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ADOPTION OF OPEN SOURCE SOFTWARE IN GOVERNMENTAL CONTEXT: A POSITIVISTIC CASE STUDY IN CHINA

Completed Research Paper

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Abstract

As the rapid development of open source software (OSS) has deeply impacted global software industry, government agencies in different countries all over the world have started to realize the huge potentials of OSS application. Based on the TOE framework for organizational level IT/IS adoption, this paper proposes a conceptual model for examining the adoption of open source software in the governmental organizational context. A positivistic case study is conducted in the government agencies of Beijing, China, so as to validate and develop the proposed model, as well as to investigate the adoption status and related influence mechanisms. Findings from the analysis demonstrate the explanatory validity of the model, and provide potentially helpful insights for future practice.

Keywords: Open source software, governmental organizations, information technology adoption, positivistic case study

Introduction

Open Source Software (OSS), such as Linux, Apache, Mozilla Firefox, OpenOffice, etc., has kept booming since 1990s. The rapid development of OSS has deeply impacted global software industry and stimulated the emergence of Web 2.0 applications (e.g. Wikipedia) with its inherent ideation of social collaboration (Bonaccorsi and Rossi 2003; Lerner and Tirole 2005; Raymond 2001). The changes that OSS brings are demonstrated not only by the innovations in business models and market competition of the software industry (Fitzgerald 2006; Watson et al. 2008), but also by the adoption and diffusion of information technologies in different types of organizations, as well as the integration between technologies, organization goals, and individual needs (Casadesus-Masanell and Ghemawat 2006). Compared with proprietary software, OSS has its unique advantages. First, from a technical perspective, OSS opens its source codes to users, and essentially enables end users to customize the software and better adapt it to specific application contexts. In addition, globalized OSS communities provide strong development forces and collaborative test beds for improving software quality (Bonaccorsi and Rossi 2003; Kuk 2006). Second, from an organizational perspective, OSS provides significant benefits with regard to costs and risk control (Economides and Katsamakos 2006; Kovács et al. 2004), and therefore is more cost-effective. Meanwhile, the modifiability and controllability of OSS also facilitate its integration with various organizational processes (Kovács et al. 2004).

On such a background, government agencies in different countries all over the world have started to realize the huge potentials of OSS application. Research on the feasibility, maintainability, and supportability of OSS adoption in governmental contexts has also started to emerge (Simon 2005). Moreover, as a global phenomenon, citizens are increasingly raising new requirements for governmental services, such as improving the convenience of services, developing one-stop solutions, and providing diverse access methods. Therefore, the development of e-Government is facing enormous technical and managerial challenges (Guo et al. 2009). Besides, miscellaneous issues including information sharing among agencies and regions, stability and reliability of information systems, and authorization and maintenance problems in government IT projects remain big concerns to e-Government practitioners (Grant 2005; Irani et al. 2007; UN. 2005). In this circumstance, the advantages of OSS in flexibility, compatibility and cost-effectiveness provide new approaches to tackling these problems. In recent years, evidences of successful OSS application in governmental organizations have kept on emerging in both developed and developing countries, while more and more nations are beginning to establish their own agenda for developing and applying OSS in government agencies (Haider and Koronios 2008).

During the past ten years, the academic field has attached considerable attention to research questions related to the development, organization, application, and evolution of OSS. Existing efforts in this area have resulted in notable findings with regard to developer motivation, coordination mechanism, business models, and project management. Accumulated literature illustrates that OSS has introduced a large amount of new research issues to the IS discipline, which deserve further investigation (von Krogh and von Hippel 2006). Related research by far, however, has largely focused on the participation behavior and organization patterns in the practice of the development and commercial operation of OSS. To the extent of our knowledge, studies on users' adoption and use of OSS are still very rare. On the other hand, information systems adoption and use have remained a central concern in the field of information systems research during the past twenty years (Sidorova et al. 2008). Since OSS features a new form of relationship between users and developers of software, it can be reasonably expected that the driving factors for OSS adoption would differ from those for traditional technologies. Particularly, in the context of governmental organizations, where security and controllability are prioritized, the adoption decision and usage behavior with regard to OSS may be determined and driven by some special mechanisms, which are different from existing findings about IT/IS adoption. Accordingly, we believe that it is worthwhile to probe into the adoption and use of OSS and the governmental context, so as to reveal the factors influencing the user behaviors and organizational practice when OSS is introduced into such organizations.

Based on such understanding, in this paper, we focus on the adoption and use of OSS in government agencies. An analytic model based on a classical framework is postulated for analyzing OSS adoption at the organizational level. A positivistic case study is conducted in the government agencies of Beijing, China, so as to empirically validate and further develop the proposed model, as well as to investigate the adoption status and related influence mechanisms. Findings of the research may provide helpful insights for better understanding the structures and patterns of OSS application in governmental organizations, which could be meaningful to both future practice and further studies.

Related Literature

As stated above, this paper is aimed at examining the adoption and use of OSS in government agencies, especially Chinese government agencies. In this sense, we hope that our effort will contribute to both open source software studies and IT/IS adoption research. In this section, we will briefly review the existing literature on open source software adoption and IT/IS adoption in governmental organizations, respectively.

Open Source Software Adoption

As the impacts of OSS grow, apart from related technical issues, the academic field is now paying more and more attention to the managerial topics about OSS, such as economic effects and user behaviors. Relevant directions of this type of research include participation motivation of OSS developers and users (Bagozzi and Dholakia 2006; Lerner and Tirole 2005; Raymond 2001; Ye and Kishida 2003), OSS project and process management (Grewal et al. 2006; Zeitlyn 2003), the organizational structure of OSS communities (Baldwin and Clark 2006; Dempsey et al. 2002), and the impacts of OSS on the software industry (Bonaccorsi and Rossi 2003; Bonaccorsi et al. 2006; Economides and Katsamakas 2006).

