

Who kicks whom?¹ Contextual and Temporal Effects in the IT Use - Performance Relationship

Research-in-Progress

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Abstract

This research extends extant literature examining the relationship between IS use and performance. While prior theory has predominantly treated IS use as an antecedent of performance and hypothesized a positive effect of use on performance, this research provides an alternative perspective. Specifically, this paper theorizes that under certain contexts performance can be an antecedent of use and that the effect can be in the opposite direction. In contrast to non-contingent models, this paper proposes a contingent model in which the IS use-performance relationship is contingent on organizational performance and varies over time. The model proposed here is tested on longitudinal data. Distributed lag model was employed for data analysis. The results support our hypotheses that performance is an antecedent of IS use and that the effect is negative, i.e. when organizational performance declines, IS use increases but after a period of increased use, the effect declines to non-significant levels.

Keywords: IT Use, Performance, Bidirectional Causality, Attribution, Business Analytics

¹ Lanham R. A. (1979) *Revising Prose* proposed that authors think about “Who kicks whom?” in order to show who drives the action. We cite it to ask this question about what drives IS use and organizational performance.

Introduction

The use of information systems (IS) has been hypothesized in prior literature to be an important antecedent of performance. DeLone and McLean's IS Success model (1992; 2003) hypothesizes that information systems use leads to greater benefits. Similarly, Burton-Jones and Grange (2012) hypothesize a model of effective use in which use is an antecedent of performance. Extant theory predominantly hypothesizes that use is an antecedent of performance and that the effect of IS use on performance is positive (Kohli and Devaraj 2004; LeRouge et al. 2007; Pavlou and El Sawy 2006).

We contribute to the literature on the relationship between IS use and organizational performance in two ways. Drawing on attribution theory (Vaara et al. 2014), we propose a bidirectional model to extend the existing use→performance model (1992; 2003). First, we propose that extant theory may not apply across all contexts of information systems use. Specifically, we theorize that the use-performance relationship for business analytics (BA) systems will be different as compared to other types of systems. Our theory suggests that for BA systems, performance is an antecedent of use and that the relationship between performance and use is negative. Second, we propose that the within-organization use-performance relationship for BA systems is dynamic and varies over performance cycles. Specifically, we hypothesize that the relationship for BA systems is different during periods of performance decline as compared to periods of stable or increasing organizational performance.

Following a review of prior research on the relationship between IS use and performance, we draw on above cited theoretical perspectives and develop a model and corresponding hypotheses to describe how organizational performance can influence the use of BA systems over time. Next, we describe our research methodology, data sources, and the distributed lag model for analysis of longitudinal data that we employed to test our hypotheses. Our results support the hypothesis that decline in organizational performance is an antecedent of BA use. Our findings provide evidence that use can also be an outcome of organizational performance and not just an antecedent of organizational performance. We conclude with a discussion of the implications of our findings and a description of further research in this domain that we are conducting.

IS Use-Performance Relationship: Literature Review and Theory Development

Understanding the relationship between IS use and performance has been one of the core issues investigated in IS research. Research in this area has resulted in a significant body of literature encompassing a variety of areas, including the IS success models, IS for decision-making, IS acceptance models and IS implementation models. Scholars have examined the relationship at the individual-, group- as well as at the organizational-level. For instance, at the organizational level, Kohli and Devaraj (2004) tested the effects of decision support systems (DSS) use on decision making capability and organizational performance while Pavlou et al. (2006) investigated the effect of use of different information technology (IT) functionalities on new product development. At the group level, LeRouge et al. (2007) examined the effect of use of telemedicine systems on decision making while Pavlou et al. (2008) investigated the effect of use of collaborative IT tools on group performance. Similarly, a number of scholars have investigated the effect of IS use on performance at the individual level (Doll and Torkzadeh 1998; Lucas and Spittler 1999; Pentland 1989). The thesis underpinning that program of research has predominantly been that use has a positive effect on performance and that use is an antecedent of performance.

