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# The Organizational Adoption of Open Source Server Software: A Quantitative Study

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# THE ORGANIZATIONAL ADOPTION OF OPEN SOURCE SERVER SOFTWARE: A QUANTITATIVE STUDY

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## Abstract

*Despite the attention that open source software (OSS) has received, relatively little is known about the factors which influence the decision of an organization on whether to adopt OSS or not. Although much anecdotal evidence has been published on this topic in practitioner literature, these claims have been insufficiently validated. Although some qualitative studies on the organizational adoption of OSS have been conducted, empirical support based on a large sample is missing. In this paper, we propose a conceptual model describing the factors that influence the organizational adoption of open source server software (OSSS). This model is based upon the results of a prior qualitative study that we have conducted in Belgian organizations. We present the results of a partial least squares analysis of survey data collected from 270 Belgian organizations. The main factors that influence the adoption of OSSS are its reliability, the presence of boundary spanners in the organization, and the switching costs involved in the migration. The latter are influenced by the availability of external support, the perception that OSSS is less expensive and the presence of boundary spanners. These results largely confirm the findings of our qualitative study. Theoretical and practical implications are discussed.*

*Keywords: open source software, innovation, adoption, information systems innovation, diffusion, survey.*

# 1 INTRODUCTION

In the past few years, open source software (OSS) has received increasing attention from both practitioners and academics. Historically, OSS has been very strong in horizontal domains such as Internet applications. Consequently, OSS server applications (e.g., Linux, Bind, Apache and Sendmail) have become a viable solution and are being increasingly adopted by organizations. Yet, relatively little is known about the factors which influence the decision of an organization on whether to adopt OSS or not. Although much anecdotal evidence has been published on this topic in practitioner literature, these claims have been insufficiently validated. Some qualitative studies have been conducted on the organizational adoption of OSS (e.g., Lundell & Lings & Lindqvist 2006, Morgan & Finnegan 2007, West & Dedrick 2005). However, empirical support based on a large-scale quantitative study is missing.

In a first phase of our research, we have conducted an exploratory qualitative study, involving 10 Belgian organizations (Ven & Verelst 2006a,b, 2008). The aim of this study was to determine the most important factors that influence the organizational adoption decision on OSS. To increase the internal validity of our study, we restricted our research to a limited set of OSS products, namely *open source server software* (OSSS), which includes applications such as operating systems, web servers and mail servers. This is consistent with the research approach taken by other researchers (e.g., West & Dedrick 2005). The data obtained during this qualitative study was analyzed in the context of adoption of innovations literature focusing on information systems (IS). Based upon the results of this qualitative study, we have developed a conceptual model describing the factors which we expect to be influencing the organizational adoption decision on OSSS. In this paper, we describe the results of the validation of this model, using data collected from a large sample of 270 Belgian organizations.

# 2 HYPOTHESES

The dependent latent variable (LV) in our model is *open source server software assimilation*. Assimilation can be defined as "*the process spanning from an organization's first awareness of an innovation to, potentially, acquisition and widespread deployment*" (Fichman & Kemerer 1997, p. 1346). Hence, the assimilation measure captures more information than the mere fact of whether the organization has adopted the innovation or not. In order to operationalize this measure, we used the previously validated Guttman scale developed by Fichman and Kemerer (1997). This scale was used to classify organizations into 7 different stages of OSSS assimilation (i.e., not aware, aware, interest, evaluation/trial, commitment, limited deployment and general deployment). Based upon our qualitative study, we have identified 7 factors which may have an impact on the organizational adoption decision. With respect to these independent LVs, we propose the following hypotheses.

Our qualitative study indicated that the *reliability* of OSSS was one of the main reasons for its adoption. On the other hand, decision makers are not likely to take any risks in adopting immature OSSS.

HYPOTHESIS 1. *Perceived reliability of OSSS is positively related to the assimilation of OSSS.*

*Trialability* refers to the fact that an innovation is easy to try out before making a final decision on whether to adopt or not (Rogers 2003). In the qualitative study, we did not obtain conclusive evidence concerning the impact of trialability on the adoption decision. Most informants considered OSSS to be easy to try out. On the other hand, some informants argued that OSSS was more difficult to try out than proprietary software since OSSS generally does not provide easy-to-use install programs. Since trialability is a frequently used construct in IS adoption research, we decided to include this construct because of its theoretical relevance.

HYPOTHESIS 2. *Trialability of OSSS is positively related to the assimilation of OSSS.*

The availability of the source code has been proposed as one of the main advantages of OSS by so-called open source advocates. However, we have found that half of the organizations in our qualitative study did not use the source code of OSSS, and its availability did not influence the adoption decision. Given the conflicting evidence on this factor, we decided to quantitatively test whether *perceived usefulness of source code availability* impacts the adoption decision.