In the current OSS literature, the amount of adoption studies is relatively small. Among the limited studies in this direction, most of them are focused on analysis at the organizational level. In this regard, the Technology-Organization-Environment (TOE) framework (Tornatzky and Fleischer 1990) provides a widely-used theoretical foundation for organization level investigations. According to this framework, the factors that affect organizations' adoption of new innovations fall in the following three categories:

- *Technological factors* refer to the characteristics of technologies, including both the existing technologies in use and new technologies relevant to the organization.
- *Organizational factors* refer to the internal characteristics about the organization, such as organizational size, degree of centralization, degree of formalization, complexity of management structure, employee skills, and the amount of slack resources available.
- *Environmental factors* refer to the external context about the organization, including sector characteristics, competition situation, external resources, policy, etc.

The framework has been effectively used in a number of empirical studies, such as Cooper and Zmud's work on MRP adoption (Cooper and Zmud 1990) and a series of e-Commerce system adoption research conducted by Zhu and others (Zhu and Kraemer 2005; Zhu et al. 2006).

Chau and Tam first proposed an organization level OSS adoption model based on the TOE framework and then used data from 89 firms to test the model (Chau and Tam 1997). In their model, all the factors were categorized into external environment, organization technology, and characteristics of "open system technology" innovation. External environment is mainly considered in terms of market uncertainty; organization technology includes complexity of IT infrastructure, satisfaction with existing systems, and formalization on system development and management; characteristics of "open system technology" innovation include perceived benefits, perceived barriers, and perceived importance of compliance to standards, interoperability and interconnectivity. In another study about the adoption of server platforms, Dedrick and West used a case study method to investigate the impacts of technological, organizational, and environmental factors (Dedrick and West 2004). Compared with Chau and Tam's work, Dedrick and West's interpretation about TOE factors is fairly different. In their model, "technological factors" include relative advantages (e.g. cost, reliability), compatibility (technology, skills, task, etc.) and triability; "organizational factors" include IT innovativeness, centrality of IT, and slack resources; "environmental factors" include available technology skills and services, legitimacy, etc. More recently, Glynn et al. added a fourth dimension, namely individual factors (e.g. ideologically pre-disposed towards OSS, existence of OSS champion, and user undervaluation of OSS), into the TOE framework (Glynn et al. 2005).

The TOE framework comprehensively takes internal factors, external factors, and the fitness between technology and organization requirements into account. However, this is a highly generalized framework, which needs to be further detailed and extended when it is applied to the examination of concrete problems. For our research with regard to the adoption of OSS in government agencies, the framework should also be specialized and reified according to the specific context.

IT/IS Adoption in Governmental Organizations

Since late 1980s, IT/IS adoption has remained a central concern in the field of information systems research. Related efforts have produced a number of theoretical models, such as technology acceptance model (TAM) (Davis 1989), to interpret the psychological and social mechanisms that potentially determine the behavior of technology adoption. Meanwhile, large amounts of empirical and field studies were conducted in various regions of the world to validate the theories.

With regard to governmental organizations, however, the issue about adoption of new information technologies or systems has not yet been sufficiently addressed. Existing efforts on information systems in governmental organizations are majorly focused on development process (e.g. Layne and Lee 2001), application types (e.g. Siau and Long 2006), and organizational transformation (e.g. Irani et al. 2005; Irani et al. 2007; Irani et al. 2008). Some researchers have also started to investigate the determinants that potentially drive the adoption of information systems in governmental organizations (e.g. Brudney and Selden 1995; Moon and Norris 2005). For instance, in a study about municipal e-government systems, Moon and Norris explored the effect of managerial innovativeness on the adoption of e-government and the association between the adoption of e-government and its outcome (Moon and Norris 2005). In a more recent study about e-government adoption in China, it was revealed that, at the individual level, e-Government systems adoption largely depends on the perceived fit or compatibility between the system and the users' work/life styles, while a low perceived fit is usually attributed to the misalignment between the system and the operations practice within the organization, as well as the lack of cross-system integration (the so-called "Information Islands" problem) (Zhang et al. 2010).

According to a general classification, the locus of adoption could be differentiated between "organization" and "individual" (Fichman 1992). Notably, most studies about IT/IS adoption in governmental organizations were conducted at the individual level. Contradictorily, a large portion of application systems in the governmental context are organization-oriented and cannot be easily explained with individual level cognitions. Therefore, it would be worthwhile to introduce a theoretical framework at the organizational level to the research about IT/IS adoption in governmental organizations. In this paper, we draw upon the TOE framework to postulate an organizational level model for understanding the adoption and use of open source software in the governmental context.

