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MANAGING USER RESISTANCE TO OPEN SOURCE MIGRATION

Completed Research Paper

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Abstract

A large amount of resources and effort have been devoted to the development of open source software like Linux. The development of Linux as the most well-known open source software with graphical user interface and useful functionalities is expected to result in the high level of Linux adoption by individual users based on the technology adoption model. However, Linux has about one percent of the operating systems market for personal computers. User resistance to switch remains one of the major obstacles in any successful open source migration. Based on the integration of equity implementation model and technology adoption model, this study examines how users form their resistance and the effect of user resistance on the adoption of Linux by individual users for their personal computers. The findings show that the adoption intention is negatively influenced by user resistance to switch. This study discusses the role and effect of user resistance to switch based on the equity implementation model in comparison with the two main determinants of technology adoption. This study contributes toward advancing theoretical understanding of OSS migration and user resistance. The findings also offer OSS community and practitioners suggestion for promoting the use of OSS by individual users.

Keywords: Open source software, user resistance, technology adoption, equity implementation model

Introduction

The emergence of open source software (OSS) with its successful projects such as Linux operating system, Mozilla web browser and Apache web server, and its most prominent advantages such as cost savings, freedom in modification and availability of the source code create a vast interest among academics and practitioners (Ebert, 2008). The development and implementation of OSS becomes one of the most current topics of interest within the academic, business and political environments (Fitzgerald 2006; Hauge et al., 2010).

In the development of OSS, the OSS community and developers have been exerting much effort to produce competitive software against the proprietary software. More developers are motivated to participate in the software development because the OSS project is a good learning opportunity to improve their skills and gain experience. As of February 2009, SourceForge (<http://sourceforge.net/>), the world's largest open source development and distribution portal, was hosting over 230,000 registered projects and more than 2 million users.

Linux is arguably the most well-known OSS project. A large amount of resources and effort have been devoted to the development of Linux. Wheeler (2001) estimated the amount of source code in GNU/Linux, using Red Hat Linux 7.1 as a representative GNU/Linux distribution. He found that Red Hat Linux 7.1 contained over 30 million physical source lines of code as of 2001 (Wheeler, 2001). The Debian GNU/Linux is also one of today's most popular Linux-based distributions. It is intended not only for final users, but also as a basis for other projects. A

study of Debian GNU/Linux found that it totalled about 300 million lines of code as of 2007 (Gonzalez-Barahona et al., 2009). In comparison, Windows 98 contained an approximate 18 million source lines of code. Using the Constructive Cost Model (COCOMO), Red Hat Linux 7.1 is estimated to have required about 8,000 person-years of development time (Wheeler, 2001). According to the study, if all this software had been developed by conventional proprietary means, it would have cost over US\$1 billion for the development in the United States (Wheeler, 2001).

As the development of OSS like Linux is growing in general, its adoption by companies and users in industry has increased (Ebert, 2008). However, the adoption and usage by individual users for their personal computers are still limited. There are several consideration factors in deciding the adoption of OSS (Ven et al., 2008). Those consideration factors can be understood as benefits (e.g., cost advantage and availability of source code) or costs (e.g., switching costs and lack of support) in the adoption. However, critics consider the features and functionality offered by the two operating systems (i.e., Linux and Microsoft Windows) to be comparable and some have even declared Linux better in areas such as customizability, reliability, and security (Wheeler, 2007). According to Market Share by Net Applications¹, the operating system market share for December 2009 indicated that Linux had 1.02 percent of the market and Microsoft Windows had a total of 92.21 percent.

This creates the interest of study – why does some OSS like Linux have a low level of individual usage though Linux has achieved a significant success due to the relatively comparable with Microsoft Windows in the perspective of performance, usability, reliability and functionality. Despite the huge development cost and effort of Linux, mentioned in the development of OSS, Microsoft Windows is still dominating the market share. Though the statistics show that the usage of OSS is growing, the growth rate is slow and the individual usage level is relatively much lower than the commercial software.

Linux is one of the successful OSS developments. It has been being developed with many useful functions for users. The development of graphical user interface makes Linux easy to use and user-friendly (e.g., [KDE](#), [GNOME](#), and [Xfce](#)). Therefore, it is expected that individual users should adopt Linux based on the two determinants of Technology Acceptance Model (TAM) – perceived usefulness and perceived ease of use (Davis, 1988). However, there are many people who still do not adopt and use the useful and easy to use Linux as their operating system in their personal computers. Moreover, although there is no doubt that users are quite comfortable with Linux servers due to the reliability, security and licensing benefits, but getting it on the desktop is going to be difficult (Express Computer, 2007). Hence, this cannot be explained by TAM alone, and we have to observe the factors that make the users difficult to adopt and use Linux on their personal computer.

One of the most viable causes is that most people are currently using an operating system which could be other than Linux. According to the market statistics, Microsoft windows family counts for nearly 90 percent of the operating system usage. That could be due to the Microsoft's business strategy – bundling up the operating system with the personal computer, and it dominates the operating system market. It is arguably true that 90 percent of computer users have already adopted the Microsoft Windows. Therefore, Linux adoption involves switching from the current operating system to the new operating system. Adoption of a specific technology is often accompanied by the discontinuance of an existing technology that is already in place (Desouza et al., 2006). In this case, adoption introduces the discontinuous use of a current system. On the other hand, the system providers hold on to their consumers, and prevent existing consumers from abandoning their products and services, and even prevent them from switching to competitors. As a result, if the users resist switching, they may not adopt Linux regardless of the usefulness and ease of use related to Linux. It is thus noted that one of the major obstacles to OSS migration is user resistance². Therefore, it is imperative to consider the effect of user resistance while studying the adoption of useful and easy to use OSS, especially Linux for personal users.