Scholars have also extended the use→performance models by proposing a number of moderating and mediating effects. For instance, Goodhue and Thompson (1995) examined over 600 individual users employing various types of IT across two different organizations, and found that IS use added value to users' performance when there was fit between the task and the technology employed. Similarly, Doll and Torkzadeh (1998) proposed that use could positively influence performance based on the extent to which the IT supports users' objectives. Easley et al. (2003) examined the relationship between use of collaborative system, team performance and teamwork quality. They hypothesized that teamwork quality will have a positive effect on technology use which in turn will have a positive effect on team performance. Their results showed that collaborative system use mediated the effect of team characteristics on team performance. Consistent with the notion of task-technology fit, they found that system use was positively

associated with team performance for tasks that were supported by IS, but found no association for tasks that were not supported by IS. Further, they also found that the actual usage was associated with team performance for creative tasks but not for decision-making tasks.

Our review of the literature also suggests that empirical support for extant theory is mixed. While a number of studies report a positive relationship between use and performance, for example, Goodhue and Thompson (1995), Doll and Torkzadeh (1998), LeRouge et al. (2007), Pavlou et al. (2008), Easley et al. (2003), Pavlou and El Sawy (2006), and Kohli and Devaraj (2004), the literature also reports a number of negative or non-significant findings. For instance, Szajna (1993) examined the effects of IS use on individual decision making performance and found a negative relationship between use and individual performance. Similarly, Pentland (1989) reported a negative relationship between IT use and efficiency and effectiveness of IT users. He found that the perceived value of IT improving performance was more symbolic than realistic. Similar negative or non-significant findings are reported by Leonard-Barton and Deschamps (1998), Yetton et al. (1999), Lucas and Spitler (1999) and Trauth and Jessup (2000).

In summary, prior research examining the use-performance relationship has predominantly argued for a unidirectional effect of use on performance. In addition, the literature also reports mixed empirical findings but offers no satisfactory explanation for the negative or non-significant findings. The cumulative empirical evidence suggests the need for further theorization and empirical research to explain the variance in findings across studies. This study offers one possible explanation for that pattern of findings by proposing that the relationship between use and performance is time and context dependent and can, in certain contexts, be bidirectional. In the following sections, we further elaborate on this aspect and theorize how the performance-use relationship for BA systems can vary across context and time.

The Effect of Context on the Use-Performance Relationship

Following Orlikowski and Iacono's (2001) call to 'theorize the IT artifact' as a precursor to theory building, we argue that theorizing of the use-performance relationship in previous research has paid little attention to the motivations of users for using the IT artifact, the capabilities of the IT artifact, the context of its use, and the effects of its use on the users' contexts (Anand et al. 2014). This limits the applicability of extant theories as they are unable to account for nuanced differences in the IS use-performance relationship across different contexts of IS use. For instance, the use of transaction processing applications deployed for automating data entry and improving productivity is likely to be motivated by and manifest in improved operational efficiencies. In contrast, the use of IT applications, such as Executive Information Systems and BA systems is likely to be motivated by and manifest in improved strategic planning and competitive actions.

Context of Business Analytics Systems Use

BA systems comprise two broad sets of capabilities, reporting and analysis (Davenport et al. 2010; Watson et al. 2002; Watson and Wixom 2007). The reporting capability is often built upon an integrated data warehouse that provides the data source for generating various pre-defined reports (Watson 2009). The analytical tools, in contrast, are employed by managers primarily for conducting *ad hoc* analysis on the data. Managers employ that functionality to discover potentially valuable insights into their customers, products, markets, processes, performance, and other aspects of their business (Anand et al. 2013; Mithas 2012; Sharma et al. 2014; Sharma et al. 2010).

Managers' use of the reporting as well as the analysis capabilities of BA systems reflects enactments of the control systems under which managers operate. Organizations employ various control systems to align the motivations of managers with the interests and goals of the organization. Output controls, e.g. management by objectives, are commonly employed by organizations to create that alignment. Output controls involve setting performance targets for managers to achieve, and offering rewards that are contingent on performance levels (Eisenhardt 1985; Flamholtz et al. 1985; Snell 1992). The effectiveness of such controls rests critically on the organization's ability to track and report performance (Snell 1992). Indeed, that is one of the key functions for which organizations employ management information systems (Pearlson and Saunders 2006). The motivational mechanism theorized to create that alignment is extrinsic motivation: since managers' rewards are tied to performance, they will be motivated to

investigate the causes of poor performance and take corrective actions to improve performance in the next period (Eisenhardt 1985; Flamholtz et al. 1985; Snell 1992).