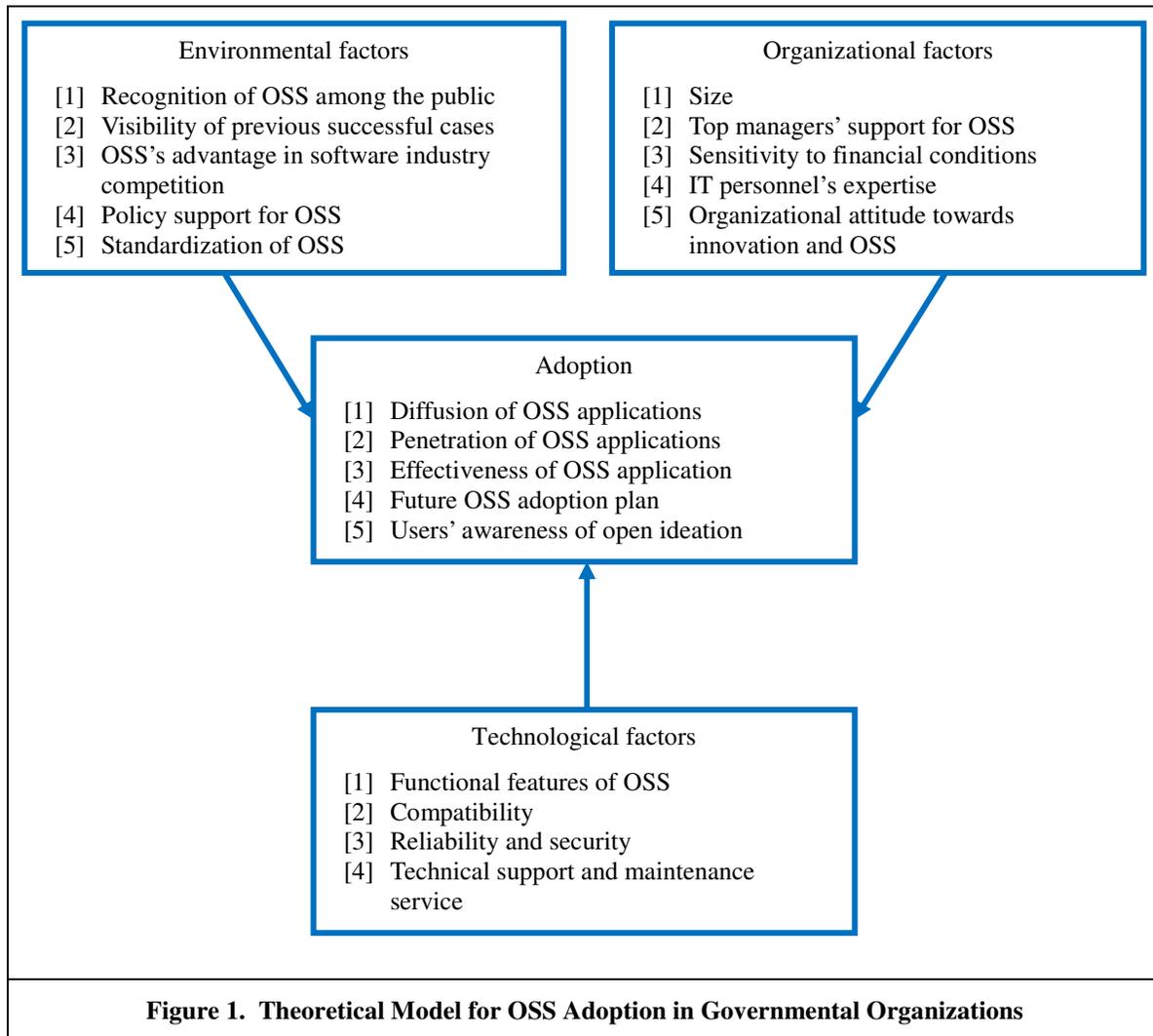
Research Model

When considering the adoption of OSS in the governmental context, it is worth noting that the characteristics of OSS bring both advantages and disadvantages to governmental organizations. On one hand, previous efforts have suggested that the major obstacles in the IT/IS application of governmental organizations, such as defective authorization mechanisms, difficulty in finding proper software providers, and information exchange hindrance among agencies and regions caused by the lack of unified standards, can be mostly addressed by the features of OSS. Consequently, government agencies are likely to be motivated to use OSS (Simon 2005). On the other hand, however, in the specific organizational context within government agencies, especially Chinese government agencies, the open philosophy of OSS may severely conflict with the long-existing organizational barriers and constraints. For example, Chinese government agencies are usually conservative and risk averse when purchasing software, but OSS essentially relies heavily on continuous changes and updates (Haider and Koronios 2008).

Meanwhile, Chinese governmental organizations are usually characterized with a highly centralized decision making structure (Chen et al. 2007). As China is changing from an isolated centrally-controlled economy to a market that opens to the global economy, Chinese government agencies have also started to transform and decentralize. In the process of transforming, the government agencies often expect that the application of information technology would accelerate the decentralization of public administration and at the same time enhance government's ability to oversee key activities (Ma et al. 2005). The concurrent pursuit of these two seemingly paradoxical objectives leads to a highly demanding context for e-government application and management in which administrative reform and systems implementation are tightly linked and frequently interacting (Zhang et al. 2009). In this regard, a comprehensive model involving both technological and contextual dimensions would be particularly helpful for understanding why and how OSS might be adopted and actually used in such organizations.

Based on the TOE framework, we propose a model for examining the adoption and use of OSS in governmental organizations, as shown in Figure 1. The model reifies the TOE framework with detailed factors drawing upon the

findings of related literature, as well as field observations collected by one of the authors. In the following sections, we will discuss the dimensions and factors of the model respectively.



Adoption

In the proposed model, adoption of OSS in governmental organizations is evaluated with five factors. Among them, diffusion (the extent to which OSS applications have reached in the organization) and penetration (the extent to which an organization depends on OSS applications) of OSS applications were adapted from a two-dimension framework designed for examining the status of IT/IS application in an organization (Zhang et al. 2007). "Effectiveness of OSS application" refers to the judgment and evaluation of users on the application performance of OSS. This factor was adapted from an earlier e-government adoption research (Moon and Norris 2005), where it is decomposed into effectiveness of websites, intranets, and online services. The other factors, "future OSS adoption plan" and "users' awareness of open ideation", have also been commonly discussed in prior research about IT/IS adoption in governments (Brudney and Selden 1995; Moon and Norris 2005).

Environmental Factors

Environmental factors are consistently considered as one important aspect in the studies about the commercial adoption of OSS. In the model proposed in this paper, "recognition of OSS among the public", "visibility of previous successful cases", and "policy support for OSS" were all adapted from related studies in commercial

contexts. Among them, the first two were discussed by Glynn et al. in their research about commercial adoption of OSS (Glynn et al. 2005). In a research about open source server platforms, Dedrick and West highlighted an environmental factor called “technological legitimacy” (Dedrick and West 2004), which can be regarded as a reflection of “public recognition”. Compared with business companies, government agencies tend to be more sensitive to public recognition (Irani et al. 2008). As the Chinese government is experiencing a transition from administrative to service-oriented agencies, e-Government information systems interact more frequently with the general public. In such a situation, it is believed that the government agencies would take public recognition into account when making a decision to adopt OSS.