Therefore, by selecting Linux as a representative OSS, this study aims to investigate the adoption of OSS (i.e., migration from the current system to OSS) by individual users from the user resistance perspective. To examine the development and effect of user resistance to switch (i.e., OSS migration), this study adopts equity implementation model (EIM) (Joshi, 1991) which was proposed to explain user resistance in IS implementation. The present study selects EIM as the theoretical foundation because EIM explains individuals decide their resistance based the net equity which is determined based on the comparison between benefits and costs. Because OSS adoption brings in

¹ Market Share by Net Application [<http://marketshare.hitslink.com/operating-system-market-share.aspx?qprid=8>]

² IOL Technology, "Resistance to change hampers OSS migration," 25 May 2009. [http://www.ioltechnology.co.za/article_page.php?iArticleId=4995967#]

several benefits as well as costs (Ven et al., 2008), it is essential to consider both benefits and costs in the migration to OSS. By integrating TAM and EIM, this study examines (1) how users decide their resistance in the migration to OSS and (2) how users decide the adoption of OSS based on user resistance and the two determinants of TAM. The theoretical model in this study is validated through a survey of personal computer users. The contributions of this study include advancing theoretical understanding of technology adoption by adding a new perspective, user resistance, and offering practitioners and organizations for managing user resistance to open source migration and promoting the use of OSS.

This paper is organized as follows: The next section reviews the literature on user resistance and discusses EIM. This is followed by the research model and hypotheses based on the integration between two theoretical models, EIM and TAM. We then describe the research methodology. After interpreting the empirical results, we discuss the theoretical and practical implications and conclude with a summary of this study.

Conceptual Background

User Resistance

Previous research on user resistance has been studied in various fields. In psychology studies, the researchers (Oreg, 2003) attribute the individual traits and attitude such as optimism, psychological resilience to the factors that affect the formation and extent of resistance. In management studies, change generally means organizational changes, and resistance commonly has been conceptualized as conduct that seeks to keep the status quo (Pardo del Val and Fuentes, 2003). Piderit (2000) suggested an attitudinal conceptualization of resistance in terms of cognitive, emotional, and intentional dimensions. In marketing studies, resistance is viewed as customer commitment as an attitude (Crosby and Taylor, 1983).

In the literature of information systems (IS) and information technology (IT), user resistance has been conceptualized in the two perspectives: behaviourally and attitudinally. The concept of resistance is adapted from psychology, management and marketing studies in most of the researches. It was behaviourally defined as an adverse reaction (Hirschheim and Newman, 1988) or the opposed intention of users to proposed changes resulting from IS implementation or use of system (Kim and Kankanhalli, 2009; Markus, 1983). By conceptualizing that resistance is manifested by behaviour, Fereneley and Sobreperez (2006) further classified resistance into opposition (e.g., challenge or disruption to initiatives), negative resistance (e.g., sabotage) and positive resistance (e.g., support or improve). Apart from the behavioural perspective, user resistance also has been conceptualized from the attitudinal perspective. Newman and Noble (1990) interpreted the users' attitude due to merely entrenched habit or dislike as resistance attitude towards any forms of change in an IS implementation. Similarly, resistance has been considered as a cognitive force precluding potential behaviour (Bhattacharjee and Hikmet, 2007).

In the present study, user resistance is conceptualized as the individual's attitude towards the change, i.e., the user is resistant to switch from his current situation (e.g., use of current operating system) to a new situation (e.g., use of Linux). This study thus defines user resistance as *oppositional attitude towards the change* (i.e., OSS migration). We adopt EIM to explain user resistance as the theoretical background.

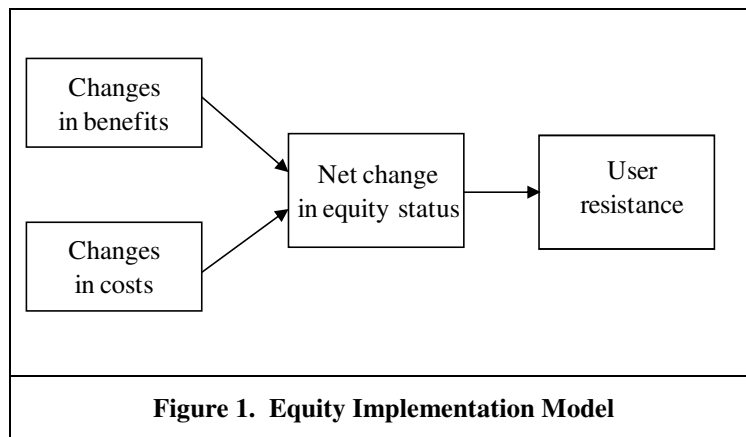
It is important to distinguish the phenomenon of user resistance from user adoption to justify why it needs to be studied separately. User resistance and user adoption are not simply the reverse of each other. User adoption has been defined as an individual's initial decision to use a system (Agarwal, 2000), intention to use, or system usage (Davis, 1989) with alternative conceptualizations that include sustained use and even emergent use (Saga and Zmud, 1994). In contrast, user resistance refers to the opposition of individuals to the changes associated with a new system adoption (Bhattacharjee and Hikmet, 2007; Kim and Kankanhalli, 2009). This points to the first difference i.e., user resistance not only targets the system but more importantly occurs in response to the multifarious changes associated with it. On the other hand, IS acceptance tends to occur more in response to the characteristics of the system (Rogers, 1995; Davis, 1989) and its job outcomes (Davis, 1989). As a result, negative change factors (e.g., switching costs) may lead to user resistance but their absence (i.e., no switching costs) may not lead to user acceptance of technology.

