8-5-2011

Antecedents and Effect of IT Usage on Performance: A Research Framework and Empirical Study

Sanjeev Kumar
University of Wisconsin - Milwaukee, kumars@uwm.edu

Terence Saldanha
University of Michigan - Ann Arbor, terences@umich.edu

M.S. Krishnan
mskrish@umich.edu

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Sanjeev Kumar
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mskrish@umich.edu

ABSTRACT

Information Technology (IT) Usage is an important construct in Information Systems research. While the relationship between IT Usage and Performance is well studied along with the antecedents of IT Usage, extant research has not yet fully explored an integrated model of IT Usage, its antecedents and impact on performance. In this paper, we propose an integrated theoretical framework for such an effort. We detail our preliminary results for a section of the theoretical model to demonstrate the viability of the research model. We find that for our research context, the preliminary results align well with theoretical predictions. We show strong statistical relationships between actual IT Usage and performance at the business unit level in both cross sectional and panel data analysis. We conclude by discussing the proposed data collection and analysis approach for testing the integrated theoretical framework for the relationship between IT Usage, its antecedents and impact on performance.

Keywords

IT Usage, Business Value of IT, Research Framework, Antecedents of IT Usage, Performance.

1. INTRODUCTION

One of the main foci of the Business Value of Information Technology (IT) research has been the relationship between IT Investment and Performance. IT Usage has been identified as a key construct in the relationship between IT Investment and performance (Devaraj and Kohli, 2003). IT Usage is also a key construct in another dominant stream of research - Technology Acceptance. The literature based on the Technology Acceptance Model (TAM) includes IT Usage as a key construct. For example, in their unified model of technology acceptance, Venkatesh, Morris, Davis, and Davis (2003) consider IT Usage as the dependent variable.

Despite the rich literature involving the IT Usage construct, most of the relevant research can be classified into two major categories - one that considers IT Usage as the dependent variable and the second that considers IT Usage as an antecedent of performance. In this research we bring the two research streams together and propose an integrated theoretical model that includes IT Usage, the antecedents of IT Usage and the effect of IT Usage on performance. The model effectively incorporates aspects of Business Value of IT and Technology Acceptance research streams in an integrated framework where IT Usage is the intermediate variable between adoption factors (operationalized as antecedents of IT Usage) and performance.

While this paper focuses mainly on our proposed research framework at a high level, we have provided preliminary results by testing a portion of the theoretical model based on the first round of data collection to demonstrate the viability of the research approach. The potential contribution of this paper to research lies in the linking of antecedents of IT usage to consequences in an integrated model. For managers, this study can potentially shed light on how to leverage IT by encouraging usage, how to drive consequent performance benefits from actual usage and how to complement IT usage with organizational resources or competencies.

The rest of the paper is organized as follows: the next section summarizes relevant previous literature on IT Usage. Section 3 proposes an integrative theoretical framework and research model for the study. Section 4 presents details of the data collection and preliminary results based on the first round of data collection. We discuss potential contributions and limitations in Section 5 before concluding the paper in Section 6 by discussing the future research direction.

2. IT USAGE: LITERATURE SUMMARY (ABBREVIATED)

IT Usage is a key construct in Information Systems (IS) research and has been well studied. For the literature summary, we look at two streams of research - one that considers IT Usage as an antecedent of performance (Business Value of IT stream) and the second that considers IT Usage as a dependent variable (Technology Acceptance stream). We then look at issues that are common to both streams of literature.