HYPOTHESIS 3. *Perceived usefulness of source code availability of OSSS is positively related to the assimilation of OSSS.*

It has frequently been suggested that the introduction of OSS in organizations is actually a bottom-up initiative in which employees in the organization suggest the use of OSS whenever a suitable project is initialized (Lundell et al. 2006, Morgan & Finnegan 2007). We have found similar indications in our qualitative study. Individuals in the organization who advocate or promote the use of OSSS are called *boundary spanners*. Organizations in which boundary spanners are present will have to invest less time and money in training personnel. Hence, the presence of boundary spanners may lower switching costs. This is similar to the observation of Li, Tan, Teo and Siow (2005) that the availability of internal skills lowers switching costs.

HYPOTHESIS 4. *The presence of boundary spanners in the organization is positively related to the assimilation of OSSS.*

HYPOTHESIS 5. *The presence of boundary spanners in the organization is negatively related to switching costs.*

In our qualitative study, we have found that the majority of organizations felt that the lower license cost of OSSS could result in cost savings. However, although many informants perceived OSSS to be less expensive, they were also aware that there are additional costs involved in the adoption of OSSS. These costs can render the adoption more expensive, making the real cost advantage less clear. Examples of such costs are the costs for support and maintenance. This would suggest that respondents take switching costs into consideration when making their decision. The perceived cost advantage of OSSS is likely to reduce these switching costs.

HYPOTHESIS 6. *The perception that OSSS is less expensive is positively related to the assimilation of OSSS.*

HYPOTHESIS 7. *The perception that OSSS is less expensive is negatively related to switching costs.*

The availability of external support for OSSS was found to be very important in the qualitative study. If sufficient external support is available, the organization will have to invest less time and money in finding appropriate partners for maintaining the OSSS solution. Conversely, if decision makers consider external support to be missing, it will require more resources to make the transition. In addition, decision makers may feel that external support for OSSS is more expensive, given its limited availability. This argumentation is similar to that of Li et al. (2005), who also hypothesized a relationship between "Accessibility to External OSS Human Capital" and "Switching Cost".

HYPOTHESIS 8. *The availability of external support for OSSS is positively related to the assimilation of OSSS.*

HYPOTHESIS 9. *The availability of external support for OSSS is negatively related to switching costs.*

Switching costs refer to the costs that are involved in terminating the use of the current technology, and adopting a new one. Switching costs are related to the compatibility of the current platform with the new one: the more compatible OSSS is with the current platform, the lower the switching costs will be. Migrating towards OSSS may, for example, require retraining of employees.

HYPOTHESIS 10. *Switching costs involved in a migration towards OSSS are negatively related to the assimilation of OSSS.*

We also investigated the influence of three control variables that are frequently used in IS adoption research: *organization size* (measured by the number of employees), *size of the IT department* (measured by the number of servers), and *sector* (public vs. private sector) (see e.g., Fichman & Kemerer 1997, Rogers 2003, Teo & Wei & Benbasat 2003).

# 3 RESEARCH METHODOLOGY

In order to test our conceptual model, a web based survey was developed. Whenever possible, previously validated measurement scales from literature were reused. Otherwise, new measurement scales were constructed based on a literature review and our own experience with OSS.

## 3.1 Instrument Validation

We subjected the measurement scales to a rigorous validation process. A first pretest—consisting of a labeled sorting exercise and a rating exercise—was conducted using 5 judges to reduce the initial item pool which was composed during a literature review. A second pretest involving 5 judges was conducted to obtain qualitative feedback on the overall design of the web survey. Based on this pretest, some minor modifications were made to the survey. Finally, a limited pilot study involving 34 IT managers was conducted to perform an initial quantitative validation of the measurement scales. It was decided to remove three items from the original measurement scales that performed poorly.

## 3.2 Survey Administration

The subjects for our survey were first contacted by telephone, and were asked for their cooperation before sending an invitation via e-mail. The sampling frame for the telephone interview consisted of the database of a Dutch marketing research organization containing data of about 25,000 organizations in Belgium, the Netherlands and the Grand Duchy of Luxembourg. A disproportional stratified sampling strategy was used (Sudman 1994). Organizations were assigned to a stratum based on whether they were already using Linux (this information was available in the database). We drew random samples from both strata, restricting ourselves to Flemish organizations, and ensuring an equal proportion of both strata. Organizations from different sectors and sizes were represented in our sample. The target person in the organization was the decision maker on IT, which was the IT manager or CIO in most organizations. In total, we contacted subjects in 622 organizations. Only 38 organizations explicitly declined to participate in the study, while 49 organizations were discarded by the researcher, since they did not meet the criteria of the study (some organizations did not have any servers installed). Of the 535 subjects who were sent an invitation, 332 replied, which corresponds to a response rate of 62.1%.

Since the survey was specifically targeted towards the use of OSSS, we needed to clearly define this term, so that each respondent would interpret it the same way. We took a similar approach as Fichman and Kemerer (1997), by narrowing our survey to a specific set of products. We therefore defined a list of 7 OSS products that qualified as “open source server software” (namely Linux, BSD, Apache, Bind, Sendmail, Postfix and Samba). The respondent was instructed on each page of the survey that the term OSSS referred to this exhaustive list of 7 OSS products.

