Blind to Time? Temporal Trends in Effect Sizes in IS Research

Research-in-Progress Paper

David Agogo
Operations and Information Management Department, University of Massachusetts, Amherst
dagogo@som.umass.edu

Traci J. Hess
Operations and Information Management Department, University of Massachusetts, Amherst
thess@isenberg.umass.edu

Abstract

This research-in-progress paper describes cumulative meta-analysis, or meta-trend analysis, a form of meta-analysis that considers temporal trends in effect sizes. While this method is common in medical sciences, it is just starting to gain traction in behavioral research, and temporal trends have typically not been addressed in IS research. A review of 64 meta-analysis papers from 15 IS journals confirms that IS research is generally blind to time. No IS paper has employed meta-trend analysis to test for temporal trends, and less than a quarter of the papers reviewed have any treatment or mention of the possible impact of time. Support from ecological systems theory, in particular the idea of proximal processes, is used to explain why IS researchers may expect temporal trends in effect sizes. To illustrate this, meta-trend analysis is conducted on several frequently examined relationships between IS constructs. Preliminary evidence of temporal trends is observed.

Keywords: meta-analysis, cumulative meta-analysis, temporal trends, systems theory, TAM

Introduction

"Don't question me! The blind have no notion of time. The things of time are hidden from them too."

- Samuel Beckett's "Waiting for Godot"

The resilience of empirical research conclusions in the social sciences is customarily put to test using meta-analysis. Meta-analysis was "created out of the need to extract useful information from the cryptic records of inferential data analyses in the abbreviated reports of research in journals and other printed sources" (Glass 2015). This method plays a critical role in synthesizing existing research (Eden 2002) and developing theory (Schmidt 1992), and has been used widely in social science research (Chan and Arvey 2012; Gustafsson et al. 2016; Schmidt 1992), with about 10% of review papers published in IS qualifying as meta-analytic (Paré et al. 2015). Disciplines which rely on meta-analysis have made it customary practice to monitor biasing effects from unavailable unpublished research (Ferguson and Brannick 2012; Schmidt and Hunter 2014), mixing together good and poor quality studies (Hunt 1999; Rosenthal and DiMatteo 2002), and a host of other study artifacts modeled as moderator effects (Ada et al. 2012; Evermann and Tate 2014; King and He 2005). However, one infrequently evaluated source of bias is the effect of time on effect sizes (Kulinskaya and Koricheva 2010).

Temporal changes of effects have been reported in medicine (Gehr et al. 2006; Trikalinos and Ioannidis 2005), ecology and evolutionary biology (Jennions and Møller 2002; Nykänen and Koricheva 2004), epidemiology and public health (Elvik 2011; Lesko et al. 2013), and the social sciences (Grabe et al. 2008). For example, it was found that the protective effect of helmets appears to decline with time (Elvik 2011) and the strength of the relationship between exposure to media images objectifying women and individuals' internalization of such publicized ideals has increased over time (Grabe et al. 2008). Within IS however, little or no attention has been paid to examining how estimates of relationships being studied may be changing with time. Currently, no IS papers on meta-analysis (e.g., Ada et al. 2012; Evermann and Tate 2014; King and He 2005) have addressed the possibility of temporal trends in the effects studied by IS researchers. Consequently, there is a need to evaluate whether IS research is "blind to time" when it comes to cumulating evidence about empirical relationships using meta-analytic methods, and if yes, figure out what can be done to fix this. First, it is important to consider why temporal trends may exist in the first place. An ecological systems perspective makes it possible to do this.