In addition, OSS’ may also influence its adoption. As OSS gains increasing competence in the software market, its reliability begins to be widely recognized. This will accelerate the governmental adoption of OSS. Meanwhile, the standardization of OSS is also a potential factor. Different from proprietary software, OSS usually follows some common open standards, which could better facilitate the integration among different OSS and different applications based on OSS. This point is often deemed as the key competitive advantage of OSS (MacCormack et al. 2006).

Organizational Factors

In this paper, we investigate the organizational dimension with the following factors: size, top managers’ support for OSS, financial conditions, organizational IT skills, and organizational attitude towards innovations and OSS.

The factor of firm size was proposed in the original TOE framework (Tornatzky and Fleischer 1990). If a government agency is small and its operational processes are simple, the obstacles the organization has to face when transiting existing proprietary systems to OSS systems would be fewer, hence OSS adoption within the organization would be easier. Besides, as replacing proprietary software with OSS is a dramatic and highly risky IT project, top managers’ support also plays important role in its successful implementation (Dedrick and West 2004).

Financial sensitivity of the organization may also have a significant impact on the adoption of OSS. This is due to the fact that “free of charge” is an important competitive advantage of OSS. By using OSS, organizations can reduce software costs significantly. This is particularly attractive to organizations with limited budgets. Meanwhile, adopting OSS requires highly skilled IT personnel, because OSS does not offer traditional legal comforts of vendor-guaranteed support and written maintenance contracts, hence organizations can only rely on their IT personnel to maintain the OSS systems (Glynn et al. 2005). Moreover, if IT personnel have sufficient technical skills and thus can participate in the development of OSS, then the organization should be able to bring the technical advantage of OSS into full play. In a word, highly skilled IT personnel can facilitate OSS use in government agencies.

Finally, the impact of organizational culture on OSS adoption should never be ignored. As mentioned above, replacing proprietary software with OSS is a drastic organizational change, which may have effects on the entire organization. Therefore, the better the organization accepts the open philosophy and transforms accordingly, the easier it adopts and promotes OSS.

Technological Factors

In the proposed model, the technology dimension includes functional features of OSS, compatibility, reliability and security, and after sales technical support and maintenance service.

Firstly, the accessibility of the source codes facilitates OSS users to customize the software products such that it can be better situated to the application context (Bagozzi and Dholakia 2006). This feature empowers OSS with the potentials to improve organization efficiency and to optimize operational processes. Since government agencies’ motivation to implement information systems is usually to improve efficiency, such potentials should be very attractive to them. Secondly, the transparency of OSS source codes provides the organizations with more control over the software and systems and thus better meets security and compatibility requirements (Bonaccorsi and Rossi 2003; Watson et al. 2008). Security is an extremely important concern for government users. With good security potentials, OSS is attractive to government users, especially to the crucial departments. Thirdly, in recent years, government agencies in many countries across the world are making efforts to realize so called “one-stop services,” which requires a higher level of compatibility. The open standards facilitate system integration among departments and regions, while OSS’s excellent modifiability enables functional upgrading and technology innovations. In this sense, OSS’s potentials to satisfy special technical requirements are proactive in encouraging OSS governmental adoption.

On the other hand, in many cases, government agencies require higher system quality and reliability. Although there are large and strong developing and testing teams in open source communities and the quality of OSS obtained directly from OSS communities is somewhat secured (Bagozzi and Dholakia 2006; Roberts et al. 2006; Ye and Kishida 2003), the specific systems or applications installed in government agencies still need professional service providers to provide technical supports. How much such support OSS users can get also has a considerable impact on government agencies' adoption decisions. Last but not the least, OSS's compatibility with existing technical infrastructures and other applications is another factor we should consider (Glynn et al. 2005).

Research Method

A positivistic case study method is used to test the model described above. The case we selected is the adoption of OSS in the government agencies in Beijing China. Qualitative data were collected through interviews, field observations, and documents provided by the organizations. In the following sections, we will introduce our research method and procedures in detail.

Positivistic Case Study Method

Case study is an important research method in the Information Systems area. In the past years, it has been widely accepted and applied by IS researchers (Myers 1997; Tsui 2006). The case study method is very helpful to study current phenomena deeply and timely. It is particularly applicable to questions in which the boundary of phenomena and background is too vague to determine. In general, case study is the most suitable method when a "how" or "why" question is being asked about a contemporary set of events over which the investigator has little or no control (Yin 2003). Our research question about governmental adoption of OSS well fits with the above criteria. Therefore, case study is considered the most appropriate method for this research.

A point worth mentioning is that most of the existing researches analyzing IT/IS adoptions use research method of survey (Schwarz and Chin 2007), and so do studies on E-government adoptions (e.g., Phang et al. 2006; Zhang et al. 2009). The survey method is most suitable for addressing research questions in the form of "what", "who", "where", "how many", and "how much", and is particularly useful in recognizing and analyzing independent and stable attributes (Yin 2003), so it fits well with the analysis about individual level user adoption. At the organizational level, however, due to the interactions among external and internal factors, as well as the complexity of cross effects, surveys usually lack the capability for revealing essential findings. It is worth noting that, although IT/IS adoption research has been prevailing in the IS area for almost twenty years, most studies in this field are conducted at the individual level, aimed at exploring the influence mechanism between individual cognition and adoption decision-making from a social psychological perspective (Benbasat and Barki 2007). With respect to the organization-oriented complicated application systems such as e-Government systems, theories based on individual cognition provide fairly limited explanation capability. Furthermore, partly due to the limitation of the survey method, existing studies IT/IS adoption are mostly focused on the decision-making behaviors at a single time point, without considering the penetration and evolution process of systems in an organization. In other words, social psychological based theories, such as TAM (Technology Acceptance Model) (Davis 1989) and its derived models (Venkatesh et al. 2003), suffer from the lack of capability to explain why and how systems continue to be used after they are adopted. Although there have been efforts in attempting to explore post-adoption issues and interpret the continued use of IT/IS (Bhattacharjee and Premkumar 2004; Burton-Jones and Straub 2006), most of them are still at the individual level and cannot be easily adapted to the organizational level. These limitations have, to a large extent, restricted existing research from providing more in-depth analyses on the IT/IS adoption and penetration mechanism in organizations. We believe that our attempt to employ case study method in our research will be a meaningful exploration for research directions of IT/IS adoption related studies.