Attribution theory suggests that managers' responses to performance variations around target performance are not likely to be symmetrical (Vaara et al. 2014). A key finding from research into attribution theory is that managers tend to attribute success to their own actions and abilities, but tend to attribute failure to external events or causes. It follows that performance below target levels is likely to motivate managers to identify external causes responsible for failure. In contrast, performance above target levels is not likely to motivate such a search since managers attribute success to their own abilities and actions.

In addition to extrinsic motivation and attributional effects, other normative forces operating in organizational contexts also suggest that managers are likely to invest effort in investigating the causes of failure, rather than the causes of success. Managers feel the need to project that they understand their business, that they are in control and that they can take corrective action to reverse performance decline (Vaara et al. 2014). One way to project that is to be able to explain cause-effect relationships behind performance decline (Snell 1992). However, the cause-effect relations articulated by managers need to be plausible and supported by argument and evidence; else they risk being considered as deceptive or untrustworthy (Vaara et al. 2014). Hence, it is likely that managers will be motivated to search for plausible explanations that they can employ to explain performance decline and on which to justify their interventions to improve performance in the next cycle.

Finally, extrinsic influences in an organizational ecosystem may also influence managerial behaviors to search for causes of performance decline. Managers' beliefs, attitudes and behaviors can be influenced by the beliefs, attitudes and behaviors of others in their social environment (Granovetter 1978; Scott 2008). Specifically, managers face institutional pressures to conform to prevailing structures and belief systems. When organizations invest in BA systems to analyze performance decline, managers feel normative pressures to use the systems accordingly (Liang et al. 2007; Schewe 1976). Managers may also face coercive pressures from their superiors to employ BA systems to analyze performance decline in order to create *post-hoc* rationalizations to justify their investments in BA systems.

Attributional effects and other complimentary influences such as output controls and normative forces combine to suggest that managers will spend time, energy and effort in investigating the causes of performance decline. However, neither the BA system nor the reports generated by it can by themselves offer any suggestions to managers regarding any specific explanations for performance decline, or any strategies for reversing the performance decline. Rather, managers need to actively search for those explanations and strategies. Bounded rationality suggest that managers typically search for explanations and solutions within the vicinity of the problem, and often limit their search for causes of performance decline to the information within the BA system (Flamholtz et al. 1985; March 1994). Indeed, the informing capability of BA systems is a distinctive capability that makes them valuable to managers for diagnosing the causes of performance decline (Burton-Jones 2014; Zuboff 1988).

Temporal Patterns in the Use-Performance Relationship for Business Analytics Systems

The above discussion on the context of use of BA systems suggests specific temporal patterns in the use-performance relationship for BA systems. Specifically, performance decline triggers a managerial response to gather and analyze available information in order to diagnose the causes of performance decline and to explain performance variances (Simons 1987; Simons 1990; Simons 2013). It is then followed by an evaluation of proposed interventions to reverse performance decline (Anthony et al. 1989; Chenhall 2003; Giglioni and Bedeian 1974; Green and Welsh 1988). Both diagnosis and evaluation are information intensive activities and require extensive use of BA systems for *ad hoc* reporting.

Drawing on the above pattern of use of BA systems, we propose that during periods of below-target performance there will be an increase in *ad hoc* reporting as managers seek to diagnose the reasons for performance decline. During periods of performance that is within the target performance range, BA systems generate only routine reports. Performance variations within this range do not trigger additional

ad hoc reports by managers. During periods of above target performance, *ad hoc* reporting is unlikely to increase because managers are satisfied with performance and are not motivated to diagnose causes (Vaara et al. 2014). Figure 1 represents the above pattern of the performance-use relationship.