Ecological systems theory (EST) involves the scientific study of the progressive mutual accommodation between a human being and the changing properties of the immediate settings in which they live (Bronfenbrenner 1992). This theory is widely used in developmental psychology to understand how the larger contexts in which individuals are embedded affects them throughout their life course. EST holds that human development takes place through enduring forms of interaction with the environment called *proximal processes*. Also, it holds that the form, power, content, and direction of the proximal processes affecting individuals vary as a joint function of the person, the environment, the nature of outcomes under consideration, and social continuities and changes occurring over time. In other words, these proximal processes impact the individual as well as the context they exist in. The ubiquitous nature of technology in today's society constitutes an important proximal process which is influencing individuals, organizations and society in general. This reality has important implications for IS research and for cumulating empirical knowledge in meta-analyses.

IS researchers focus on exploring various IT artifacts and the capabilities, practices, and impact associated with their usage in different contexts (Benbasat and Zmud 2003), creating and testing a range of original and adapted theory as a result (Straub 2012). These theories connect different aspects of technology to individuals, teams, organizations and even society. This reality places the IS field, not only at the center of studying a tremendous force shaping society, but also in societies being constantly shaped by the force of technology. Yet, neither technology, individuals nor societies are static. As such, while the nature and capabilities of IT artifacts evolves constantly, they change alongside the perceptions and attitudes of individuals who use these IT, and the dominant norms and practices of the organizations and societies within which these IT are put to use. The understanding that these changing layers constitute the whole is central to the ideas of 'systems thinking' (Alter 2004; Dibbern et al. 2012; Lee and Green 2015; Richter and Basten 2014; Turpin and Alexander 2014), which is a long-standing theme within IS research. As these underlying elements morph under the impact of ubiquitous technology, it is possible that changes in effect sizes calculated using meta-analysis may be observed. Fortunately, new approaches to empirically identify such changes in effect sizes over time have been developed.

In the rest of this paper, the possibility of shifts in effect sizes due to the growing ubiquity of technology is explored using theoretical support from ecological systems theory (EST). Afterwards, new approaches for detecting temporal trends in meta-analysis are discussed and then a review of meta-analysis papers published in IS journals is conducted. The aim of this review is to evaluate just how 'blind to time' IS research currently is. Following this, basic cumulative meta-analysis methods are applied to select relationships between prominent IS constructs to determine if such temporal trends can be observed in reality. In conclusion, the implications of these findings will be discussed and plans for moving this research in progress project forward are detailed.

Theoretical Development

The Power of Technology over Individuals and Society

No aspect of human life has remained immune to the transformative forces of the ongoing technology revolution. Truly, 'technology has become the leitmotif of the modern world" (Willoughby 2004, p. 12). IT is now a "fundamental element in the changed nature of work processes, in organizational restructuring and in societal transformation" (Walsham 2001, p. 4). Trends in the development, adoption and proliferation of new technologies do not suggest that the spread of IT's impact across different aspects of daily life is slowing down. It seems, for better or worse, the future of mankind will be shaped by computer systems widely adopted across the globe. This notion of transformation is at the core of the IS discipline (Lucas Jr et al. 2013), and has been a subject of interest to many influential social scientists and philosophers. For instance, Herbert Marcuse coined the term 'technological rationality' to describe how the rational decision to incorporate more technology into society, can change what is considered rational within that society as soon as that technology becomes ubiquitous (Marcuse 1941, 1964). This kind of transformation of individuals and society is very well explained by the idea of proximal processes from ecological systems theory.

The Ecological Systems Theory

A system is a 'whole' consisting of interacting and interrelated parts. The systems approach to social science research involves seeing "interrelationships rather than things, patterns of change rather than snapshots" (Senge 1990, p. 68). This acknowledges the complexity of the real world (Sterman 2000) and represents a fundamental shift in orientation to enable the systematic examination of complex and multi-layered issues (Symons and Walsham 1991). The ecological systems approach was created to provide a broader perspective on the development of individuals through time within unique environments (Bronfenbrenner 1977). The Ecological Systems Theory (EST) has four principal components, the core of which is the *proximal processes* operating over time to a *person* within the immediate and remote environmental *context* they find themselves over *time*. Proximal processes are reciprocal interactions between an individual and other persons, objects and symbols in their immediate setting (Ceci et al. 1997) capable of influencing the individual and even their context (Bronfenbrenner 1999). Proximal processes occur as individuals regularly and actively engage in activities over an extended period of time. In order to qualify as a proximal process, an interaction must be enduring and increasingly lead to more complex behavior (Bronfenbrenner 1999; Ceci et al. 1997). Further, it should invite reciprocal behavior from other agents and also invite attention, exploration, manipulation, elaboration, and imagination (Bronfenbrenner 1999; Bronfenbrenner and Evans 2000). By this definition, the regular use of various consumer technologies (e.g. mobile phones and computers) is clearly a proximal process at work on individuals situated in modern society.