Second, user resistance can come into play even before the deployment of a system, whereas the issue of acceptance arises after the IS is ready or has been deployed. Accordingly, most user acceptance research has modeled the concept and collected data after the IS implementation (e.g., Davis, 1989; Nah et al., 2004; Venkatesh et al., 2003;

Wixom and Todd, 2005). Users typically decide to accept a technology after experiencing its characteristics (Davis, 1989; Venkatesh et al., 2003), though they may be influenced by others to try it out. However, user resistance can occur before the system is ready (i.e., during the IS project) or after. In the first case, user resistance can result in project delays and overspending (Verton, 2002). In the second situation, consequences could be low usage (Barker and Frolick, 2003) or even refusal to use the system (Kim and Pan, 2006). In a certain sense, user resistance can be considered as the reverse of user acceptance (system usage) after the system has been implemented, though the absence of factors that cause user resistance do not necessarily cause user acceptance. Also, user resistance can include behaviors such as sabotage, which do not fall within the continuum of system usage (from none or low to high). Accordingly, it is important to study user resistance as a distinct phenomenon. Previous research (Bhattacharjee and Hikmet, 2007) also mentioned that “IT usage and resistance must be examined jointly within a common theoretical model because user resistance is clearly a barrier to IT usage in organization.” User resistance is thus not the mirror opposite of user adoption, but a possible antecedent to IT adoption (Bhattacharjee and Hikmet, 2007).

Equity Implementation Model

For the theoretical explanation of user resistance, the present study selects EIM which provides a theory-based understanding of IS users’ resistance to change (Joshi, 1991). In this study, we examine the attitudinal perspective of user resistance when the users have to switch from the system they are currently using to a new system, an OSS. The users may evaluate the inputs and outcomes based on the changes (i.e., OSS migration) of their system, and they may resist the changes or switching from their current system. EIM evaluated the net equity by comparing the changes in outcomes and changes in inputs, and the positive or negative net equity influences the resistance to switch (see Figure 1). EIM describes a process of comparison which is absent in TAM. Therefore, we believe that EIM helps us understand the user resistance attitude in OSS migration, which the users will have from the changes (i.e., switching operating systems).



According to EIM, users evaluate the change related to a new system based on the net equity. The net change in equity status is estimated based on the comparison between changes in benefits (i.e., outcomes) and changes in costs (i.e., inputs). If the net equity due to the change is negative, users would view the change as unfavourable and be resistant to the change. Conversely, if the perception of the net equity due to the change is positive, users would be favourably inclined towards the change. Joshi (1991) operationally defined net equity as following: $\text{Net equity} = \Delta\text{Outcomes} - \Delta\text{Inputs} = (\text{Increase in outcomes} - \text{Decrease in outcomes}) - (\text{Increase in inputs} - \text{Decrease in inputs}) = (\text{Increase in outcomes} + \text{Decrease in inputs}) - (\text{Increase in inputs} + \text{Decrease in outcomes})$. The combination of *increase in outcomes* (e.g., higher productivity resulting from the system use) and *decrease in inputs* (e.g., less effort in using the system) means benefits in the switching (i.e., switching benefits). The combination of *increase in inputs* (e.g., more efforts in using the system) and *decrease in outcomes* (e.g., lower productivity or efficiency resulting from the system use) mean costs in the switching (i.e., switching costs). Similar to the benefits and costs in switching, Ven et al. (2008) discussed the advantages and disadvantages of OSS that organizations need to consider before adopting it. There are several advantages such as free of charge, lower hardware costs, course code

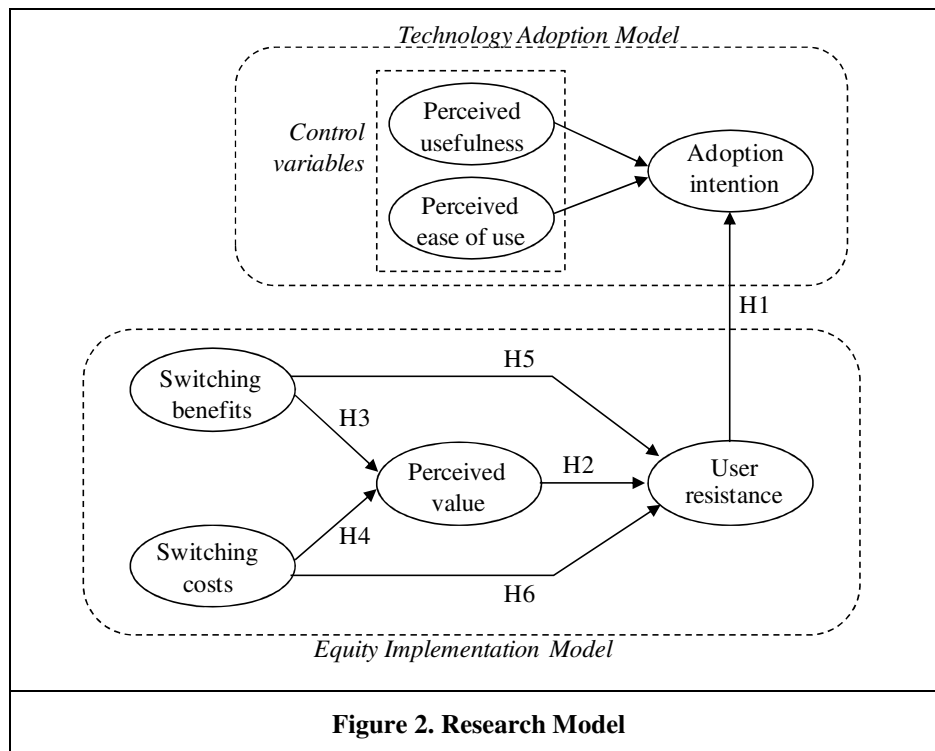
availability, and maturity of OSS. There are also disadvantages such as unclear total cost of ownership, lack of knowledge, unreliability of OSS, and lack of support.