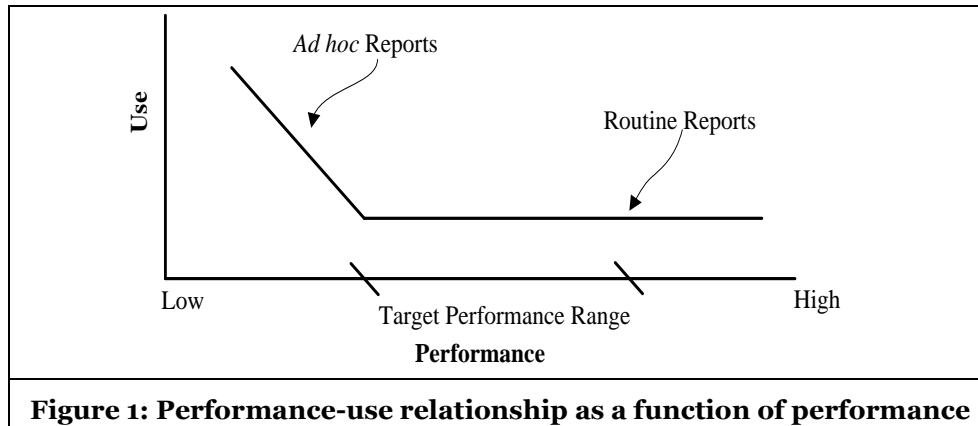
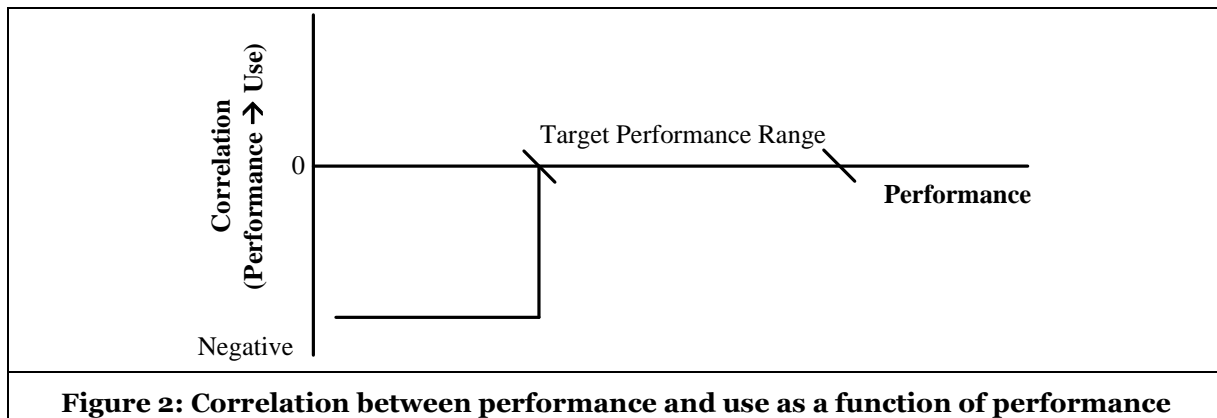


Figure 2 represents the pattern of performance-use correlation as a function of performance. Note that the graph in Figure 2 is the first-order derivative of the graph in Figure 1. As Figure 1 shows, use increases when performance falls below the target performance range: assuming a linear relationship (for arguments sake), the correlation between performance and use will be negative and constant within that range. When performance is within the target performance range or above the target performance range then performance has no effect on use, hence the correlation is zero.

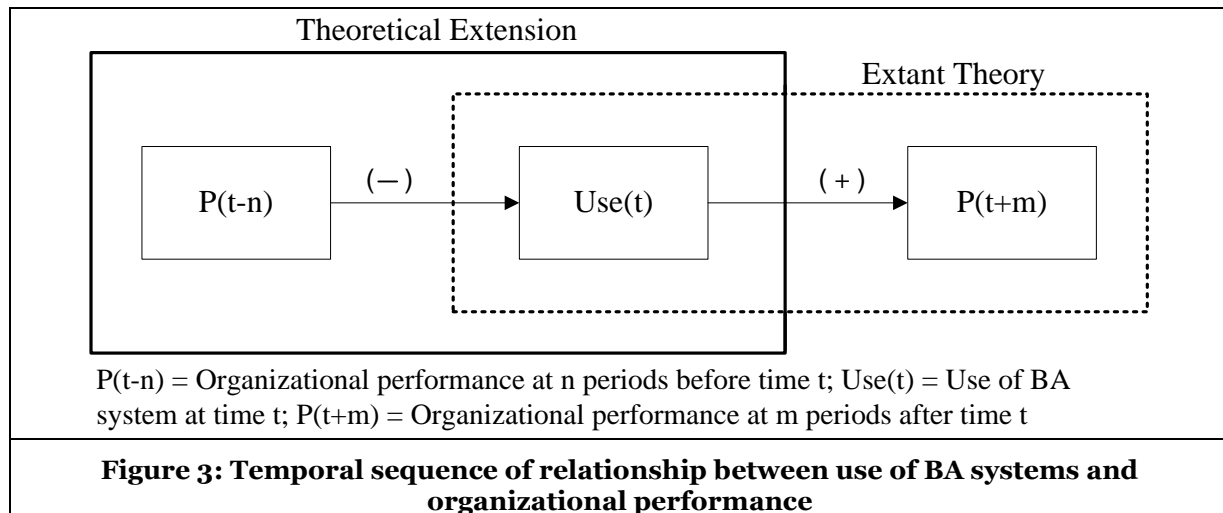
The temporal sequence of the mutual effects of performance and use over time for BA systems is represented in the model in Figure 3. A decline in performance triggers a temporally lagged increase in use of BA systems, which causes a temporally lagged improvement in performance.