# 4 DATA ANALYSIS

Before performing the main analysis, our data was subjected to a careful screening process (Tabachnick & Fidell 2001). The data was examined for the presence of outliers and missing values. A total of 270 cases remained available for final analysis. To perform our main analysis, the Partial Least Squares (PLS) method was adopted, using the SmartPLS 2.0M3 program (Ringle & Wende & Will

2005). We chose the PLS approach mainly because of two reasons. First, PLS does not impose distributional assumptions on the data (Barclay & Thompson & Higgins 1995, Chin 1998). Second, PLS is appropriate for prediction-oriented studies, especially in the early stages of theory development (Barclay et al. 1995, Chin 1998).

### 4.1 Measurement Model

All LVs were modeled as reflective constructs. Since the data for the number of employees and the number of servers was skewed, the natural logarithm of both measures was used (see e.g., Fichman & Kemerer 1997, Teo et al. 2003). Sector was operationalized using a dichotomous item (0 = private sector; 1 = public sector).

A first step in analyzing the model was to assess factorial validity (Barclay et al. 1995). We decided to remove 4 items with loadings that didn't meet the proposed minimum of .707 (Barclay et al. 1995, Hulland 1999). Next, the convergent validity of the independent LVs was assessed by examining the item reliability, average variance extracted (AVE), composite reliability (CR) and Cronbach's alpha (Chin 1998) (see Table 1). Except for *PBS1*, all items had a loading exceeding .707. Since the loading was very close to the proposed minimum, we considered this to be acceptable. Both the CR and Cronbach's alpha for all constructs exceed the criterion of .70 (Tabachnick & Fidell 2001), and all AVEs exceed the recommended threshold of .50 (Chin 1998). Discriminant validity was assessed in two ways. First, as can be seen in Table 2, the square root of the AVE is much larger than the interconstruct correlations for each construct (Barclay et al. 1995, Hulland 1999). Second, the cross loadings in Table 3 show that each item loads higher on the construct it intends to measure, than on any other construct.

| Construct/item | Loading | AVE | CR | Cronbach's alpha | Construct/item | Loading | AVE | CR | Cronbach's alpha |
|---|---|---|---|---|---|---|---|---|---|
| *PSWC* | | .61 | .86 | .79 | *PREL* | | .79 | .94 | .91 |
| PSWC1 | .749 | | | | PREL1 | .895 | | | |
| PSWC2 | .809 | | | | PREL2 | .913 | | | |
| PSWC3 | .787 | | | | PREL3 | .899 | | | |
| PSWC5 | .778 | | | | PREL4 | .856 | | | |
| *ACCSC* | | .83 | .96 | .95 | *EXTSUP* | | .69 | .92 | .89 |
| ACCSC1 | .823 | | | | EXTSUP1 | .776 | | | |
| ACCSC2 | .910 | | | | EXTSUP2 | .789 | | | |
| ACCSC3 | .935 | | | | EXTSUP3 | .816 | | | |
| ACCSC4 | .926 | | | | EXTSUP4 | .893 | | | |
| ACCSC5 | .947 | | | | EXTSUP5 | .880 | | | |
| *PBS* | | .65 | .90 | .86 | *SWCOST* | | .74 | .93 | .91 |
| PBS1 | .677 | | | | SWCOST1 | .799 | | | |
| PBS2 | .853 | | | | SWCOST2 | .888 | | | |
| PBS3 | .800 | | | | SWCOST3 | .936 | | | |
| PBS4 | .883 | | | | SWCOST4 | .882 | | | |
| PBS5 | .799 | | | | SWCOST5 | .787 | | | |
| *TRIAL* | | .81 | .93 | .89 | | | | | |
| TRIAL1 | .826 | | | | | | | | |
| TRIAL2 | .915 | | | | | | | | |
| TRIAL3 | .953 | | | | | | | | |

*Table 1. Reliability and Convergent Validity*

| | ACCSC | EXTSUP | PBS | PREL | PSWC | SWCOST | TRIAL |
|---|---|---|---|---|---|---|---|
| **ACCSC** | .91 | | | | | | |
| **EXTSUP** | .19 | .83 | | | | | |
| **PBS** | .25 | .26 | .81 | | | | |
| **PREL** | .32 | .32 | .46 | .89 | | | |
| **PSWC** | .31 | .28 | .28 | .53 | .78 | | |
| **SWCOST** | -.34 | -.29 | -.52 | -.51 | -.40 | .86 | |
| **TRIAL** | .21 | -.08 | .08 | .07 | .20 | .04 | .90 |

Note: Diagonal elements represent the square root of the AVE.