In this study, at the individual level, the users may have to switch from their current system in order to adopt the new system, OSS, and switching the systems serves as a change for the users. Hence, there may be a case of user resistance due to the switching (i.e., user resistance to OSS migration). As per EIM, there is no fundamental or irrational resistance to a switch. Thus, the users may evaluate the switching related to the new system, OSS, based on the net equity perceived by them. The net equity is perceived or assessed by comparing the additional benefits gained relative to the new system (i.e., switching benefits) and additional costs incurred from switching (i.e., switching costs). There are different types of costs related to the switching such as procedural costs (i.e., the expenditure of time, effort, and economic resources incurred in switching operating systems), psychological costs (i.e., psychological or emotional discomfort due to the switching of operating systems), and loss costs (i.e., losses due to investments already made in the current operating system) (Burnham et al. 2003; Jones et al. 2002; Whitten and Wakefield 2006).

As a corresponding factor to net equity, we select value which has been conceptualized as the net benefits based on the comparison between benefits and costs (Zeithaml, 1988). Based on EIM, this study thus explains that user resistance to switch would be influenced by value which is perceived based on the comparison between switching benefits and switching costs.

Research Model and Hypotheses

Based on the integration of EIM and TAM, we develop the research model (see Figure 2). EIM explains how users become resistant to OSS migration which in turn would reduce the OSS adoption intention. TAM explains that people decide to adopt technology based on the perception of usefulness and ease of use. TAM and EIM thus complement each other in explaining OSS migration and adoption. Because TAM and its two determinants (usefulness and ease of use) are well tested, this study proposes the two factors as control variables without hypothesis proposition.



User resistance to switch refers to opposition of an individual to the use of a new system (Hirschheim and Newman, 1988; Kim and Kankanhalli 2009; Markus, 1983). In our study, the switch refers to the migration from the current operating system to a new operating system (i.e., Linux), and we conceptualize the individual's attitude on such switching in terms of user resistance. Therefore, user resistance to switch is defined as the individual's oppositional attitude towards the use of new system (i.e., OSS). Attitude is defined as an individual's positive or negative tendency or orientation toward performing the target behaviour (Ajzen, 1991). Most previous research on technology adoption (e.g., Taylor and Todd, 1991; Wixom and Todd, 2005) has examined the effect of positive attitude on the adoption. Venkatesh et al. (2003), however, argued against the role of positive attitude as an affective reaction in explaining and predicting adoption intention. In contrast, user resistance is conceptualized as a negative attitude which will affect the adoption intention negatively according to the theory of planned behaviour (TPB). In the perspective of TAM alone, the users may adopt the new system based on perceived usefulness and perceived ease of use related to the new system. When the users are resistant to the switch, however, they may not easily decide to adopt the system even with the usefulness and ease of use of the target system. Thus, user resistance may decrease the adoption intention in the context of OSS (i.e., Linux) migration from the current operating system. Hence, we hypothesize,

H1: User resistance has a negative effect on adoption intention.

As a corresponding factor to net equity in EIM, perceived value means *the perceived net benefits (perceived benefits relative to perceived costs) of switching to a new system* (i.e., OSS migration) (Kim and Kankanhalli, 2009). According to the EIM, the users' judgments of the switching affect their resistance attitude. Further, perceived value evaluates whether the benefits derived from the switch are worth the costs incurred in switching from the current situation (status quo) to the new situation. If the net change in the equity status proves to be positive, the switch will be welcomed. However, if the net change in the equity status is negative, switching to the new system will be resisted (Joshi, 1991). Therefore, if the perceived value from switching is high (perceived benefits are more than perceived costs), users are likely to have lower resistance to switch. Conversely, if the perceived value is low (perceived benefits are less than perceived costs), users are likely to have greater resistance to OSS migration. Moreover, people have a strong tendency to maximize value in their decision making and consequently are less likely to resist changes that deliver a higher perceived value (Joshi, 1991). Hence, we hypothesize,

H2: Perceived value has a negative effect on user resistance.

The benefits from the switch (i.e., OSS migration) have been conceptualized as the benefits or advantages people perceived from the switch (Moore and Benbasat, 1991). In our study, switching benefits refers to *the perceived additional utility a user would enjoy in switching from the current system to the new system* (Kim and Kankanhalli 2009). Perceived value is assessed as the overall evaluation of the net benefits of switch based on the comparison between switching benefits and costs (Kahneman and Tversky, 1979). According to the EIM, the change in equity status is positively affected by the changes in benefits (Joshi, 1991). As per the rational decision-making principles, higher switching benefits would increase the net benefits or perceived value of the change to users because value is assessed based on the benefits relative to the costs of change (Joshi, 1991; Zeithaml, 1988). Therefore, the values will be increased when the switching benefits are higher and the switching costs are lower. Hence, we hypothesize,

H3: Switching benefits have a positive effect on perceived value.

Following the previous research, switching costs represent the psychological costs such as uncertainty costs and emotional costs (Whitten and Wakefield, 2006), one-time costs in the process of switching such as set up costs and learning costs (i.e., procedural costs) (Burnham et al., 2003) and loss costs such as lost benefit costs and sunk costs (Jones et al., 2002). In our study, switching costs are defined as the perceived disutility a user would incur in switching from the current system to a new system (Chen and Hitt, 2002). As we have mentioned, perceived value is assessed as the overall evaluation of the net benefits of switch based on the comparison between switching benefits and costs (Kahneman and Tversky, 1979). According to the EIM, the change in equity status is negatively affected by the changes in costs (Joshi, 1991). As per the rational decision-making principles, higher switching costs in any forms would lower the net benefits or perceived value of the switch to users because value is assessed based on the benefits relative to the costs of change (Joshi, 1991; Zeithaml, 1988). Therefore, the values will be decreased when the changes in benefits are lower and the changes in costs are higher. Hence, we hypothesize,

H4: Switching costs have a negative effect on perceived value.