The case study of the current research was conducted in the light of the theoretical model proposed above. The goal of the case study is to collect real data and then test the theoretical model and provide valid explanations. As this study can be regarded as a positivistic and explanatory case study (Benbasat et al. 1987), we followed the steps suggested by a widely accepted set of guidelines (Klein and Myers 1999; Yin 2003) to ensure the rigor of our research.

Interviewee Selection

In order to fully understand the status and potential factors of OSS adoption in Beijing government agencies from different perspectives, we selected three different types of interviewees: decision makers and promoters for software and e-Government applications in the government agencies, software users in the organizations, and OSS providers. Interviews with different interviewees are very helpful in data combination and cross-testing, so as to obtain “evidence triangulation” (Yin 2003) and guarantee the construct validity of our case study.

In April and May of 2009, after reviewing relevant documents, we first interviewed the Vice Director of Software Promotion Center of Beijing Scientific and Technological Commission and Chief of e-Government Division in Beijing Municipal Office of National Information Infrastructure, from whom we collected data on the perspective of software adoption decision makers and application promoters. After that, we interviewed the Vice President of Red Flag, the biggest Chinese Linux system provider, and collected data on the perspective of OSS product suppliers. Finally, we interviewed Beijing Municipal Administration Commission (interviewees included the chief of its technology division and the director of its information center) and the Pinggu District Government (interviewees included the Director of its information center and a technical staff in charge of OSS application) and collected data on the perspective of users. We believe that these two agencies are qualified representative users, because they represent two major types of subdivisions of Beijing Government, namely commissions and regional governments. Altogether, we interviewed 7 interviewees from 5 organizations, as shown in Table 1.

Table 1. Interviewee Summary			
No.	Type	Organization	Position
1	Decision makers and promoters	Software Promotion Center of Beijing Scientific and Technological Commission	Vice Director
2		e-Government Division, Beijing Municipal Office of National Information Infrastructure	Chief
3	Software providers	Red Flag, Inc.	Vice President
4	Users	Beijing Municipal Administration Commission	Chief, Technology Division
5			Director, Information Center
6		Pinggu District Government	Director, Information Center
7			Technical staff

Interview Design

We designed at least one question for each specific factor in our model. These questions are all semi-structured. Semi-structured questions allow interviewees to control the progress of the interview, while the answers will not be biased by researchers’ subjective attitudes. This sort of questions is extremely useful when the target of the interview is to achieve their unique experiences (Yin 2003). As a supplement, we also designed one open question at the beginning and the end of each interview respectively. The one at the beginning aims to collect the most important adoption factor in interviewees’ minds, while the latter one is used to capture the factors that may not be represented in the theoretical model we proposed. In total, we designed 25 questions before hand, fully covering factors in the three dimensions of the model, and then made necessary modification for each interview in accordance with the different statuses of the interviewees. We also added or removed some questions temporally in the interview processes.

Data Coding

We recorded each interview both by hand and with voice recorders. Once we finished an interview, we always compiled the raw information into drafts as soon as possible. The drafts kept as many details in the interview

circumstances as possible. If any policy or project was mentioned by the interviewees, we would check associated documents so as to better interpret the interviewees’ answers. We then coded our conversations with the interviewees into data that can be used to justify our theoretical model. To ensure the objectivity of the data coding process, after one of the authors finished coding, another author would double check the results obtained. When there was any disagreement between the two, a discussion would be conducted to reach consensus.

An example of data coding is illustrated in Table 2. There are two data items, tagged as X61 and X62, coded in the table. The process of coding can be described as follows. First, we listed the questions that we asked in the interview (the 4th column in Table 2). Second, we split the interviewees’ answers to each question into multiple sense segments (the 5th column in Table 2, where X indicates the interviewee) and then marked the sense segments with tags (as shown in the 1st column, the tag X61 represents the first sense segment in interviewee X’s answer to Question 6). Third, we extracted a summary (The 3rd column) from each sense segment. Fourth, we mapped the summary into the four components of the model, namely adoption, technical factors, organizational factors and environmental factors (in the example, E2 in the 2nd column means this sense segment is related to the second environmental factor), and then judged whether the factor’s effect is significant (the 0 in 2nd column means the effect is not significant). If it is significant, we further decided whether the factor has a positive or negative effect (“+” or “-” in the 2nd column). Finally, we summarized the tagged items for each factor in the model and tried to draw corresponding conclusions. In total, we compiled 191 tagged data items. We mapped the tags to the theoretical model proposed previously to test our model. The mapping will be elaborated on later.

Table 2. Data Coding Example				
Time: April 13th,2009		Interviewee: X		
Position: Vice Director of Software Promotion Center of Beijing Scientific and Technological Commission, Secretary-General of Changfeng Open Standards Platform Software Alliance				
Tag	Factor	Summary	Question	Sense segment
X61	E2(0)	OSS adoption experiences from other countries have little impact	Z: do you know any successful case of OSS adoption in foreign governments? If so, how did their successes affect your decisions?	X: Foreign experiences are not very useful to us, because national reality vary a lot among countries. In foreign countries, different government agencies have consistent goals, and so policies can be implemented fluently. In China, however, government goals are often multi-dimensional. Government strategic directions are always changing. It is often the case that in a certain period, independent innovation gains great attention, but only a short period later, no one mentions it at all, and sometimes, other policies against OSS adoption are taken into action.
X62	E4(+)	Policies were not carried out. Policy makers did not have a strong determination, which hindered the OSS adoption		X: Sometimes, government agencies’ goals conflict with each other. As a result, many policies or guidelines are not carried out. The fundamental reason lies in governments’ lack of determination.