*Table 2. Discriminant Validity*

| | ACCSC | EXTSUP | PBS | PREL | PSWC | SWCOST | TRIAL |
|---|---|---|---|---|---|---|---|
| **ACCSC1** | **.82** | .14 | .28 | .32 | .33 | -.31 | .23 |
| **ACCSC2** | **.91** | .12 | .24 | .37 | .33 | -.33 | .18 |
| **ACCSC3** | **.94** | .18 | .20 | .24 | .25 | -.31 | .18 |
| **ACCSC4** | **.93** | .21 | .22 | .27 | .23 | -.28 | .18 |
| **ACCSC5** | **.95** | .22 | .21 | .26 | .25 | -.32 | .18 |
| **EXTSUP1** | .06 | **.78** | .15 | .17 | .17 | -.21 | -.14 |
| **EXTSUP2** | .15 | **.79** | .24 | .29 | .18 | -.34 | -.07 |
| **EXTSUP3** | .18 | **.82** | .28 | .35 | .29 | -.25 | -.01 |
| **EXTSUP4** | .19 | **.89** | .19 | .23 | .27 | -.19 | -.07 |
| **EXTSUP5** | .18 | **.88** | .19 | .25 | .23 | -.20 | -.06 |
| **PBS1** | .09 | .31 | **.68** | .30 | .18 | -.38 | -.05 |
| **PBS2** | .21 | .13 | **.85** | .40 | .29 | -.39 | .15 |
| **PBS3** | .18 | .20 | **.80** | .26 | .12 | -.38 | .06 |
| **PBS4** | .27 | .19 | **.88** | .45 | .30 | -.45 | .11 |
| **PBS5** | .23 | .23 | **.80** | .39 | .22 | -.47 | .03 |
| **PREL1** | .28 | .25 | .41 | **.89** | .43 | -.45 | .05 |
| **PREL2** | .23 | .30 | .45 | **.91** | .43 | -.52 | .02 |
| **PREL3** | .29 | .32 | .41 | **.90** | .52 | -.45 | .06 |
| **PREL4** | .34 | .28 | .36 | **.86** | .50 | -.40 | .11 |
| **PSWC1** | .35 | .24 | .29 | .45 | **.75** | -.44 | .12 |
| **PSWC2** | .23 | .20 | .26 | .42 | **.81** | -.22 | .24 |
| **PSWC3** | .15 | .19 | .14 | .33 | **.79** | -.26 | .11 |
| **PSWC5** | .17 | .21 | .17 | .42 | **.78** | -.27 | .17 |
| **SWCOST1** | -.24 | -.25 | -.43 | -.37 | -.25 | **.80** | .01 |
| **SWCOST2** | -.28 | -.24 | -.44 | -.44 | -.34 | **.89** | .02 |
| **SWCOST3** | -.35 | -.27 | -.50 | -.47 | -.41 | **.94** | .07 |
| **SWCOST4** | -.34 | -.25 | -.46 | -.44 | -.39 | **.88** | .00 |
| **SWCOST5** | -.23 | -.25 | -.39 | -.47 | -.31 | **.79** | .08 |
| **TRIAL1** | .17 | -.05 | .03 | .04 | .15 | .12 | **.83** |
| **TRIAL2** | .18 | -.11 | .05 | .05 | .22 | .04 | **.92** |
| **TRIAL3** | .21 | -.05 | .10 | .07 | .17 | .00 | **.95** |

*Table 3. Crossloadings*

### 4.2 Structural Model

An evaluation of the structural model is shown in Table 4. Bootstrapping with 500 resamples and construct-level sign change was performed to estimate the significance of the path coefficients. Since the paths were unidirectional in nature, a one-tailed t-test was used (Teo et al. 2003). To assess the impact of the control variables, we have estimated 3 models: the *full model*, the *theoretical model* and the *control model* (see e.g., Fichman & Kemerer 1997, Teo et al. 2003). Comparison of the full model

and the theoretical model shows that the full model explains 5.3% more variance in assimilation than the theoretical model. It can also be noted that both the size of the organization (*SIZE*) and the number of servers (*ITDEP*) have significant paths at $p < .01$ or better. Hence, we can conclude that the full model offers a better explanation of assimilation than the theoretical model, although the latter still explains 38.3% of the variance. Examination of both the theoretical and full model shows that six hypotheses were supported (at $p < .05$ or better). Figure 1 also shows an overview of which paths were found to be significant.

| | | **Full Model** | **Theoretical Model** | **Control Model** |
|---|---|---|---|---|
| ACCSC | → ASSIMILATION | .057 | .032 | |
| EXTSUP | → ASSIMILATION | .046 | .066 | |
| PBS | → ASSIMILATION | .302*** | .368*** | |
| PREL | → ASSIMILATION | .149* | .173** | |
| PSWC | → ASSIMILATION | .068 | .064 | |
| SWCOST | → ASSIMILATION | -.139* | -.111* | |
| TRIAL | → ASSIMILATION | .000 | .037 | |
| EXTSUP | → SWCOST | -.116* | -.116* | |
| PSWC | → SWCOST | -.249*** | -.249*** | |
| PBS | → SWCOST | -.419*** | -.419*** | |
| ITDEP | → ASSIMILATION | .319*** | | .532*** |
| SIZE | → ASSIMILATION | -.189** | | -.388*** |
| INDUSTRY | → ASSIMILATION | -.009 | | .059 |
| $R^2$ ASSIMILATION | | .436 | .383 | .143 |
| $R^2$ SWCOST | | .351 | .351 | |

