators and inhibitors. Reviewing case studies in public companies that have previously adopted or are in the process of adopting open-source software has highlighted the elements that have a significant impact and influence on the adoption of OSS adoption. The findings highlighted the crucial elements these firms already confronted with, which may prompt other prospective adopters to take additional care to ensure a smooth and evident path to successful OSS adoption. According to prior research, developed countries have established government agencies to foster and give public agencies and organizations a national framework to follow to ensure a successful adoption process.

6. CONCLUSION AND RECOMMENDATION

The spread of open source software within public sector enterprises was influenced by various factors that might be viewed as either a hindrance or a driver to the adoption process. The paper clearly outlines that the most impacting aspects were cost reduction and top management support after analyzing a few publications covering three domains within the public sector: higher education institutions, healthcare, and local government. Other factors such as license deletion, a lack of in-house development, a lack of security, and a reduction in the amount of technical assistance required were regarded as secondary. Public organizations have significant reservations about adopting open-source software and lack a clear understanding of the variables they should prioritize or avoid. Our study will make a humble contribution to public organizations by raising awareness among management levels in these companies about leaping new technologies by making the right decision. The findings establish a clear picture of the crucial aspects that may favorably influence the adoption process, based on past case studies in various public domains. The primary element that influenced the effective adoption of OSS was cost savings, followed by several secondary considerations.

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