Reliability and Validity

The quality of an empirical study is commonly measured by its construct validity, internal validity, external validity and reliability (Creswell 2009; Yin 2003). In order to secure a high level of validity and reliability, we attached our attention to these four aspects while designing and conducting the research.

There are three methods to improve the construct validity: (1) to use multiple sources of evidence; (2) to construct an evidence chain; and (3) to ask key interviewees to comment on preliminary case study reports (Yin 2003). Accordingly, we used multiple sources of evidence in our research, which includes: (1) academic literature of OSS organizational adoption; (2) media coverage of OSS governmental adoption and relevant policies; and (3) interviews with OSS adoption practitioners. In addition, the case analysis was conducted by a team composed of three

researchers. As mentioned above, in the coding process, after one member completed the analysis, another member would double check the results to eliminate the inaccuracy that may be caused by the subjective judgment.

Internal validity mainly focuses on whether the causal relationships or inferences in the conclusion are valid or not. Pattern Matching is an effective strategy to enhance internal validity (Yin 2003). Pattern Matching means comparing empirical patterns with predicted models. If the theoretical models fit the empirical results, then the validity of the causal inference will be reinforced; on the contrary, if there is any inconsistency, the causal relationships will be discredited, and we need to modify the model accordingly. This is an iteration of “theoretical model-evidence-theoretical model”, in which model and evidence interact with each other repeatedly. Researchers should adjust their theoretical hypotheses, and then apply adjusted theoretical hypotheses to the analysis of reality. This data analysis method has some potential problems. For example, presumably the theoretical model ignores certain important factors or makes an incorrect assumption, then it is very likely that important factors not included in the theoretical model and evidences that contradict the assumption will be completely omitted in the interviews. In order to fix the problem, although we assigned positive and negative signs to the factors in our model, the questions we designed for the interviews are mostly “whether it exerts impact on OSS adoption” and “whether it facilitates or impedes the OSS adoption”. By doing so, we avoid the problem that the interviewees be intervened by our presumptions. Meanwhile, we added open questions into our interviews on purpose to capture potential factors that might be ignored in our theoretical model.

Although we have interviewed 7 people from 5 organizations, the research subject in our study is the aggregation of government agencies within Beijing. In other words, we take the governmental OSS adoption in Beijing as our research case. In this sense, we are using a single-case study in this paper. The external validity of single-case studies is often questioned, because opponents may argue that the conclusions derived from a single case are probably not applicable to other cases. People attacking single case study with its small sample size usually unconsciously compare samples in single-case study to survey samples. Nevertheless, this analogous is not valid. Survey study is based on statistic generalization, while case study is based on analytic generalization (Yin 2003). In our study, this analytic generalization was first reflected in the selection of target city and interviewees. We selected Beijing as our target city because it was one of the earliest cities whose government agencies adopted OSS and OSS applications were still well accepted. The early initiatives of OSS adoption provide us with more potential target agencies with longer adoption experience to conduct interviews. Secondly, when selecting interviewees, we carefully considered subjects’ representativeness, status and personality. Besides, OSS adoption in the government agencies in Beijing is a very broad case. Different agencies’ and their subdivisions’ adoption behaviors are relatively independent. Therefore, our “single case” could be deemed as a case composed of many smaller cases. In a sense, our case study still has the external validity that a multi-case study possesses (Creswell 2009; Yin 2003).

Theoretically, reliability is measured by the similarity between the conclusions derived from one case study and conclusions from another case study conducted with exactly the same research steps and the same target case but by other researchers (Yin 2003). The major method to improve reliability is to record the study process as detailed as possible, so that the followers can precisely duplicate this research. In our case, we made detailed research plan, discussed it and modified it for several times before the interviews. Moreover, we kept complete documentations of the entire process of the case study, including interviewee selection, interview question design, interview records, coding and data-model mapping.

Results and Discussions

Mappings between factors and coding tags are summarized in Table 3. The 1st column of the table lists all the factors in the model (adoption status also included). The 2nd column lists the observation points generalized from the data items. The 3rd column lists the numbers of data items (tags) from which a certain factor gets support. Due to limited space, we do not enumerate all the tags; instead, we listed only the number of supporting tags for each factor.

Based on the analysis above, we discarded the factors proven to have little effect, adjusted the coverage of some factors, and emphasized key factors with decisive roles (marked with “*” in the figure). The verified and revised governmental OSS adoption model is shown in Figure 2. From the results shown in the figure, it is demonstrated that the Governmental OSS adoption model proposed in this paper is supported by the empirical case of Beijing government agencies, which indicates strong explanatory power. Important factors in technical, organizational and environmental dimensions are all disclosed in the model.