Significance: *p < .05, **p < .01, ***p < .001

*Table 4: Structural Model*

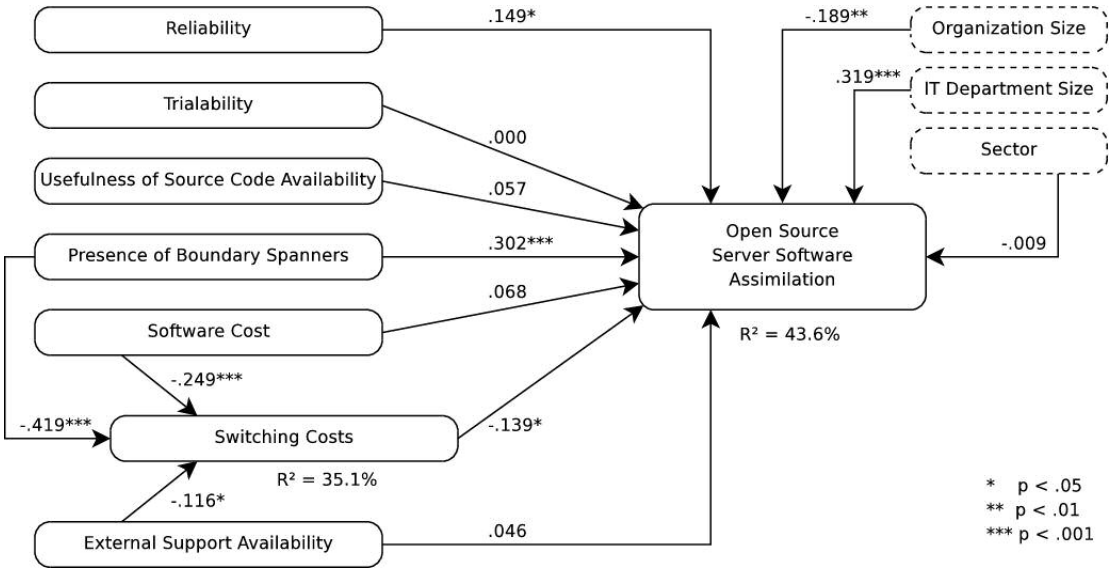


*Figure 1. Evaluation of Structural Model*

# 5 DISCUSSION

## 5.1 Discussion of Findings

We were not able to detect a significant relationship between perceived usefulness of source code availability and the assimilation of OSSS. This was our expectation based on our qualitative study. Although decision makers may find it useful to have access to the source code, we did not obtain evidence that this impacts their decision making. This may mean that the source code availability does not matter for OSSS, and that respondents have no or little reason to study or modify the source code of (stable) OSSS. It appears that the availability of the source code of OSSS is not an advantage over proprietary software. Indeed, there are alternative ways in which organizations can obtain the source code of proprietary software (e.g., through escrow agreements). However, it would be interesting to see if different results would be obtained for other types of OSS, for which the availability of the source code may be more important. For example, the source code availability may be more useful for developer-oriented products (e.g., JOnAS, Hibernate and Maven) that allows developers to gain more insight into these OSS products.

Trialability did not have a significant effect on assimilation either. Although respondents seemed to agree that OSSS was easy to try out, it did not impact the adoption decision. One possible explanation is that trial and demo versions are also available for proprietary software and that OSS does not really provide an advantage with respect to trialability. Alternatively, it might be possible that trialability is mainly important in the first stages of assimilation, more particularly to reach the evaluation/trial stage. Also, different results may be obtained for other types of OSS (e.g., a content management system). Finally, given the impact of boundary spanners in the organization, it is possible that these boundary spanners are in fact responsible for trying out OSSS outside the work place.

Our results indicate that if decision makers believe that using OSSS can result in cost savings, switching costs will be lower. However, we did not obtain evidence that the possibility to realize cost savings has a direct impact on the assimilation of OSSS. This suggests that decision makers will not adopt OSSS because of its lower license cost. Instead, they also consider other costs involved in the migration. This would lead us to conclude that although the lower cost of OSSS may be one of the reasons that organizations start to look at OSSS, it is not decisive in the adoption decision.

Similarly, the availability of external support was found to lower switching costs. This indicates that if organizations feel that sufficient support for OSSS is available, the cost of switching to OSSS will be lower. In this case, the organization will need to invest less time and money in finding appropriate and reliable support providers. The absence of a significant direct relationship between external support availability and assimilation suggests that a lack of external support will increase the switching costs for an organization, but is not prohibitive for the adoption of OSSS.