2.1 Business Value of IT

Business Value of IT literature has shown the performance payoff of IT Investment (Bharadwaj, Bharadwaj and Konsynski, 1999; Brynjolfsson and Hitt, 1996). As part of the performance payoff, the relationship between IT Usage and organizational payoff has been well studied. For example, DeLone and McLean (1992), in their well known IS Success Model, placed System Use as one of the key constructs leading to individual impact and organizational impact. Several studies have considered IT Usage as an independent variable and studied its effect on performance (Lucas Jr and Spitler, 1999).Recently, studies have looked at objective measures of IT Usage, controlling for voluntariness of IT Usage as well as task technology fit to show that increased IT Usage leads to better performance (Devaraj and Kohli, 2003). However, the empirical evidence of the link between IT Usage and performance is mixed with studies often showing IT Usage to have less than theorized impact on performance (Goodhue and Thompson, 1995). Lucas Jr and Spitler (1999) found that IT Usage had no effect on performance while Szajna (1993) actually found a negative relationship between IT Usage and performance. As noted by Devaraj and Kohli (2003, pp. 276), one reason for the mixed evidence in prior research could be that much of the research on IT usage have "generally utilized self-reported usage" measures which are subject to several limitations including often weak correlation well with actual usage (Straub, Limayem, and Karahanna-Evaristo, 1995).

In this paper, we argue that though the positive relationship between IT Usage and performance is well theorized, IT Usage is only the mediation variable that channels the impact of several independent variables to the dependent variable of performance. Hence, we are proposing an integrated research framework that includes IT Usage as an intermediate variable that mediates the effect of several independent variables on organizational performance.

2.2 Technology Acceptance

Much of the extant research has looked at antecedents of IT Usage with IT Usage as a dependent variable (Venkatesh et al., 2003) in the context of technology acceptance (Davis, 1989). Researchers have studied a large number of antecedents for IT Usage (Adams, Nelson, and Todd, 1992) through different theoretical frameworks (Taylor and Todd, 1995). Starting with the well known Technology Acceptance Model (TAM), a unified view of antecedents of IT Usage has been developed (Venkatesh et al., 2003). Similarly, Zhu, Kraemer, and Xu (2006) approach the antecedents of different stages of IT Usage using a TOE (Technology, Organization and Environment) framework. However, the antecedents of IT Usage have been shown to account for only a small amount of variance in IT Usage (Compeau and Meister, 2002).

In this paper we follow the approach of technology acceptance literature and consider the antecedents of IT Usage, but argue that IT Usage by itself is not the important consideration. IT Usage is valuable only so far as it leads to improved performance. Hence, we incorporate antecedents of IT Usage as only one component of an integrated model with IT Usage as the intermediate variable and performance as the dependent variable.

2.3 Issues in IT Usage Research

The measurement of IT Usage is challenging and most studies have used self-reported measures of IT Usage. However, self-reported IT Usage measures have several limitations including strong correlations with other self-reported variables and actual usage being significantly lower than self-reported usage (Straub et al., 1995). User have been shown to be poor estimators of their own behavior (e.g. such as IT Usage) (Wagner III and Gooding, 1987). Szajna (1996) concluded that self-reported usage may not be an appropriate substitute for actual usage. Devaraj and Kohli (2003) argued that in light of limitations of self-reported measures of IT Usage, technology impacts can be better assessed by examining actual IT Usage rather than self-reported IT Usage. Based on this research evidence, in this research we are focusing on objectively measured IT Usage variable derived from actual usage data rather than self-reported sources.

With the rich literature about IT Usage comes the issue of varying interpretation of the construct. IT Usage has been varyingly measured as a binary variable (use or do not use), proportion of use, duration of use, extent of use et cetera (Burton-Jones and Straub, 2006). Recent studies have argued that there is a need for a deeper, more integrative exploration from a theoretical perspective, of the IT Usage construct (Burton-Jones and Gallivan, 2007). In this research, we are attempting to capture a rich operationalization of IT Usage construct which includes its system, task and user components.

We expect that our research will result in a deeper understanding of IT Usage as the intermediate construct connecting the antecedents of IT Usage and performance.

3. PROPOSED RESEARCH MODEL

In this paper, we explore the impact of IT on performance through an integrated model with IT Usage as an intermediate variable. As identified as a weakness of previous studies, we plan to use objective measures of IT Usage and performance, employing a panel dataset to capture longitudinal effects. Such integrated models have been employed before, most notably by Zhu and Kraemer (2005) linking the antecedents of e-Business use based on the TOE framework to e-Business use and consequently to e-Business value.