Table 3: Summary of Mappings between Factors and Data Items		
Factors	Observation points	Number of tags
A[1]	OSS takes small share of government software application	1
	Among different types of OSS, open desktop operation systems and open office software are best accepted.	5
A[2]	OSS is mainly used in non-central operation processes	1
	Some E-government systems based on OSS have high penetration	1
A[3]	Deviate a lot from expectation; adoption situation is worse than expected	1
	Some representative cases emerged	4
	At the beginning, the size of OSS purchase is large, but actual use shrinks later on	1
A[4]	Will increase domestic software (OSS) use	1
	Have already made relevant measures to advance future purchase	1
A[5]	Users play the role of testers in the OSS application development	1
E[1]	The general public's support to OSS adoption is helpful	Positive effect: 1
E[2]	Foreign cases' impact is limited	No effect: 2
	Local government hope they can follow foreign successful cases	Positive effect: 1
	Cases in other regions of China has little impact	No effect: 1
E[3]	OSS performed badly in software industry, which impedes OSS adoption	Negative effect: 5
	OSS takes small market share, hence there are only a small amount of hardware that is compatible with OSS, which greatly impedes OSS adoption	Negative effect: 1
E[4]	There is neither long-term strategic guideline nor policy plan to support domestic software, which impeded OSS adoption	Negative effect: 6
	Governments' actions supporting domestic software are in favor of OSS adoption	Positive effect: 26
	Government agencies have invisible pressure to use domestic software	Positive effect: 1
	Governmental adoption of domestic software plays an exemplary role	Positive effect: 2
	Policy is a factor, but not the primary factor	Positive effect: 1
	Government's effort to eliminate pirate software could force agencies using pirate software to use OSS	Positive effect: 1; Negative effect: 1
E[6]	OSS standard can improve inter-system compatibility, and facilitates its adoption	Positive effect: 2
	The proposal of OSS standard is a symbol of the rising status of OSS, which is in favor of OSS adoption	Positive effect: 1
	The introduction of OSS standard made it possible for proprietary software to follow, and OSS's advantage in system compatibility will be weakened	Negative effect: 1
O[1]	Agencies with smaller size and low information process requirements tend to use domestic software	Positive effect: 10
O[2]	Top managers' support plays essential role in OSS adoption	Positive effect: 4
O[3]	Sectors with limited budget tend to use OSS	Positive effect: 3
	Government agencies do not take financial factors seriously	No effect: 5
	Taking the costs of training employees to use OSS and replacing hardware into account, OSS does not have any cost advantage	No effect: 2
	Subsidies provided to sectors using domestic software are attractive, and thus can stimulate OSS adoption	Positive effect: 1

O[4]	The better knowledge of OSS that IT personnel's within organization have, the better OSS is adopted in the agency	Positive effect: 8
	As IT personnel in government agencies participate little in application development and government information systems are often outsourced, government agencies do not care whether the software is open or not	Positive effect: 7
O[5]	End users' attitude to OSS and organization acceptance of OSS have little impact	No effect: 4
	Lack of efforts to promote OSS ideation can impede OSS adoption	Positive effect: 1
T[1]	If OSS can satisfy operation requirements and enhance efficiency, then it will be better adopted; vice versa	Positive effect: 15
	If domestic software can be integrated to operational process, then it would be better adopted	Positive effect: 3
T[2]	If proprietary software is widely used in higher, lower and closely related same level departments, then compatibility problem will be extremely severe, which hinders OSS adoption	Negative effect: 6
	The flexibility of OSS and compatibility among agencies have little impact on OSS adoption	NO effect: 1
	Hardware currently used is not compatible with OSS, which hinders OSS adoption	Negative effect: 2
	The cost of technology transformation is too high, which impedes OSS adoption	Negative effect: 6
T[3]	Agencies with higher security requirements tend to use OSS	Positive effect: 7
	Concerns on domestic software's quality hinders OSS adoption	Negative effect: 31
T[4]	Using OSS does not require better IT hardware	No effect: 1
	Cooperation between OSS providers and other domestic software producers is needed to improve OSS's long term service ability	Negative effect: 2
	Current IT infrastructure has no significant effect on OSS adoption	No effect: 1

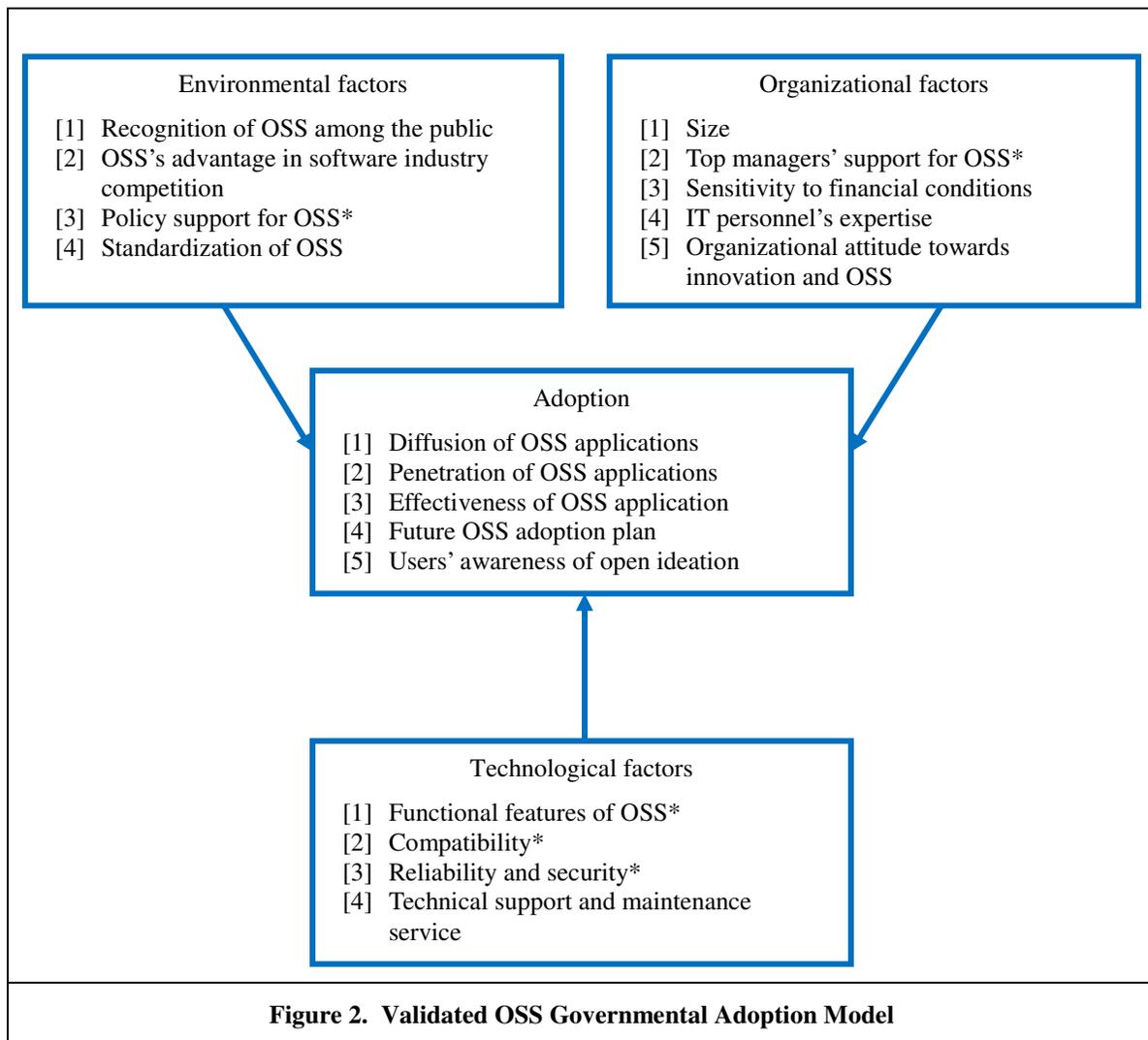
Among environmental factors, the assumption that government policy support to domestic software (in the Chinese governmental context, OSS and domestic software are considered to be closely related) can stimulate OSS adoption was supported by a large number of both positive and negative demonstrations. We may conclude that this factor is the most important one among environmental factors, or even the most crucial factors in the entire model. Interestingly, apart from the effect of government policies that explicitly support domestic software, there seems to be an invisible pressure to use domestic software, and the exemplary effect is often taken into consideration. On the other hand, the public's attitude towards OSS and OSS's status in software market competition also have significant impacts. Successful adoption in either domestic or foreign government agencies has little effect on the adoption decision in Beijing government agencies.