Noteworthy is the impact of the presence of boundary spanners. Previous IS adoption research has shown that the impact of boundary spanners or product champions can be important (e.g., Rai & Patnayakuni 1996, Srinivasan & Lilien & Rangaswamy 2002). Our results suggest that the introduction of OSSS is to a large degree the result of a bottom-up initiative in the organization. In fact, this LV explains 16.6% of the overall variance in assimilation, which corresponds to 38% of the explained variance in assimilation. This finding has important practical considerations which will be discussed Section 5.2. Our results also show that the presence of boundary spanners will lower switching costs. This can be explained by the fact that these employees will have experience with OSS outside the work environment. These employees will require less training to get familiar with OSSS, and will also be able to assist their colleagues in getting to know the OSSS product. Hence, the organization will need to invest less time and money in training employees. In addition, since in-house knowledge on OSSS is available, the organization is less dependent on an external party to provide support for OSSS.

Another factor that influences the assimilation of OSSS is the switching cost involved in a migration. As mentioned earlier, switching costs are determined by the perception that OSSS is less expensive, the availability of external support and the presence of boundary spanners in the organization. These three factors explain a substantial portion (35.1%) of the variance in switching costs. Based on these results, we can deduct that the availability of both internal and external knowledge on OSSS is important in the adoption decision. Organizations that cannot easily obtain this knowledge will be less likely to adopt OSSS. Overall, the more compatible OSSS is with the current IT infrastructure and experience of employees, the more likely it is that it will be adopted.

Finally, the degree to which respondents consider OSSS to be reliable, also influences the adoption decision. This is consistent with our observation in the qualitative study that organizations will not adopt OSSS if they consider it to be unreliable. Our results also show that some respondents considered OSSS to be unreliable. It would be interesting to gain more insight into the reasons for this perception. It may be possible that some decision makers are currently not sufficiently familiar with OSSS, and base their perception on outdated information. On the other hand, it is possible that in some environments OSSS cannot provide a sufficiently reliable solution.

Concerning the impact of the control variables, we can note that organizational size has a significant negative impact on the assimilation stage. This seems to imply that mostly small organizations are adopting OSSS. Most studies on the organizational adoption of IS have found a positive effect, which can be explained by the fact that large organizations have more resources to innovate (Rogers 2003). However, within the context of OSSS, it is possible that small organizations with limited resources try to lower their costs by adopting OSSS. Another possibility is that larger organizations have policies in place that prevent, or discourage, the use of OSSS. Our data may also suggest that as organizations grow, they tend to abandon or decrease the use of OSSS in favour of proprietary software. The same may also apply when the organization is acquired by another organization. We observed this in one of the cases included in our qualitative study. Second, the number of servers used by the organization is positively related to assimilation. This may indicate that organizations with a large installed server base, will try to limit operational costs by using OSSS. It is also possible that OSSS provides a more scalable solution to those organizations. It is interesting to note that organization size and the number of servers in use have an opposite influence on the assimilation of OSSS. As it is reasonable to assume that larger organizations tend to have more servers installed, it may indicate that if the organization becomes large enough, it will become more likely to adopt OSSS. Finally, given the recent activities of public organizations with respect to OSS, it was expected that public organizations were using OSSS to a larger degree than private organizations. Our data, however, failed to detect a difference between these sectors. This may indicate that the activities of public organizations with respect to OSS are primarily focused on the adoption on desktop computers.

### 5.2 Implications

This study has a number of theoretical and practical implications. A first theoretical implication is that this study is the first to present an integrated model describing the factors that influence the assimilation of OSSS, and to quantitatively test it. The model was grounded in both IS adoption of innovations and OSS literature, and was subjected to a rigorous validation procedure. The model is capable of explaining a large portion of the variance in assimilation (43.6%). Investigation of the structural model shows that the model closely reflects the findings of our qualitative study. Based on our results, much of the anecdotal evidence on the organizational adoption of OSSS can be either confirmed or rejected. Second, we developed and validated a new scale to measure the usefulness of source code availability. This scale may be useful to test its impact on the adoption decision on other types of OSS.

Our study has three main practical implications. First, the conceptual model provides managers with the most important factors that facilitate the assimilation of OSSS. This enables managers to take appropriate measures if they consider adopting OSSS. This should also allow them to make better

informed choices on how to innovate with OSSS. Second, our results show which characteristics of OSSS are valued the most by organizations. This is useful for individuals and vendors who want to promote the use of OSSS. From our results, it would make more sense to stress the reliability of OSSS, rather than the availability of the source code. Finally, the importance of the presence of boundary spanners in the organization has major implications for organizations. Managers may consider promoting the creation of informal groups of employees with experience in OSSS that can provide the organization with advice on when OSSS can be used in future projects. On the other hand, given the influence of these boundary spanners, it is important that they remain pragmatic in their promotion of OSSS. Previous research has shown that this seems to be the case (West & Dedrick 2005). Nevertheless, in some very small organizations with a single decision maker who has a background in OSS, decision making can be rather ideological (Ven & Verelst 2008). Future research may try to gain a better understanding of the role of boundary spanners in the adoption decision. Such studies could provide more information on which employees act as boundary spanners, and how they try to promote the use of OSSS in their organization. It may also be interesting to know if the opinion of these boundary spanners is valued and taken into account by decision makers.