Apart from the indirect effects of switching benefits and switching costs on user resistance to switch through perceived value, we also expect the direct effects of them on user resistance. The switching benefits and switching

costs are conceptualized as beliefs according to TPB which adopts from theory of reasoned action (TRA). Based on TRA, a person's attitude toward behaviour is determined by his or her salient beliefs (Davis et al., 1989). Therefore, users' beliefs in gaining additional benefits from the switching (i.e., OSS migration) will affect their attitude towards the switch. In other words, switching benefit (i.e., users' beliefs) has influence on user resistance to switch (i.e., attitude towards the switch). The potential advantages (i.e., benefits) of switching from the current system to a new system provide users with the motivation to switch. In contrast, if the new system provides fewer switching benefits, users are more likely to resist switch from their current system (Martinko et al., 1996). Higher switching benefits may thus reduce user resistance to switch. Hence, we hypothesize,

H5: Switching benefits have a negative effect on user resistance.

Additionally, switching costs may directly influence user resistance to switch. Switching costs refer to any perceived disutility (Chen and Hitt, 2002) a user would experience from switching to a new alternative. Based on TRA, a person's attitude toward behaviour is determined by his or her salient beliefs (Davis et al., 1989). Therefore, users' beliefs in incurring costs from the switch will affect their attitude towards the switch. Switching costs can be the psychological costs, procedural costs and loss costs which are conceptualized as the perceived disutility. These switching costs will inhibit the users to switch, OSS migration, because they generate disutility which is not welcomed by the user. Due to the disutility, people do not want to switch to the new system (Chen and Hitt, 2002). Therefore, higher switching costs would increase user resistance to switch. Hence, we hypothesize,

H6: Switching costs have a positive effect on user resistance.

Research Methodology

Data to empirically validate the research model of Figure 2 were collected through a field survey using a questionnaire.

Instrument Development

The survey instrument was developed based on the research model by adapting existing validated scales where possible. To measure adoption intention, we follow the scale guidelines of the Theory of Reasoned Action and ensure that the questions are specific and consistent with respect to action (adoption), target (Linux), context (individual purpose) and time (within the next six months). The three items of adoption intention were then adapted from Karahanna et al. (1999). The measurement items for user resistance were modified from Pritchard et al. (1999) to fit in the context of switching to a new system. Scales for perceived value were modified from the value construct of Sirdeshmukh et al. (2002) to the context of OSS migration. The items represent procedural aspect (PVL1), loss aspect (PVL2), and psychological aspect (PVL3) in the net benefit assessment. We developed the measurement items for switching benefits based on the definition and by referring to the items of relative advantage (Moore and Benbasat, 1991). Switching costs were conceptualized as a single-dimensional construct, with scales adapted from Jones et al. (2000) to reflect procedural costs (SWC2), psychological costs (SWC3), and loss costs (SWC1 and SWC4). Scales for perceived usefulness and perceived ease of use were adapted from Davis et al. (1989).

All items were phrased with respect to Linux under study. Three IS researchers reviewed the instrument for its face validity. The measurement items were anchored on seven-point Likert scales (1 = strongly disagree, 7 = strongly agree). The final version of the measurement items are presented in Table 1.

Table 1. Measurement Instrument			
Construct	Item	Wording	Reference
Adoption intention	INT1	I intend to adopt Linux within the next 6 months	Karahanna et al., 1999
	INT2	During the next 6 months, I plan to experiment with or regularly use Linux	
	INT3	I predict I would use Linux within the next 6 months	
User resistance	RST1	My preference to use my current operating system would not willingly change	Pritchard et al., 1999
	RST2	Even if close friends recommended Linux, I would not change my preference for my current operating system	
	RST3	To change my preference from my current operating system would require major rethinking	
Perceived value	PVL1	Considering the time and effort that I have to spend, switching to Linux is worthwhile	Sirdeshmukh et al., 2002
	PVL2	Considering the loss that I have to incur, switching to Linux is of good value	
	PVL3	Considering the hassle that I have to experience, switching to Linux is beneficial to me	
	PVL4	Considering everything, switching to Linux would deliver me good value	
Switching benefits	SWB1	Switching to Linux would give me greater control over my work than using the current operating system	Moore and Benbasat, 1991
	SWB2	Switching to Linux would make it easier to do my work than using the current operating system	
	SWB3	Switching to Linux would enhance my effectiveness on the work than using the current operating system	
	SWB4	Overall, I would find switching to Linux to be more advantageous in my work than using the current operating system	
Switching costs	SWC1	I have already put a lot of time and effort into mastering the use of current operating system	Jones et al., 2000
	SWC2	It would take a lot of time and effort to switch to Linux	
	SWC3	Switching to the Linux could result in unexpected hassles	
	SWC4	I would lose a lot in my work if I were to switch to Linux	
Perceived ease of use	EOU1	I would find it easy to get Linux to do what I want it to do	Davis et al., 1989
	EOU2	It would be easy for me to become skillful at using Linux	
	EOU3	I would find Linux easy to use	
	EOU4	Linux would be easy to operate	
Perceived usefulness	USF1	I would find Linux useful in performing my work	Davis et al., 1989
	USF2	Using Linux would help me perform many things conveniently	
	USF3	Using Linux would help me accomplish my work effectively	

Data Collection

We considered the population of interest to be composed of computer users. The database of a market research firm was used to draw up a sample frame of panel members 19 years of age or older. The market research firm randomly selected members from a panel pool and sent each member an email invitation to participate in the survey and included a link to a Web-based survey questionnaire. The online survey was conducted for one week. A total of 216 respondents were collected. The valid respondents should own personal computer or laptop computer. They also should have authority to change the operating system in their computers. They should not use Linux as the current operating system in their computers but should have some ideas about Linux. Among 216 responses, we dropped 18 invalid responses because 8 of the respondents do not have the authority to change their operating system and 10 of the respondents are completely unfamiliar with Linux.

Table 2 describes the descriptive statistics of 198 valid respondents. The majority of respondents were male (75.1%) with an average age of 34.2 years (s.d. = 8.6), and an average usage experience of their current operating system of 3.4 years (s.d. = 2.2). All the subjects own a computer, and they have at least 2-year experience in using their current operating system. The average familiarity level of Linux (3.6, completely unfamiliar (1) to completely familiar (7)) shows that they know Linux as an alternative operating system.