While the latter part of this temporal sequence has been theorized in prior literature (see, for example, Burton-Jones and Grange 2012; DeLone and McLean 1992; DeLone and McLean 2003), we contribute to that literature by proposing the former part of the temporal sequence.

Figure 4 represents the temporal pattern of the correlation between use of BA systems and performance. Note that the correlation is not constant over time. Rather, it moves from negative to positive over time as the organization goes through the temporal sequence depicted in Figure 3. However, while the magnitude of the correlation is captured in Figure 4, what is not evident from the graph is that the period of negative correlation corresponds to the period where performance is the causal antecedent of use, while the period of positive correlation corresponds to the period where use is the causal antecedent of performance. Prior theory has generally focused on the positive-positive quadrant of the relationship. This research extends

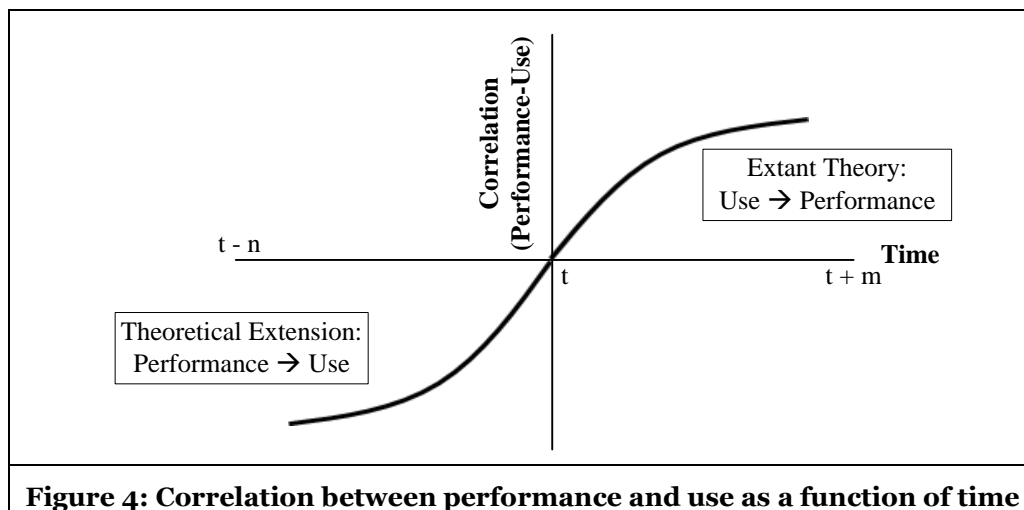
prior theory to propose that, in the context of BA systems, the relationship is as depicted in the negative-negative quadrant of Figure 4.



Based upon the above discussion, we propose that the use of BA systems increases following periods of performance decline. *Formally,*

H1: Decline in performance increases the use of Business Analytics (BA) Systems in subsequent periods.

H2: After increased use of Business Analytics (BA) Systems following performance decline, the effect of performance on use of Business Analytics Systems will plateau over subsequent periods.



Methods, Analysis and Results

This study employs longitudinal data collected over a period of 49 months to test the hypotheses. Monthly data was collected for the *ad hoc* use of a decision support system employed by a hospital to monitor financial performance. The system was designed to monitor, diagnose and report performance measures and to simulate the effect of strategies on financial performance and other performance metrics.

The measure for IS use is a composite of three items: total number of *ad hoc* reports generated by users, the CPU time and Disk Input/Output cycles consumed in generating the reports. The latter two measures capture the complexity of *ad hoc* reports requested by users. Similar measures of IS use have been employed and validated in prior research (Devaraj and Kohli 2003). Consistent with previous studies

(Devaraj and Kohli 2003; Kohli and Kettinger 2004), performance is operationalized by net patient revenue per day (NPRDAY). This is a key performance metric monitored by the top management of the hospital from where data was collected. The decision support system was designed to evaluate the effect of strategies on key financial metrics.