If the ubiquitous presence and use of technology in modern societies constitutes a proximal process, and new norms and rules of rationality are being written as time progresses, how are empirical effects being studied by IS researchers changing with time? More broadly, is there empirical evidence to support the possibility that such a shift in society is occurring? If this is the case, there are significant practical and philosophical implications for the work of IS researchers, as well as several other domains. Fortunately, there is one methodological tradition for cumulating research knowledge that provides a means to explore this question in some detail, the meta-analysis.

Cumulative Nature of Meta-Analysis

Meta-analysis is a systematic method of analyzing results from individual studies for the purpose of integrating the findings (Glass 1976). It is useful for synthesizing the body of literature on specific empirical relationships in a rigorous and quantitative fashion (King and He 2005). A meta-analysis cumulates individual research findings and makes it possible to draw aggregate-level conclusions across multiple studies. Despite the prominence and popularity of this method in the social and behavioral sciences (Hedges and Olkin 1986), it is not without its criticisms (Glass 2015). Sampling bias (King and He 2005), publication bias (Ferguson and Brannick 2012; Schmidt and Hunter 2014), and the "garbage in and garbage out" problem (Hunt 1999; Rosenthal and DiMatteo 2002) are some major ones. King and He (2005) discuss these issues in an IS context. Commonly, diagnostic tests are run to check for these biases and study artifacts are modeled as moderator effects (Ada et al. 2012; Evermann and Tate 2014; King and He 2005). However, approaches to detecting biases in effects due to time have been late in catching on within IS.

The cumulative meta-analysis or meta-trend analysis is the oldest approach to evaluating whether a temporal bias exists. It is "not a different analytic method than a standard analysis, but simply a mechanism for displaying a series of separate analyses in one table or plot" (Borenstein et al. 2011, p. 371). The cumulative meta-analysis involves performing a meta-analysis multiple times while sequentially adding individual studies ordered by a criterion factor one at a time. The estimates of effect size (and its precision) are then plotted to illustrate pictorially how the effect changes as a function of this factor (Borenstein et al. 2011). When studies are arranged chronologically, a visual inspection of the cumulative meta-analysis plot will show the existence of a time-trend in effect size. This method, and indeed many others, of visualizing meta-analysis have been sparsely used over the last three decades despite the clear benefits they provide (Schild and Voracek 2013). Nevertheless, any such visual approach is primarily descriptive and does not provide the means to statistically test for the presence of a temporal trend. Three methods for testing this statistically have been proposed, including meta-regression, the use of quality control charts and Bayesian meta-analysis methods.

The meta-regression is conducted by testing how the effect size of individual studies varies as a function of year of publication (Borenstein et al. 2011). In the medical sciences, it is fairly common to test whether year of publication is a significant predictor of effect sizes observed (Jess et al. 2005; Papakostas and Fava 2009; Renehan et al. 2004). Since most meta-analyses tend to include meta-regressions to test the effect of moderating factors, this practice does not deviate from the regular practice of meta-analysis, yet this practice is uncommon in IS. The use of statistical quality control charts has been recommended as a tool to evaluate whether significant temporal trends exist (Kulinskaya and Koricheva 2010). The $\bar{X}$ (X-bar) chart and the CUSUM (cumulative sum) charts were developed to assess whether the variability of a production process is due to chance or due to assignable causes. These tools have been used to show the presence and absence of significant temporal trends (Kulinskaya and Koricheva 2010), however the method is only suitable for fixed-effects models (Dogo et al. 2015) and is yet to catch on in practice. Finally, Bayesian methods have been proposed to test for temporal trends in situations where a meta-regression yields insignificant results due to wild point estimates from using only a small number of studies (Baker and Jackson 2010). Such methods are considered suitable for small sample estimation, and are increasingly being applied to get cumulatively better estimates of parameters under the umbrella of Bayesian approaches to meta-analysis (Evermann and Tate 2014; Sutton and Abrams 2001; Zhang 2014).