Demographic variable		Frequency	Percentage
Gender	Male	151	75.1
	Female	50	24.9
Age (years) [mean = 34.2, s.d. = 8.6]	19-29	73	36.9
	30-39	102	51.5
	40 – above	23	11.6
Profession	Student	52	26.3
	Professional	141	71.2
	Others	5	2.5
Total		198	100.0

Data Analysis and Results

Instrument Validation

To validate the survey instrument, we assessed its convergent and discriminant validity. We first performed confirmatory factor analysis (CFA) using LISREL. Convergent validity can be established using three criteria. First, the standardized path loading must be statistically significant and greater than 0.7 (Gefen et al., 2000). Second, the composite reliability (CR) and the Cronbach's α for each construct must be larger than 0.7 (Nunnally, 1978). Third, the average variance extracted (AVE) for each construct must exceed 0.5 (Fornell and Larcker, 1981).

The standardized path loadings were all significant and greater than 0.7 except RST1. The CR and the Cronbach's alpha for all constructs exceed 0.7. The AVE for each construct was greater than 0.5. The convergent validity was thus supported (see Table 3).

Construct	Item	Std. Loading	AVE	CR	α
Adoption intention (INT)	INT1	0.80	0.71	0.88	0.90
	INT2	0.88			
	INT3	0.85			
User resistance (RST)	RST1	0.69	0.65	0.85	0.80
	RST2	0.79			
	RST3	0.92			
Perceived value (PVL)	PVL1	0.72	0.73	0.91	0.90
	PVL2	0.85			
	PVL3	0.92			
	PVL4	0.91			
Switching benefits (SWB)	SWB1	0.70	0.69	0.90	0.88
	SWB2	0.85			
	SWB3	0.86			

	SWB4	0.89			
Switching costs (SWC)	SWC1	0.87	0.79	0.92	0.76
	SWC2	0.88			
	SWC3	0.91			
Perceived ease of use (EOU)	EOU1	0.76	0.68	0.89	0.88
	EOU2	0.71			
	EOU3	0.92			
	EOU4	0.88			
Perceived usefulness (USF)	USF1	0.78	0.70	0.87	0.87
	USF2	0.83			
	USF3	0.88			

Discriminant validity of the measurement model is assessed by comparing the square root of AVE for each construct with the correlations between that construct and other constructs. Discriminant validity is established if the square root of AVE for a given construct is greater than the correlations between that construct and other constructs (Fornell and Larcker, 1981). The square root of AVE for each construct (diagonal term) exceeded the correlations between the construct and other constructs (off-diagonal terms) (See Table 4).

As one of the correlation terms in the table was greater than the prescribed threshold of 0.6 (Carlson et al., 2000), we conducted a second test of discriminant validity using a process of constrained CFA as suggested by Anderson and Gerbing (1988). From the results of this test, all χ^2 statistics were found significant indicating that the measurement model was significantly better than other alternative models (obtained by combining pairs of latent constructs). Hence, discriminant validity of the instrument was established.

We further tested our data for common method variance using the Harman’s single-factor test following the guidance of previous research (Podsakoff et al., 2003). Harman’s single-factor test involves an exploratory factor analysis (EFA) of all items to determine whether the majority of the variance is accounted for by one general factor. The test showed that the first factor accounts for 39.83 percent of the total variance. We further carried out principal component analysis using varimax rotation, which revealed that each of seven principal components explained almost an equal amount of the 75.96 percent of total variance, ranging from 8.65 percent to 13.14 percent. Results of the test indicate that our data do not suffer from common method variance.

	Mean	S.D.	INT	RST	PVL	SWC	SWB	EOU	USF
INT	3.31	1.66	0.84						
RST	4.49	1.21	-0.50	0.81					
PVL	3.62	1.15	0.63	-0.59	0.85				
SWC	4.65	1.12	-0.24	0.29	-0.32	0.89			
SWB	3.49	1.14	0.51	-0.47	0.60	-0.22	0.83		
EOU	3.99	1.11	0.43	-0.38	0.42	-0.28	0.33	0.82	
USF	3.96	1.10	0.46	-0.36	0.50	-0.27	0.61	0.61	0.84

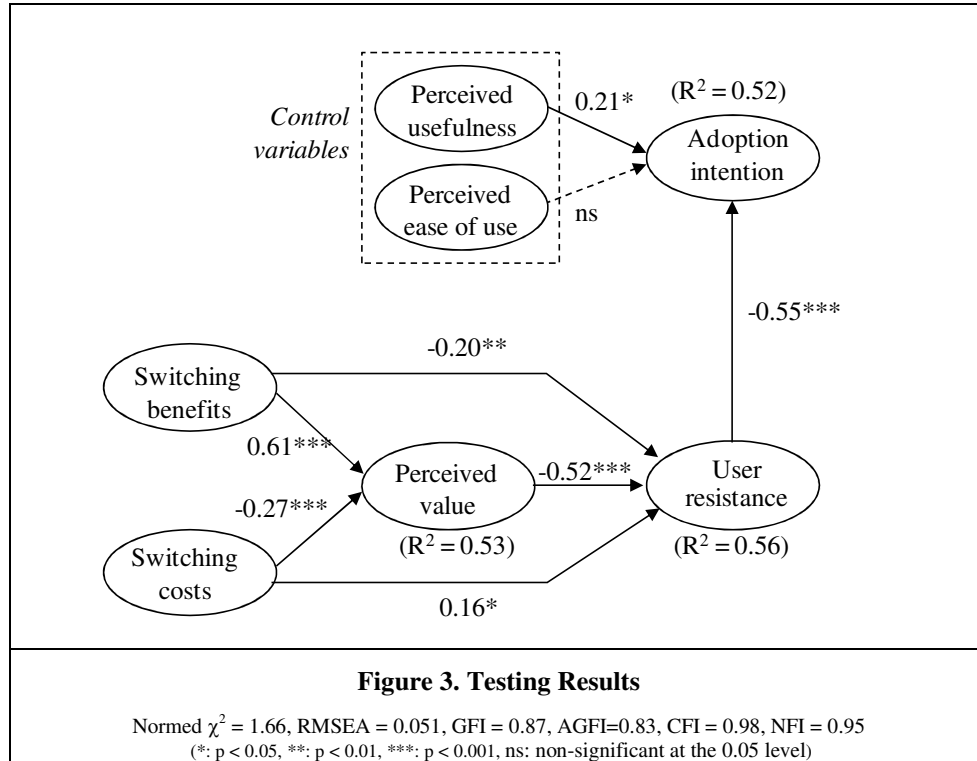
Note: Leading diagonal shows the squared root of AVE of each construct