We propose to extend the research by employing a similar integrated model for a traditional retail business, in an emerging economy context including any potential longitudinal effects. In this research, we propose a two-stage research model that will include both the dominant streams of research on IT Usage: the antecedents of IT Usage and the effect of IT Usage on performance. Furthermore, though the broad notion of complementarities is well-established in the IS literature (Melville, Kraemer and Gurbaxani, 2004), scant IS research, to our knowledge, specifically examines the role of moderators to the antecedents-usage and usage-performance links using objective measures of usage and performance in an integrated framework.

There are several theoretical reasons why contextual factors may have an impact on the usage-performance link. For example, the fit of the technology to the task is critical to achieve improved performance (Goodhue and Thompson, 1995). Prior research also argues (but did not test) that benefits from IT usage may depend on the extent to which the IT use is voluntary or mandated (Devaraj and Kohli, 2003). Furthermore, if IT usage is not accompanied by business process transparency and human capital capabilities, then this lack of a complimentary "social architecture" of the organization (Prahalad and Krishnan, 2008, pp. 148) would hinder the realization of benefits from IT usage. Similar arguments hold for potential moderators of the effects of antecedents on IT usage. For example, while incentives to use may be one antecedent of IT usage, other organizational practices and organizational culture potentially moderate this link.

In sum, we argue that though prior research has examined the antecedent-usage and usage-performance links, there is a need for a more complete understanding of the conditions under which these effects would be enhanced or mitigated. Our theoretical model captures these inter-relationships in a nomological integrated model of IT Usage. In this paper, we only present a broad schematic of the research model because of space constraints and also because many data collection instruments are currently under development for the second phase of data collection. The proposed research model is presented in Figure 1.

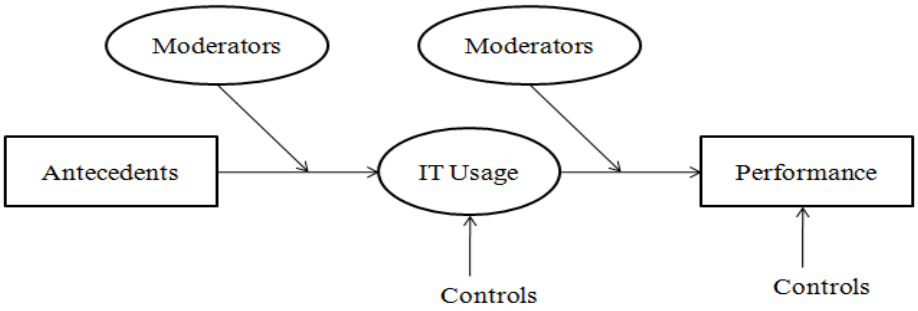

Figure 1: Integrated Research Model to study IT Usage

4. DATA COLLECTION AND PRELIMINARY ANALYSIS

The data collection for this research is being performed in two stages. A dual-stage approach where data collection of independent and dependent variables is temporally separated has added benefit in that it further minimizes potential for common-method bias (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). In the first stage, we have collected preliminary data on IT Usage and performance on a monthly basis for one year. The purpose of the first stage of data collection is to conduct preliminary data analysis and confirm that there are no significant issues in conducting the empirical study. In this paper we are reporting the results from the first stage of data collection and the corresponding analysis. Since the results of the preliminary analysis have been encouraging, (as detailed below), we are proceeding with the second stage of data collection that includes antecedents of IT Usage and several control and moderating variables. As the IT Usage and performance variables have been theorized as a reflective construct, components of these constructs are being collected as

well. Finally, the preliminary data includes only a one year time frame which does not allow us to conduct longer duration lagged effect analysis. We are collecting the expanded dataset for a longer time horizon.