Among technical factors, OSS's functional features, compatibility, and reliability all have expected effects. As to functional features, OSS's contributions to organizations' efficiency and process reconstruction advance OSS adoption. As to compatibility, the incompatibility between OSS and proprietary software lowers its efficiency and productivity. This problem is one of the major hindrances to OSS adoption. As to reliability and security, the positive effect of OSS's advantages in information security is again supported by evidences. However, since the IT personnel in government agencies seldom participate in the development of OSS applications, OSS's advantages in customizability and inter-system compatibility are not fully exploited. Besides, OSS's support and maintenance services also have certain effect. Due to the weak persistency of OSS service providers, it is difficult to dispel government agencies' concerns about maintenance risk.

In this case, OSS has taken a considerable share in Beijing government agencies' software application, but the level of adoption is still far from expected. In the present stage, a large portion of Chinese software is built on OSS. As a result, OSS often appears in Chinese market in the form of "the base of domestic software". Moreover, as pointed out in previous discussions, government policies' direct support to domestic software also plays essential role in

OSS governmental adoption. Consequently, the primary motivations for government agencies to adopt OSS are: (1) to response to the policies supporting technology independent innovation; and (2) to follow the moral norm. Government’s decisions on OSS adoption also highly depend on top managers’ support. These motivations are completely different from the motivations of foreign governments. In the western countries, government agencies adopt OSS mainly to take its advantage in source code customizability and inter-system compatibility to meet public’s requirement of one-stop solutions. This significant difference in OSS adoption motivation is stemmed from the difference in the development model of government information systems. In the west, government IT personnel often engage in system development and maintenance directly, and thus they are very familiar with the bottom layer source code, which enables them to realize the technical advantages of OSS. On the contrary, in China, the most prevalent approach of developing a government information system is outsourcing. Government agencies only care about system’s usability, ease of use and maintenance services, but not whether the system is open or not. Compared with the factors affecting commercial adoption of OSS, government users do not care about cost-effectiveness as much as business users.

Meanwhile, although the Beijing government agencies are now moving ahead in OSS adoption in China, they are still confronting many problems. The most severe ones are the OSS’s low stability, poor maintenance services and bad compatibility with proprietary software. As most government organizations are risk averse, unless these problems mentioned above can be successfully resolved, it would be hard to popularize OSS in government agencies.



Conclusion

Based on the TOE framework for organizational level ICT adoption, this paper proposes a conceptual model for examining the adoption of open source software in the governmental organizational context. A positivistic case study is conducted in the government agencies of Beijing, China, so as to validate the proposed model, as well as to investigate the adoption status and related influence mechanisms. We believe that the findings of the paper may provide potentially helpful insights for future practice and related studies.

As a typical example of the fast developing trend of open collaboration, OSS is always advocating spirits of sharing, communication, and cooperation, which represent the main theme of the Web 2.0 era. Therefore, studies on OSS adoption mechanism are of important academic value. Meanwhile, OSS adoption in China is also closely related to the development of Chinese software industry, which would also make the exploration of OSS adoption mechanism in this paper meaningful to practitioners.

Meanwhile, the results from our study demonstrate that the TOE-based framework provides comprehensive theoretical support for understanding information technology adoption in governmental organizations, and would consequently contribute the IT/IS adoption literature. On the other hand, our study follows a rigorous methodology of positivistic case study. We carefully designed the research method to ensure the validity and reliability of this study. We hence believe that our work demonstrates the effectiveness and applicability of positivist case study in examining IT/IS adoption related questions in organizational contexts, and to some extent provides a comparably new methodological approach to the long-lasting IT/IS adoption research.

A major limitation of this study is that we only investigated the case at one time point. Although we included a large set of historical records in our interviews, we still lack direct observations of OSS's development process in China. In the future researches, we will attempt to overcome this problem by introducing longitudinal study methods and enhancing our research model with the Adaptive Structural Theory (Orlikowski and Robey 1991), which may provide us with a more dynamic view for understanding the evolution of OSS adoption and use. Another limitation of the current study is the number of interviews. In the on-going research, we are planning for additional interviews for collecting more data to verify our proposed model more extensively.

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