In the rest of this paper, the extent to which these different approaches have been applied within IS research will be evaluated. Following that, the basic visual approach to cumulative meta-analysis will be applied to select examples to illustrate that temporal effects might in fact exist in IS research. The implications of these preliminary findings and future research directions are then presented.

Methods and Preliminary Results

Are IS Papers Blind to Time? Literature Search for Meta-Analysis Papers

A literature search of 15 IS journals was conducted, by searching for papers with the word meta-analysis in their title. This yielded a total of 64 meta-analysis papers published before May 2016 Of this number, 39 (61%) were quantitative meta-analysis papers which analyzed effect size parameters. In other words, cumulative meta-analysis methods could have been applied to this subset of papers. The remaining 25 papers were either literature reviews, theory and review papers, or scientometric papers. A list of the journals searched and the number of papers retrieved is shown in Table 1 below and names of papers are included in references.

Journal Name	# of Papers	# Quantitative
Information & Management	22	15
International Journal of Human-Computer Studies	8	5
Journal of Management Information Systems	6	3
MIS Quarterly	6	5
Journal of the Association for Information Systems	5	1
European journal of information systems	5	3
Journal of Information Technology	4	0
Decision Sciences	2	2
Decision Support Systems	2	2
ACM SigMIS Database	2	1
IEEE Transactions on Engineering Management	1	1
Information Systems Research	1	1
Information Systems Journal	0	0
Journal of Strategic Information Systems	0	0
Information & Organization	0	0
Grand Total	**64**	**39**

Table 1. IS Journals Consulted

Preliminary Findings

Each meta-analysis paper was read and then qualitatively coded on three characteristics, (1) the use of any cumulative meta-analysis approach (2) the use of any graphic or analysis that illustrated the effect of time, and (3) the mere mention of a possible effect of time on effect sizes in the discussion. Preliminary analysis shows that no single paper used any cumulative meta-analysis approach intended to detect the presence of temporal trends. Twelve papers (19%) provided a list or table of the number of studies reviewed for meta-analysis, by year, including one paper that reported an ANOVA checking for differences in measure reliability by year (Chau 1999). In addition to the twelve papers with tables, three other papers mention the possible effect of time in some way as part of the discussion. These preliminary results support the conclusion that IS research is generally blind to time, and a formal examination of temporal trends in IS research is needed.

Examples of Possible Temporal Trends in Effect Sizes

To investigate the possible existence of temporal trends within certain domains of IS research, several effects are tested. They include the relationship between computer anxiety and computer self-efficacy (original data collected for this paper), the relationship between system usage and satisfaction (per Bokhari 2005), and the relationships between the TAM constructs of perceived ease of use, perceived usefulness, and behavioral intention (original data collected for this paper). The existence of proximal processes in today's technological societies is offered as a likely explanation for the temporal changes observed in these effect sizes.