One limitation of our research is that we focused on Belgian organizations. As cultural differences may impact the adoption decision, future research can be conducted to see whether these findings also hold in different regions. Another avenue for future research is to determine to which degree our results are applicable to other types of OSS.

## References


Barclay, D., Thompson, R. and Higgins, C. (1995). The partial least squares (PLS) approach to causal modeling: Personal computer adoption and use as an illustration. Technology Studies, 2 (2), 284–324.

Chin, W.W. (1998). The partial least squares approach for structural equation modeling. In Modern Methods for Business Research (Marcoulides, G.A. Ed.), pp. 295–336, Lawrence Erlbaum Associates, Mahwah, NJ.

Fichman, R.G. and Kemerer, C.F. (1997). The assimilation of software process innovations: An organizational learning perspective. Management Science, 43 (10), 1345–1363.

Goodhue, D.L. and Thompson, R.L. (1995). Task-technology fit and individual performance. MIS Quarterly, 19 (2), 213–236.

Heide, J.B. and Weiss, A.M. (1995). Vendor consideration and switching behavior for buyers in high-technology markets. Journal of Marketing, 59 (3), 30–43.

Hulland, J. (1999). Use of partial least squares (PLS) in strategic management research: a review of four recent studies. Strategic Management Journal, 20 (2), 195–204.

Igbaria, M., Zinatelli, N., Cragg, P. and Cavaye, A.L.M. (1997). Personal computing acceptance factors in small firms: A structural equation model. MIS Quarterly, 21 (3), 279–305.

Karahanna, E., Straub, D.W. and Chervany, N.L. (1999). Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. MIS Quarterly, 23 (2), 183–213.

LaRose, R. and Hoag, A. (1996). Organizational adoptions of the internet and the clustering of innovations. Telematics and Informatics, 13 (1), 49–61.

Li, Y., Tan, C.H., Teo, H.H. and Siow, A. (2005). A human capital perspective of organizational intention to adopt open source software. In Proceeding of the 26th Annual International Conference on Information Systems (ICIS 2005), Las Vegas, NV, December 11–14, 2005 (Avison, D., Galletta, D. and DeGross, J.I. Eds.), pp. 137–149, Association for Information Systems, Atlanta, GA.

Lundell, B., Lings, B. and Lindqvist, E. (2006). Perceptions and uptake of open source in Swedish organisations. In Open Source Systems, IFIP Working Group 2.13 Foundation on Open Source Software, Como, Italy, June 8–10, 2006 (Damiani, E., Fitzgerald, B., Scacchi, W., Scotto, M. and

Succi, G. Eds.), volume 203 of IFIP International Federation for Information Processing, pp. 155–163, Springer, Boston, MA.
Moore, G.C. and Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research, 2 (3), 192–222.
Morgan, L. and Finnegan, P. (2007). How perceptions of open source software influence adoption: An exploratory study. In Proceedings of the 15th European Conference on Information Systems (ECIS 2007), St. Gallen, Switzerland, June 7–9, 2007 (Österle, H., Schelp, J. and Winter, R. Eds.), pp. 973–984, University of St. Gallen, St. Gallen, Switzerland.
Ping, Jr, R.A. (1993). The effects of satisfaction and structural constraints on retailer exiting, voice, loyalty, opportunism, and neglect. Journal of Retailing, 69 (3), 320–352.
Premkumar, G.P. and Roberts, M. (1999). Adoption of new information technologies in rural small businesses. Omega, 27 (4), 467–484.
Rai, A. and Patnayakuni, R. (1996). A structural model for CASE adoption behavior. Journal of Management Information Systems, 13 (2), 205–234.
Ringle, C.M., Wende, S. and Will, A. (2005). SmartPLS 2.0 (M3) beta. University of Hamburg, Hamburg, Germany, http://www.smartpls.de.
Rogers, E.M. (2003). Diffusion of Innovations. 5th edition. The Free Press, New York, NY.
Rowjee, P. (2005). Factors Affecting the Adoption of Open Source Software. Master's thesis, University of the Witwatersrand, School of Economic and Business Science.
Srinivasan, R., Lilien, G.L. and Rangaswamy, A. (2002). Technological opportunism and radical technology adoption: An application to e-business. Journal of Marketing, 66 (3), 47–60.
Sudman, S. (1994). Sampling. In Principles of Marketing Research (Bagozzi, R.P. Ed.), pp. 73–115, Blackwell Publishers, Cambridge, MA.
Tabachnick, B.G. and Fidell, L.S. (2001). Using Multivariate Statistics. 4th edition. Allyn and Bacon, Boston, MA.
Teo, H.H., Wei, K.K. and Benbasat, I. (2003). Predicting intention to adopt interorganizational linkages: an institutional perspective. MIS Quarterly, 27 (1), 19–49.
Ven, K. and Verelst, J. (2006a). Idealism vs. pragmatism: Investigating the organizational adoption of open source software. In Proceedings of the 12th Americas Conference on Information Systems (AMCIS 2006), Acapulco, Mexico, August 4–6, 2006 (Romano, N.C. Ed.), pp. 789–796, Association for Information Systems, Atlanta, GA.
Ven, K. and Verelst, J. (2006b). The organizational adoption of open source server software by Belgian organizations. In Open Source Systems, IFIP Working Group 2.13 Foundation on Open Source Software, Como, Italy, June 8–10, 2006 (Damiani, E., Fitzgerald, B., Scacchi, W., Scotto, M. and Succi, G. Eds.), volume 203 of IFIP International Federation for Information Processing, pp. 111–122, Springer, Boston, MA.
Ven, K. and Verelst, J. (2008). The impact of ideology on the organizational adoption of open source software. Journal of Database Management, 19 (2), 58–72.
West, J. and Dedrick, J. (2005). The effect of computerization movements upon organizational adoption of open source. In Proceedings of the Social Informatics Workshop: Extending the Contributions of Professor Rob Kling to the Analysis of Computerization Movements, Irvine, CA, March 11–12, 2005.
Wixom, B.H. and Todd, P.A. (2005). A theoretical integration of user satisfaction and technology acceptance. Information Systems Research, 16 (1), 85–102.