Hypotheses Testing

We examined the structural model using LISREL. We applied the following indices and standards to assess model fit (Gefen et al., 2000): normed χ^2 (χ^2 to degree of freedom) lower than 3, root mean square of approximation (RMSEA) lower than 0.08, goodness-of-fit index (GFI), comparative fit index (CFI), and normed fit index (NFI) greater than 0.9, and adjusted goodness-of-fit index (AGFI) greater than 0.8.

The results of testing the structural model are shown in Figure 3. The structural model satisfied the threshold for all indices except GFI (0.87), which is close to the threshold: Normed $\chi^2 = 1.66$, RMSEA = 0.051, GFI = 0.87, AGFI = 0.83, CFI = 0.98, NFI = 0.95. The structural model thus appears to adequately fit the data.

The results indicate that user resistance (H1) together with perceived usefulness had significant effects on the adoption intention, explaining 52 percent of its variance. Perceived value (H2), switching benefits (H5) and switching costs (H6) had significant effects on user resistance, explaining 56 percent of its variance. Switching benefits (H3) and switching costs (H4) had significant effects on perceived value, explaining 53 percent of its variance. However, we could not find a significant relationship between perceived ease of use and adoption intention. We additionally included three control variables (gender, age, profession) as alternative predictors of adoption intention. None of these variables had a significant effect on adoption intention.



Discussion and Implications

Discussion of Findings

There are several salient findings from this study. The first finding is that user resistance to switch has a significant negative impact on user adoption intention in the context of Linux migration. It supports the TPB where the individual's intention is determined by the attitude toward the behaviour (Ajzen, 1991). Our study extends this idea by conceptualizing user resistance as negative attitude towards the migration to Linux from the current operating system. This study also supports the ideas of having two characteristics in OSS (i.e., Linux) migration such as adopting a new system and discarding the current system. Most users have already adopted and used a proprietary system (e.g., Microsoft Windows) in their personal computers. In order to adopt Linux which is alternative of their current system, they have to discontinue the existing system. Therefore, the users can be resistant to OSS migration and discarding the current system, which then affects adoption intention.

The second finding is that perceived value has a significant negative impact on user resistance to switch. In addition, switching benefits increase perceived value while switching costs reduce perceived value, which is consistent with the EIM (Joshi, 1991) and previous research (Kim and Kankanhalli, 2009). If users perceive overall loss in net equity (greater switching costs than switching benefits) which means low perceived value, they develop the oppositional attitude and become averse to switch to the new system. It also supports the arguments of previous

research (Joshi, 1991; Joshi and Lauer, 1999) that changes delivering high perceived value are less likely to be resisted than those with low perceived value.

The third finding is that switching costs and switching benefits have direct impacts on user resistance to switch. The direct effect of switching costs parallels prior research (Kim and Kankanhalli 2009) that has argued that switching costs create resistance to switch. Moreover, the direct influence of switching benefits to user resistance to switch is consistent with the previous research (Martinko et al., 1996) which explained that the individuals' beliefs on the positive outcomes or switching benefits regarding the new system reduce user resistance.

The fourth finding is that perceived usefulness has a significant impact on user adoption intention while perceived ease of use has not, which is in conflict with TAM (Davis, 1989). One possible reason is that users may put the usefulness of a system in the higher priority than its ease of use when they are deciding to adopt the system. In our study, users may find usefulness of Linux is more important than its ease of use in deciding the adoption of it. Another possible reason is that most respondents have used computers for very long time and so their computer skills are high. There are no special features which make Linux difficult to use compared to other operating systems³. They may not perceive difficulties in using Linux. Hence, ease of use could be of less concern for them in deciding the OSS migration.

Limitations and Future Research

The results of this study should be interpreted in the context of its limitation. This study selected Linux as a representative of OSS and tested the research model based on the data collection from computer users. Especially, we focused on the use of Linux by individual users for their personal computers. We should note that many corporate users have used Linux as an operating system in their products such as server system and mobile devices. In contrast, Linux has only about one percent of the individual operating system market. Future research needs to check other types of OSS at different levels (i.e., individual level or organization level). While Linux migration requires switching from the current operating system to Linux, other types of OSS do not require such switching. Depending on the type of OSS, the theoretical research model should be redeveloped.

This research also suggests and opens a number of future research opportunities. First, the user resistance to OSS migration could be influenced by other factors besides the factors proposed in EIM. Further research could extend the model to study the factors that have influence on user resistance to switch and their direct effects on OSS migration intention. Second, further research could study in depth about the classification of switching costs which is a relevant and important concept in OSS migration. The study of switching costs might create a rich research potential on this topic. Next, further research could investigate the demands of the users regarding OSS and the factors that would increase the benefits of using OSS.

Implications for Research

This research offers several implications for research. First, this study has examined the relationship between user acceptance and user resistance and how they are different and linked. TAM explains that users decide the adoption of technology based on the perception of the target technology (i.e., OSS). In contrast, user resistance to OSS migration based on the EIM explains that users decide the resistance based on the overall evaluation and benefits and costs related to the switching (i.e., migration from the current system to a new system). This study has also conceptualized user resistance to switch as attitude and explained the relationship between user resistance and adoption based on the attitude-behaviour link of TPB.