4.1 Data

The data for this study is collected from dealers of a manufacturer in India. The company has implemented an information system for managing dealer operations at each of its dealers (approximately 450 in number) across the country. We henceforth refer to this system as 'Dealer Management System' (DMS). The DMS connects the dealer's IT systems to the company's ERP system seamlessly and provides valuable and timely information on dealer level system usage, customer behavior, dealer performance and product performance. The preliminary results presented in this paper utilize monthly data for the year 2010 on DMS system usage and billing amounts. The variables used are the following:

System *Usage*: This is a measure of the overall usage of the DMS system by the dealer. It is calculated on a scale of 0-100 and consists of two components. The first component is a sales metric, which captures system usage in terms of frequency of data transfer to the company and number of inquiries. The second component is a service metric, which captures usage in terms of the number of job items, number of customer complaints and the frequency of warranty claims. These two components of usage can be broadly viewed as capturing usage for related but different purposes. The sales metric captures usage from the company's perspective to manage its sales operations. The service component refers to usage of system related to servicing customers. Our measure of overall usage is consistent with objective measures of usage used and recommended in prior research (Straub et al., 1995).

Billing: This is a measure of monthly sales by the dealer (in terms of revenue). Consistent with much prior IS research, we use this sales metric as a measure of performance of the dealer.

State: Demand patterns and regulations may vary by location of dealer. Hence, we control for the location (geographical state) in which the dealer is located. Since our sample consists of dealers located across 26 states in India, we include 25 dummy variables as control variables (one dummy variable is dropped as the base dummy variable) where each variable is 1 if the dealer is located in that state and 0 otherwise.

Table 1 shows the summary statistics for the variables *Usage* and *Billing* for the month of December 2010.

Variables	Mean	Std. Deviation	Min	Max
Usage	83.56	13.87	7	100
Billing	278.73	250.79	18	1603
n = 430				

Table 1: Descriptive Statistics

4.2 Preliminary Results

For the preliminary analysis we are focusing on a single segment of the proposed integrated theoretical framework presented in Figure 1 - the link between IT Usage and performance. Based on the literature summary presented earlier, we can posit the following hypothesis for their relationship:

Hypothesis 1: Higher levels of IT Usage will be associated with higher levels of Performance.

We now present four sets of preliminary results in this paper in an effort to test the hypothesis above and serve as a sanity test for the preliminary data collected. All analyses were performed using Stata software package (version 10).

4.2.1 Pair-wise Correlations

Table 2 shows the correlations between system usage and dealer performance (*Billing*) for each of the 12 months in our study. The pair-wise correlations indicate preliminary support for the positive and significant association between System Usage and performance of the dealer. This positive and statistically significant relationship exists for each of the 12 months of our study.

Month	January	February	March	April	May	June	July	August	September	October	November	December
Number of dealers (n)	441	443	440	440	441	441	438	437	434	432	431	430
Correlation between *Usage* and *Billing*	0.260*	0.268*	0.196*	0.259*	0.253*	0.268*	0.262*	0.219*	0.188*	0.201*	0.278*	0.249*
Notes: * indicates significance at p < 0.0001. The number of dealers differs slightly from month-to-month because of missing data.												

Table 2: Month-wise Correlation between System Usage and Dealer Performance

4.2.2 Ordinary Least Squares (OLS) Regression

Cross Sectional OLS Analysis

Second, we estimate an OLS regression model of performance (*Billing*) on system usage (*Usage*) controlling for the geographical state (State) where the dealer is located. We report the OLS estimates for a single month (July 2010) in Table 3 (Column A) below. The model is significant (F-statistic = 9.73, p <0.0001) with an adjusted R-square of 0.333. We find a positive and statistically significant relationship between system usage and dealer performance (beta = 2.231, p <0.01), suggesting that usage of the system is positively associated with performance.