Computer Anxiety and Computer Self-Efficacy

The relationship between computer anxiety and computer self-efficacy (CSE) has been widely validated in IS research. Computer anxiety is defined as anxiety about the implications of using computers (Thatcher and Perrewe 2002), while CSE is referred to as an individual's judgement of their capabilities to use computers in diverse situations (Compeau and Higgins 1995; Marakas et al. 1998). The link between these two concepts finds support in Social Learning Theory (Bandura 1977, 1997), and is well established in IS research (Compeau and Higgins 1995; Marakas et al. 2007; Thatcher and Perrewe 2002; Venkatesh 2000). Individuals with higher levels of CSE tend to have lower levels of computer anxiety, results that have been confirmed using meta-analysis (Karsten et al. 2012). However, given the ubiquity of technology in modern society, average levels of both computer anxiety and CSE can reasonably be expected to have changed. While a detailed discussion of the possible nature and direction of these changes is beyond the scope of this research-in-progress paper, prevailing research has proposed both an increase (Korukonda 2007; Rosen and Weil 1997) and a reduction (Gorhan et al. 2014; Howard 1986; Howard and Smith 1986) in general levels of computer anxiety. Similarly, the pervasiveness of various forms of technology in society and the rapid introduction of new technology is believed to be influencing computer self-efficacy (Marakas et al. 2007). The prevalence of technology may mean people now feel higher levels of CSE, while on the other hand, rapid advances may be leading people to feel less capable where technology is concerned. Thus, one might expect the effect sizes for the relationship between these two constructs to diminish over time. The exact direction notwithstanding, it is important to explore whether shifts in the effect size between these two concepts has occurred with time.

Using data collected for this paper, forty-five bivariate correlation estimates from thirty-eight empirical studies published in major IS journals, a cumulative meta-analysis indicates that the effects sizes for CSE and computer anxiety may have changed. Due to space limitations, a separate listing of these studies is not provided, but studies are included in the references. A visual representation of how the effect size of this relationship has changed over two decades is shown in Figure 1.

Computer Usage and User Satisfaction

The second example, from the IS success research stream, uses estimates from a meta-analysis of the relationship between system usage and user satisfaction (Bokhari 2005). This meta-analysis study provides a table of 58 effect sizes, sample size and study year (from 55 studies) and therefore lends itself to easy application for the purpose of checking for temporal trends. System usage is defined as the amount of effort expended in interacting with an information system, while user satisfaction is the extent to which users believe the information system available to them meets their information requirements. Both these concepts are commonly used as surrogate measures of IS Success (DeLone and McLean 1992; Delone and McLean 2003). Over time, one could expect that as users increased their usage of a system, gaining greater exposure to all system features, the correlation between usage and satisfaction with that system may increase. However, at some point, exposure to additional system features may not have a greater effect on system satisfaction. Re-analyzing the data from this original study as a cumulative meta-analysis, and visually inspecting a scatterplot of effect sizes against year of publication, there also appears to be a temporal-based variation as shown in Figure 2. The relationship seems to suggest that the effect size between usage and satisfaction hit a high point in the late 1980's and has declined somewhat since that time. One can see how this u-shaped trend may reflect a stronger effect size as users are provided with greater access to new systems, and a weaker effect size as the additional usage time had less impact than it did when these systems were first implemented.