The nature of the data collected here is cross-sectional observations across time. Accordingly, we chose the distributed lag model (DLM) analysis to test our hypotheses (Gujarati 2012; Kmenta 1971). DLM analysis enables us to examine the lagged effects between organizational performance and IS use (Equation 1).

$$SU_t = \alpha + \beta_1 OP_{(t)} + \beta_2 OP_{(t-1)} + \beta_3 OP_{(t-2)} + \dots + \beta_n OP_{(t-n)} + u_t \quad \text{Equation 1}$$

where, SU_t is the IS use at time t , OP_t to OP_{t-n} are lagged performance over time t , u_t is the error term at time t and n represents the number of lags.

For Equation 1, H1 will be supported if $\beta < 0$ for $0 \leq t < m$ and $0 < n < m$, where m is the time period when use declines and H2 will be supported if $\beta = 0$ for $t \geq m$ and $n > m$.

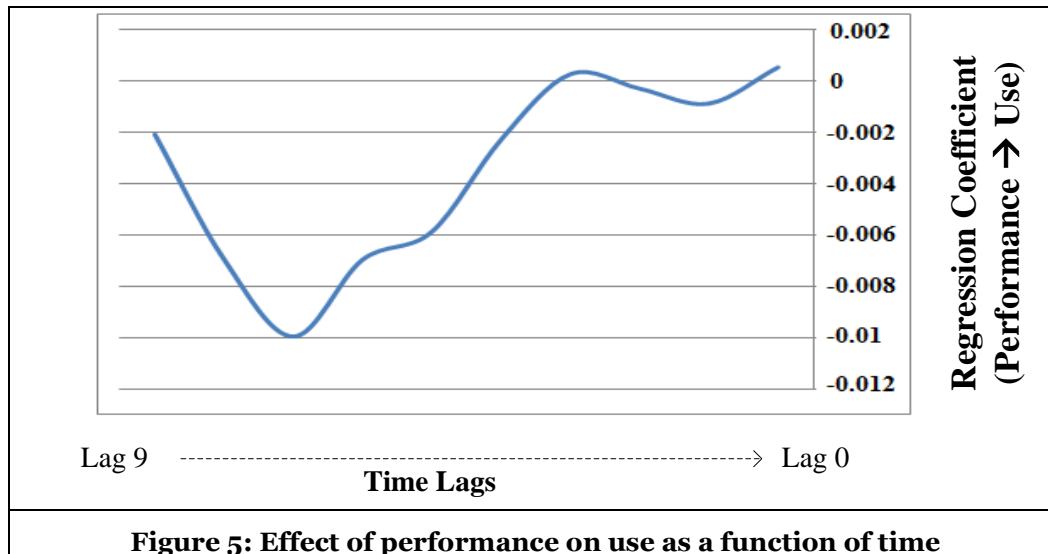
Akaike Information Criteria and Final Prediction Error were employed to predict the number of lagged terms to be selected for the causality test (Akaike 1974; Gujarati 2012; Kmenta 1971). Analyses from the Akaike Information Criteria and Final Prediction Error both estimated the lag selection order of nine.

To test the direction of causality, we conducted the Granger Causality Test (Gujarati 2012): whether IS use affects organizational performance or organizational performance affects IS use. The tests indicated a unidirectional causality: lagged organizational performance affects IS Use; however, lagged IS Use did not have a significant effect on organizational performance.

The results (Table 1) support H1 and H2. The regression coefficient for Net Patient Revenue per Day is non-significant for the lags 0 to 3 and, consistent with H1, is consistently negative after lag 4 with the coefficient for lags 5, 6, 7 and 8 being significantly negative ($p < 0.05$). Further, consistent with H2, the coefficient for lag 9 is non-significant. We tested the results for robustness against validity threats arising from multicollinearity, outliers and influential observations.

Table 1. Lagged Effects of Performance on IS Use			
	B_{NPRDAY}	p-value (two-tail)	R^2
Lag 0	.0005301	0.856	0.0007
Lag 1	-.0008822	0.767	0.0020
Lag 2	-.000301	0.921	0.0002
Lag 3	.0002603	0.934	0.0002
Lag 4	-.0022892	0.475	0.0122
Lag 5	-.0058753	0.071	0.0774
Lag 6	-.0069594	0.039	0.1021
Lag 7	-.0099496	0.004	0.1914
Lag 8	-.0069493	0.066	0.0864
Lag 9	-.002091	0.456	0.0151

In Figure 5, we plot the ten lags shown in Table 1. It shows the pattern of the effect of performance on use over time. The correspondence of the pattern in Figure 5 with that hypothesized for the lower left negative-negative quadrant in Figure 4 provides support for the theory developed here.