	Dependent Variable = *Billing* (t)	
	OLS for July 2010	Pooled OLS
	(A)	(B)
Usage $_{(t)}$	2.231*** (2.90)	1.297*** (7.23)
intercept	-145.634 (-0.59)	-30.274 (-0.46)
F-statistic	9.73	75.05
Prob > F	0.0000	0.0000
Adjusted R-square	0.333	0.268
Observations (N)	438	5248
Notes: (1) t-statistics in parentheses. (2) 25 dummies for state were included in the regressions. Estimates for state dummies not shown for brevity. (3) Significant at *10%, **5% and ***1% level.		

Table 3: Parameter Estimates

Pooled OLS Analysis

We also estimate the pooled OLS model for the 12 months of our study. The pooled OLS estimates are reported in Table 3 (Column B). The model is significant (F-statistic = 75.05, p<0.0001) with an adjusted R-square of 0.268. We find a positive and significant relationship between system usage and dealer performance (beta = 1.297, p <0.01), further supporting the preliminary findings from the pair-wise correlations and cross-sectional month-wise OLS estimation.

Lagged Effects Analysis

There is likely to be a time lag between IT Usage and the corresponding impact on performance. To explore such lagged effects, we performed the above two estimations with a three-month lagged variable of IT Usage as well. This is consistent with prior research that suggests using lag periods of less than 6 months in the context of usage of technology (Devaraj and Kohli, 2003). Such lagged effect estimation is well accepted in Information Systems research to capture the inherent time lag (Brynjolfsson, Hitt, andYang, 2002). The results for the lagged effect analysis are comparable in magnitude and direction with those presented above. The results are shown in Table 4 in Columns A and B.

4.2.3 Panel Data Analysis

Finally, we consider panel data analysis to take advantage of the longitudinal aspect of the dataset. As described earlier, consistent with prior research, we use the measure of usage lagged by 3 months (Devaraj and Kohli, 2003). The pooled OLS results presented above (Table 4, column B) is likely to be problematic since it assumes a constant intercept for all dealers. The Breusch-Pagan Lagrange Multiplier test (Breusch and Pagan, 1980) indicates that the individual effects are indeed significant (p <0.0001) and so OLS estimates on the pooled data is not appropriate. The test suggests that since the null hypothesis of no heterogeneity among dealers is rejected, individual-level heterogeneity must be accounted for. Hence, we have also estimated the fixed-effects and random-effects panel data models (Greene, 2003). Table 4 (Columns C and D) report the fixed-effects and random-effects estimates. The Hausman test (Hausman, 1978) of the fixed-effects model versus random-effects model is rejected (p <0.01), indicating that the random-effects model is inconsistent, whereas the fixed-effects model is consistent, though inefficient (Greene, 2003). Therefore, we interpret the fixed-effects estimates. As shown in Table 4 (Column C), we find a positive and significant coefficient of *Usage* (beta = 0.262, p <0.05), further corroborating the preliminary findings from the pair-wise correlations, month-wise cross-sectional and pooled OLS estimation and lagged effect month-wise cross-sectional and pooled OLS estimation.

	Dependent Variable = *Billing* $_{(t)}$			
	OLS for December 2010	Pooled OLS Model	Fixed-effects Model	Random-effects Model
	(A)	(B)	(C)	(D)
Usage $_{(t-3)}$	2.066*** (3.12)	1.601*** (11.2)	0.262** (2.17)	0.339*** (3.28)
intercept	-36.985 (-0.17)	-38.912*** (-2.90)	257.135*** (27.30)	66.036 (0.85)
F-statistic	8.67	80.23	4.72	-
Wald Chi-square	-	-	-	237.26
Prob > F or Prob > Chi-square	0.0000	0.0000	0.0303	0.0000
R-square	0.317	0.275	0.065	0.268
Dealers (n)	430	-	444	444
Dealer-year observations (N)	-	3924	3924	3924
Notes: (1) t-statistics in parentheses. (2) 25 dummies for state (dealer location) were included in the regressions. Estimates for state dummies not shown for brevity. (3) Significant at *10%, **5% and ***1% level.				