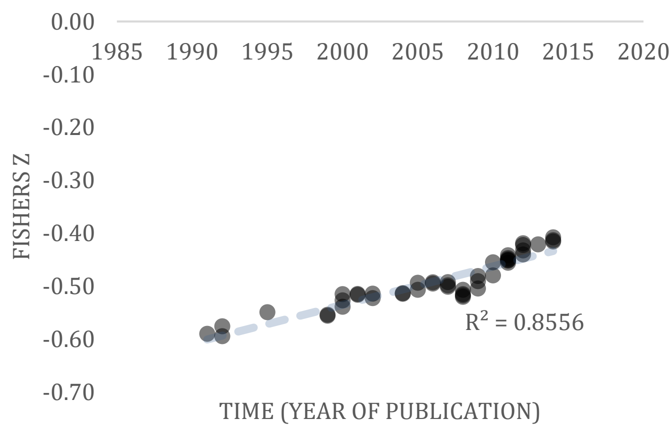

Figure 1. Plot of Fishers Z against Time, CA ←→ CSE Correlation

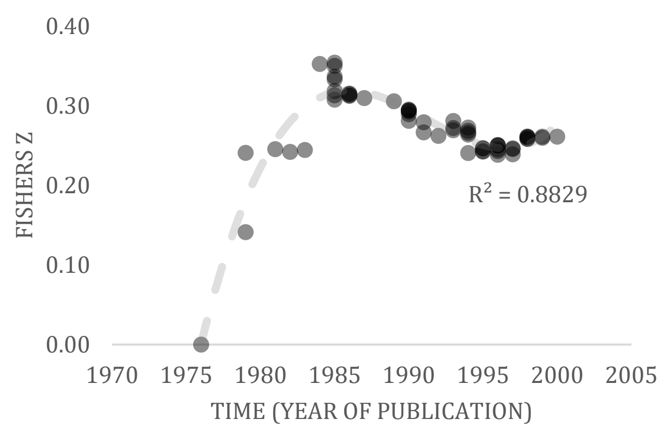

Figure 2. Plot of Fishers Z against Time, System Usage ←→ User Satisfaction Correlation from Bokhari (2005)

Relationships Among Technology Acceptance Model Constructs

Effect sizes for the relationships among the technology acceptance model (TAM) constructs (i.e., perceived usefulness (PU)→behavioral intention (BI) (152 correlations) and perceived ease of user (PEOU)→BI (139 correlations)) were also examined for temporal trends. We did not expect to see temporal trends, as PU and PEOU are still expected by users and are still determinants of BI. While software has advanced, and users have become more tech savvy, users' expectations have also increased. Users continue to have needs and expectations for their systems in terms of PEOU and PU, and their future/continuance behavior depends on the level of PU and PEOU. These constructs are unlike CSE and

CA, where users CSE and CA have increased over time. Our initial examination, however, suggests a temporal trend for PEOU→BI (pictured in Figure 3), and no temporal trend for PU→BI (not pictured).

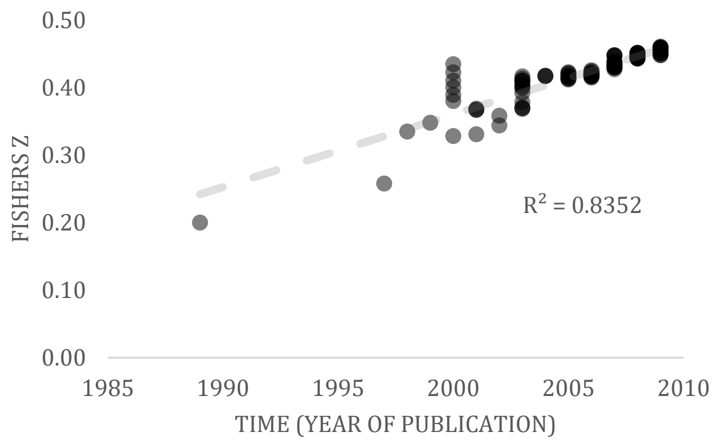

Figure 3. Plot of Fishers Z against Time, Perceived Ease of Use ←→ Behavior Intention Correlation from Hess et al (2013)

Discussion & Future Research

There are clearly a growing number of meta-analysis studies being published in IS research today. A large proportion of these studies tend to deal with multiple relationships and consider a wide range of moderator variables. However, meta-analysis research in IS is 'blind to time' with only 19% (12 papers) of the meta-analysis papers in top IS journals even discussing temporal aspects of the effects being evaluated. And, those studies simply listed papers published by year, else they were scientometric publications reviewing the state of the IS field or specific research streams (e.g., Arnott and Pervan 2005; Claver et al. 2000; Gallivan and Benbunan-Fich 2007; Grover et al. 2006). Following this, an analysis of multiple different effect sizes shows visual evidence of temporal trends - a steady linear shift in the computer anxiety to CSE and the perceived ease of use to behavior intention relationships and a parabolic change in the correlation between system usage and user satisfaction. These preliminary findings call into focus the need for IS research to adopt approaches to identifying temporal trends when conducting meta-analyses.