Discussion and Directions for Further Research

This study contributes to the extant literature on the relationship between IS use and performance and argues that the relationship is much more complex than that hypothesized in prior research. Extending prior research, which primarily hypothesizes IS use as an antecedent of performance, this study develops, tests and finds support for a model that hypothesizes performance as an antecedent of IS use in the specific context of business analytics systems. Further, while prior literature argues that the effect of IS use on performance is positive, this study extends that literature by theorizing and testing a model that finds the relationship could be negative too. This study has highlighted the need to identify contingencies that influence the IS use-performance relationship, especially in the context of volitional use technologies.

This study has significant implications for research into the IS use-performance relationship. Prior research has primarily hypothesized non-contingent models of the use-performance relationship. Further, prior research has not hypothesized temporal effects in the relationship between IS use and performance. Extending prior research, this study finds that the magnitude, sign and the direction of causality of the IS use-performance relationship are contingent on the level of performance itself and vary over time.

An important theoretical implication of the above findings is that cross-sectional studies are not likely to yield valid data for testing the use-performance relationship, at least for business analytics systems. Since the relationship is sensitive to within-organization performance cycles, only within-organization longitudinal data would yield valid tests of the relationship. Our review of the literature indicates that the relationship has primarily been examined in studies employing cross-sectional data. The findings of this study suggest that the cumulative findings of prior studies may not yield a valid test of relationship between IS use and performance.

This study makes several contributions to practice. First, by recognizing that BA use is influenced by prior organizational performance, we expect that senior managers will form realistic expectations of business value of their IT investments. Based upon the dominant paradigm of use→performance, senior managers will expect improved performance. With the benefit of understanding the performance→use link, senior managers are likely to be patient and sustain investments in BA systems. Second, with the benefit of our findings of the performance→use relationship, IT professionals can be proactive in offering training so that if or when performance declines, managers can quickly gather, analyze and model turn-around strategies to improve performance. Finally, managers who use BA systems will better understand the dynamics of the performance→use→performance relationship. Understanding that dynamic relationship will help managers devise appropriate strategies for creating value from investments in business analytics.

Our study has a number of limitations and the findings are subject to a number of validity threats. The measure of IS use employed here is not dimensionally as rich as the measure of effective use

conceptualized by Burton-Jones and Grange (2012). However, the strength of our measure of use is that it is based on archival records and is collected as a longitudinal record spanning over 4 years of system use. Another limitation of this study is the measure of performance employed to test the hypotheses. Specifically, since the system investigated focuses on managing financial performance, Net Patient Revenue per day has been employed as the measure of performance. Since one of the key objectives of decision makers using the system investigated in this research is to manage that particular metric, it is an appropriate measure of performance to be employed. However, further research should test the hypotheses employing multiple measures of performance. Finally, another limitation of this study is that the period of usage investigated shows only the negative-negative quadrant of Figure 4, and does not provide evidence of the pattern hypothesized for the positive-positive quadrant of Figure 4 (results are not reported here, but are available from authors). We speculate that this is because the data were collected during a time of financial stress and the performance gains from the use of the system may have been offset by other macro-level factors affecting the industry. Against that backdrop, the key contribution of this study is to hypothesize and test the relationship between IS use and performance in the negative-negative quadrant, which has not been discussed in prior research. In contrast, the relationship in the positive-positive quadrant has been the focus of extant theory and empirical research.

Our future research in this area will focus on testing the robustness of the theory developed here to test its generalizability. In particular, we will analyze data from six additional hospitals to seek further granularity in the bidirectional relationship between use-performance. Particularly, we will examine how direction of causality and the strength of the use-performance relationship varies across various performance levels experienced by organizations.

Conclusion

Our study extends the extant theorizations on IS use-performance. While prior research predominantly treats IS use as an antecedent of performance and hypothesizes a positive effect, we theorize that use-performance relationship is contingent on the context and varies across time. Our results show that performance can also be an antecedent of IS use and that the performance-use correlation in that context is negative.

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