Table 4: Results of Lagged Effects and Panel Regression

Our preliminary findings are consistent with research in other industry contexts that found a positive association between IT usage of a Decision Support System (CPU time) and revenue of hospitals (Devaraj and Kohli, 2003).

4.3 Future Data Collection

Our current data collection efforts include additional variables to control for other factors (such as dealer size) that could influence or moderate the relationship between usage and performance, along with antecedent variables that determine usage. We are exploring antecedents and moderators such as human capital investments, incentives and training at the dealer locations. As noted earlier, such organizational capabilities can potentially promote and complement IT usage.

Considering the panel nature of the proposed dataset (450 dealers across several years), we anticipate to analyze the dataset using panel data models. As discussed above, our preliminary results are encouraging and suggest a strong potential for testing the integrated theoretical model presented in Figure 1.

5. POTENTIAL CONTRIBUTIONS AND LIMITATIONS

5.1 Contributions to Research

The potential contributions of our work to research are three-fold. First, we propose a single integrated theoretical model encapsulating IT Usage in a nomological network of relationships with antecedents and consequences. This will potentially provide a more complete understanding of how IT usage mediates the link between various antecedents and performance. Our study is a step towards responding to the call of prior research to test a "comprehensive framework… that incorporates… actual use of the technology, and its impact on individual and organizational performance" (Devaraj and Kohli, 2003, pp. 286). Second, our ensuing empirical study in a developing economy (India) will potentially complement other studies of IT Usage conducted in the United States and developed economies. Third, our study will also shed light on and provide an avenue for researchers to further examine the underlying mechanisms influencing IT Usage and its impact on performance.

5.2 Contributions to Practice

For practicing managers, our work will potentially provide guidance on how to encourage IT usage and achieve consequent performance benefits. Despite advanced developments in technology, it is not uncommon for business and IT managers to find that their large investments in technology are not beneficial, simply because the technology either remains unused or because the use does not translate to commensurate performance improvements. We hope that our results will shed light on the pathways from antecedents of IT usage to performance that will provide actionable insights to practicing managers.

5.3 Limitations

Notwithstanding the potential contributions described above, it is important to view this study in light of its potential limitations. First, the study is limited to a single industry. While this helps to control for variations across industries, future studies will benefit by examining antecedents, moderators and consequences of IT usage across industries. A similar caveat

applies to the context of our empirical study. Although focusing on a developing economy is a benefit as described above, it is also a limitation which would hinder the generalizability of the findings to other countries. Third, our measure of performance is based on revenue. Though this measure is consistent with other IT usage studies (Devaraj and Kohli, 2003), it would be beneficial to also capture the cost of implementing the IT system, which would facilitate capturing performance as a measure of revenue per dollar invested in the system. Nevertheless, given that the DMS is implemented by the same company, it is likely that the cost of implementing the DMS (after controlling for dealer characteristics such as dealer size) is largely similar across dealers in our sample. Hence, we do not expect our results to significantly change, even when performance is measured as revenue per dollar invested in the system.

6. CONCLUSION AND WAY FORWARD

Based on the preliminary analysis of the data collected in the first phase of data collection, we feel confident in the potential of the research approach. The DMS data provides an opportunity to address significant research gaps and build an integrative model of antecedents of IT Usage and the effect of IT usage on performance. The preliminary data analysis shows that the currently available measures present significant statistical results and may lead to a strong model. However, building a robust research model would require significant further details regarding IT Usage and performance data as well as collection of primary data regarding antecedents of IT Usage and several moderating and control variables. We are continuing to develop the measurement instruments for collecting additional data elements and expanding the DMS dataset. We anticipate to present the results of the testing of the integrated research framework using the expanded dataset in the AMCIS 2011 conference.

ACKNOWLEDGEMENTS

We thank the anonymous reviewers, mini-track chairs and track chairs of AMCIS 2011 for their valuable comments and suggestions. We also thank the anonymous company (unnamed for preserving confidentiality) for providing us the data. Any remaining errors and/or oversights are ours alone.

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