Preliminary meta-regressions with time as a predictor of the changes in these effect sizes shows significant effects (shown in Table 2 below). This work will be concluded by applying both meta-regression and Bayesian meta-analysis methods to evaluate the statistical significance of temporal trends in the examples above and discussing both the approaches and findings in more detail. Further, guidelines on how to use these meta-trend methods in IS research will be offered. Finally, a discussion of the role of proximal processes in shaping effect sizes will be included for each of the examples evaluated in this paper.

Research Implications

There are several theoretical and practical implications of this research-in-progress paper. There are three major theoretical implications we identify. First, given that researchers inevitably spend most of their time engaged in incremental cumulative research (Kuhn 1975), the possibility that temporal trends may exist and remain undetected calls into question the accuracy of much of our research. Major IS theories may have to be reexamined with a view to how they have been and are being impacted by proximal processes at work in today's society. Secondly, if temporal shifts are prevalent in the relationships being studied, then more must be done to advance and test process theories and other systems-driven approaches that can account for any dynamics due to time. Third, the question of whether theories being proposed in IS may be time-dependent needs to be addressed as part of the process of theorizing. There have been active calls for researchers to discuss possible boundary conditions when proposing new theory

(Grover et al. 2008; Grover and Lyytinen 2015) and the likelihood that empirical effect sizes may have shelf-lives makes such calls all the more important.

There are also some practical implications for conducting research in IS. First, if effect size estimates are changing with time, IS researchers should advance and adopt analytical methods to identify, track and suitably anticipate such shifts over time. Also, established methods such as longitudinal research should be encouraged and supported within our discipline's top journals. A second practical implication is that researchers must become more sensitive to the existence of temporal trends in various types of publications. Research articles should provide means of item measures, treat values from earlier research as baseline numbers and comment on any changes observed with time. Meta-analysis papers should also explicitly address temporal trends in addition to discussion of other forms of bias typically included. Rather than being a chore, such practical approaches may in fact enrich research projects and provide authors with interesting new directions for follow up studies within their research streams.

It is our hope that this research-in-progress sparks a conversation that can improve the practice of research in our discipline in this particular regard. Otherwise, if left unaddressed and unattended, findings such as these threaten the reputational capital for high quality research that our field has built and calls the practicality, robustness and generalizability of IS research into question.

	CSE <--> CA (k = 45)			
	Fixed Effects		**Random Effects**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Intercept	**-0.6631 (0.000)**	**-0.6261 (0.000)**	**-0.6128 (0.000)**	**-0.4816 (0.001)**
Time	**0.0165 (0.000)**	0.0040 (0.407)	**0.0126 (0.033)**	-0.0169 (0.465)
Time Squared		**0.0006 (0.008)**		0.0012 (0.186)

	Usage <--> Satisfaction (k = 58)			
	Fixed Effects		**Random Effects**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Intercept	**0.2840 (0.000)**	**0.4664 (0.000)**	**0.2433 (0.001)**	**0.2887 (0.024)**
Time	-0.0010 (0.589)	**-0.0312 (0.002)**	0.0013 (0.7544)	-0.0069 (0.727)
Time Squared		**0.0011 (0.003)**		0.0003 (0.670)

	PEOU <--> BI (k = 139)			
	Fixed Effects		**Random Effects**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Intercept	**0.3370 (0.000)**	0.0618 (0.465)	**0.3545 (0.000)**	0.1314 (0.505)
Time	**0.0082 (0.000)**	**0.0466 (0.000)**	0.0076 (0.165)	0.0416 (0.121)
Time Squared		**-0.0013 (0.000)**		-0.0012 (0.196)

Table 2. Preliminary Results of Meta-Regression with Time & Time^2 as Predictors

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