Another theoretical implication is the development of the user resistance model based on the EIM to understand the reasons of resistance. Few theoretical foundations with empirical validation exist in the literature for explaining the user resistance. EIM (Joshi, 1991) provides an explanation about the role of net equity in causing user resistance and some examples of inputs and outcomes, but it does not examine the assessment of net equity based on the increase and decrease in outcomes and inputs, and has not been tested in the context of OSS. This study developed and tested a theoretical model to explain appraisal of switching to a new system through survey methodology.

³ What's a desktop environment? Linux.com, Available at <http://www.linux.com/whatislinux/114379>

The present study adds to previous research on user resistance, especially Bhattacharjee and Hikmet (2007) and Kim and Kankanhalli (200). Bhattacharjee and Hitmet (2007) examined the relationship between resistance to change and intention to use healthcare information technology. They conceptualized resistance to change as a generalized opposition to change engendered by the expected adverse consequences of change. They have a contribution in finding the negative relationship between resistance to change and intention to use. However, they have a limitation in explaining the antecedents of resistance to change. They examined perceived threat as the main antecedent of resistance to change following the argument of previous conceptual research (Krovi, 1993; Lapointe and Rivard, 2005; Markus, 1983). In contrast, the present study has derived and empirically tested a theoretically grounded model to understand how OSS migration is evaluated for user resistance to occur. Especially, our study has shown that user resistance is influenced by not only threats or costs but also benefits.

Kim and Kankanhalli (2009) examined causes of user resistance based on an integrative framework centered on the theory of planned behaviour. They explained the key role of switching costs in causing user resistance. However, they have considered user resistance in the context of IS implementation, not technology adoption. For this reason, they did not pay attention to the relationship between user resistance and user acceptance. In contrast, the present study has examined the relationship between them.

This study also adds to OSS literature. Especially, there have been many researches on the characterization of OSS and the adoption of OSS (e.g., Fitzgerald 2006). Based on previous research, Hauge et al. (2010) classified ways of OSS adoption and discussed two main areas (i.e., deploying OSS products and using OSS in software development) in which organizations can benefit from OSS. However, there has been no consideration about the two different types of OSS. One requires switching the other one does not require switching. If the target OSS does not require users switch from existing system to it, the two main determinants of TAM will surely explain OSS adoption. However, the two determinants of TAM cannot explain the low market share of Linux as the most well-known OSS in the operating system market for individual users. The second type of OSS like Linux requires users switch from existing system. In this type of OSS, individual users may consider not only the characteristics of OSS and the issues related to the migration. By finding the role and effect of user resistance to OSS migration, the present study thus adds to OSS literature.

Implications for Practice

There are also several practical implications. The results of this study suggest OSS community and developers that just developing useful and easy to use OSS is not enough for facilitating the use of OSS. They need to pay attention on how to alleviate user resistance to switch in order to increase the OSS migration. Although the developed OSS like Linux is useful and easy to use, the oppositional attitude of users based on their value assessment of the migration may hinder the switch to the new system. OSS developers and advocates should thus be aware of the critical effect of user resistance on the adoption intention and aim to reduce it by increasing the perceived value.

Developers can attempt to increase the perceived value of switching to reduce user resistance. In evaluating perceived value, users estimate whether or not the cost for switch exceeds the benefits associated with the switch (Joshi, 1991; Zeithaml, 1988). In this study, the switch refers to the switching from current system to the new system, OSS. In order to increase the perceived value, the advantages of the OSS over the proprietary software (i.e., switching benefits) should be emphasized from the viewpoint of the user. Therefore, switching benefits in comparison with the current system need to be stated clearly together with the release of the developed OSS.

Developers can further increase perceived value and reduce user resistance to switch by reducing switching costs. Although the developed OSS is useful and has some benefits, the users may still be resistant due to the higher switching costs (i.e., costs is greater than benefits) (Joshi, 1991). The users can perceive the switching costs in different forms such as psychological cost (Whitten and Wakefield, 2006), procedural costs (Burnham et al., 2003) and loss costs (Jones et al., 2002). Therefore, developers should aim to reduce these switching costs perceived by the users.

Developers should aim to allay the users' psychological costs by informing them clearly about the further changes in technology and feasible solutions for various anticipated issues which may be encountered by the users. Next, developers can attempt to alleviate procedural costs by providing the comprehensive and effective user guide of the OSS so that the users may find it easy to set up and learn how to use it. Again, developers should also try to eliminate the loss costs by providing them the benefits over their existing system so that they will perceive that it is worth to use the OSS.

Conclusion

This study identifies user resistance to switch as one of the most critical issues in the migration to OSS. Although OSS communities and developers have developed a number of useful and easy to use OSS, the number of individual OSS users for their personal computers is quite low. This is because most of the users have adopted a system and they may have to discontinue their existing system in order to adopt the new system. When the users need to discontinue and switch from the current system to the new system, they may resist switching in their adoption of the new system. The discontinuous and switching from the current system to the new system may cause the users to develop and have the resistant attitude. Therefore, the OSS developers should not just focus on the development of useful, easy to use and successful OSS, and they should also pay much attention on how to alleviate the user resistance in promoting the OSS migration.

Going beyond previous research, this study develops a model for user resistance based on equity implementation model (Joshi, 1991). This study also highlights the significance of perceived value, switching costs and switching benefits as key determinants of user resistance to switch based on the EIM. This study further shows that user resistance has a negative effect on user adoption intention. As such, this research provides the theoretical understanding of how users evaluate the OSS migration and how user resistance is formed. The findings from the research also offer the OSS communities and developers suggestions for minimizing user resistance to switch, thereby increasing the adoption of OSS. It also provides the practitioners methods to lower people's resistance when involving the switching and opens a number of further researches in investigating the adoption of OSS, the characteristics of user resistance and its causes and effects.

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