# Appendix: Measurement Items

**Cost advantage (PSWC)** (Rowjee 2005, LaRose et al. 1996)
1. OSSS can be used to realize cost savings [(b)]
2. OSSS can be acquired at a lower price than proprietary software
3. Upgrades for OSSS can be acquired at a lower price than proprietary software
4. OSSS has lower initial costs than proprietary software [(c)]
5. The license costs of OSSS are lower than those of proprietary software [(b)]

**Reliability (PREL)** (Goodhue et al. 1995, Wixom et al. 2005)
1. OSSS is subject to unexpected down times [(a)]
2. OSSS is subject to frequent problems and crashes [(a)]
3. OSSS operates reliably
4. We can count on OSSS to be "up" and available most of the time

**Trialability (TRIAL)** (Karahanna et al. 1999, Moore et al. 1991)
1. Before deciding on whether or not to adopt OSSS, we would be able to use it on a trial basis
2. Before deciding on whether or not to adopt OSSS, we would be able to properly try it out
3. We would be permitted to use OSSS on a trial basis long enough to see what it can do
4. We are able to test OSSS as necessary [(c)]
5. We can have OSSS for long enough periods to try it out [(c)]

**Usefulness of Source Code Availability (ACCSC)** (developed for this study)
1. The availability of the source code of OSSS provides more trust in the program [(b)]
2. The availability of the source code of OSSS is a benefit [(b)]
3. We find the availability of the source code of OSSS useful [(b)]
4. It is convenient to have access to the source code of OSSS [(b)]
5. In general, we find it valuable to have access to the source code of OSSS [(b)]

**Presence of Boundary Spanners (PBS)** (Rai et al. 1996, Srinivasan et al. 2002)
1. OSSS has no strong advocates here [(a)]
2. There are one or more people here who are pressing for OSSS usage
3. Employees make an effort to convince managers of the benefits of OSSS
4. There are one or more people in our organization who are pushing for OSSS very enthusiastically
5. Nobody in our organization has taken the lead in pushing for adoption of OSSS [(a)]

**External Support Availability (EXTSUP)** (Igbaria et al. 1997, Li et al. 2005, Premkumar et al. 1999)
1. An external party is available for providing support for OSSS products
2. Guidance is available to me in the selection of hardware and software for OSSS products
3. There are businesses which provide technical support for effective use of OSSS
4. Our organization can access external vendors who can provide support for OSSS deployment
5. Our organization can access external consultants who can provide support for OSSS deployment
6. Our organization can access external freelance IT people who can provide support for OSSS deployment [(c)]

**Switching Costs (SWCOST)** (Heide et al. 1995, Li et al. 2005, Ping 1993)
1. Acquiring OSSS would require significant cost in retraining a large number of our employees
2. Developing procedures to deal effectively with OSSS would take a lot of time
3. Generally speaking, the cost to switch to OSSS would be high
4. Considering everything, the cost to stop using the existing software and start using OSSS would be high
5. Developing working relationships with new vendors for OSSS would be a time-consuming process

(a) Reversely scored item.
(b) Item developed specifically for this study.
(c) Item removed based on assessment of measurement model.

All items were measured using a 7-point Likert scale with each point labeled (ranging from strongly disagree to strongly agree).