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Statistical Analysis Methods Used in Information Systems Journals

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1. Abstract

This paper seeks to identify common themes in statistical methods for IS research. The 80 peer-reviewed papers published in 2010 by MIS Quarterly and the European Journal of IS were reviewed to identify which papers used statistical methods. Of those reviewed 60 included empirical studies employing statistical methods and these were examined in detail. From this analysis I conclude the IS discipline is dominated by a positivist epistemology based on the frequent use of models and hypotheses to explain the forces under investigation.

While the focus of IS research advocated by many influential authors is confined to IS-centric themes, others in the field debate the benefit of expanding the research scope to better understand human relationships with IS. Consequently, many empirical studies reviewed here collect and analyze data to measure variance in classic IS dependent variables such as organizational success while others borrow from psychology, sociology and medicine to measure variables such as fear, trust and brain activity.

Although EJIS had more qualitative, inductive and theoretical papers than MISQ, both relied heavily on the use of surveys to collect data (42% of studies[1]). Therefore, common method bias was one of the most often cited threats to statistical validity and covariance tests were frequently included in the analysis. Traditional methods such as ANOVA, regression and component analysis were effectively used to statistically analyze results. However, a significant development is the frequency of SEM (34%) analysis, although its use was rarely justified and the reporting of results was inconsistent.

2. Introduction

The field of information systems (IS) research relies heavily on statistical analysis of data and this paper examines how statistics are used in IS literature. This analysis is based on reviews of two of the top academic research journals, MIS Quarterly (MISQ) and the European Journal of IS (EJIS). I reviewed in detail each of the 38 articles from MISQ and 42 from EISJ published in the year 2010 (see Appendix A Detail of Statistical Methods Used in IS Articles). Out of the 80 journal articles, 60 analyzed empirical data (MISQ: 35, EISJ: 25) and this paper will characterize these studies use of statistics.

Based on the papers reviewed, one may surmise the goal of IS research is to develop explanatory models of the underlying forces in information system phenomenon. These models are theoretically derived and frequently supported by empirical evidence which is statistically analyzed to validate the hypotheses. Theoretical papers are also common which often formulate explanatory models grounded in so called *qualitative methods* (Easterby-Smith et al., 2009) such as a literature review, case study or interviews. Some papers may combine both approaches, using theoretical methods to establish a model which is later supported by collecting data. Mixed-method studies were more common in MISQ than EISJ.

[1] Unless otherwise noted, percentages cited in this paper refer to the 60 papers which employed statistical methods. Thus when reporting that 42% used surveys, this corresponds to 26 papers (MISQ:14, EISJ: 12).

The IS discipline's approach to research reflects a positivist epistemology (Easterby-Smith et al., 2009) common in the sciences (de Regt, 2006, Van Fraassen, 1980, Popper, 2002) which assumes IS is a well-ordered phenomena and can be accurately described. While not all researchers agree with this approach (Floridi, 2004, Travis, 2004) over 90% of articles in prominent IS journals display a positivist bias (Reid et al., 2010).

A typical approach to empirical IS studies in MISQ and EJIS follows the pattern depicted in Table 1 and consequently this paper is roughly organized to discuss the use of statistical methods found in each section.

Structure	Typical Section Headings
1. Identify an IS phenomenon and describe its significance	Abstract Introduction
2. Review related work to show how this phenomenon relates to other efforts in the field	Background Literature review
3. Present a research model to explain the underlying forces	Framework Model/Hypothesis
4. Analyze evidence collected to measure those forces and justify the model's validity	Methodology Analysis Results
5. Discuss significance of the preceding steps	Discussion Conclusions and limitations Future work

Table 1. Common structure of IS papers

3. Research Topic

The field of IS has been a distinct area of research for nearly 50 years, and many of today's research topics reflect the perspective of early contributing disciplines such as computer science, management, organization science, accounting, economics, and psychology among others (Taylor et al., 2010). The rapid pace of technical change in IS means the emphasis of research topics change frequently over time. As a consequence, there are ongoing debates –cynically referred to as an "identity crisis" by some (Somers, 2010), regarding the core thematic areas of IS research.

Many of the most influential authors in the field fall into the *technology artifact* camp who argue that IS research should primarily focus on the interaction between people, processes, data and technology which is how IS has been traditionally defined (Taylor et al., 2010, Beynon-Davies, 2010). This group contends that including other disciplines such as psychology, social science and medicine may fragment the discipline and eventually make IS irrelevant (Taylor et al., 2010). These authors prefer to use empirical research typically measuring classic dependent variables such as IT success (DeLone and McLean, 1992, Delone and McLean, 2003). For example, the *Empirical Analysis of Information Capabilities on Outsourcing* is one study that used statistical analysis to identify a link between IT capability and perceived benefits of an outsourcing relationship (Mani et al., 2010).

However, there is increasing acknowledgement that technology has become heavily entangled in the social fabric of our lives (Orlikowski and Scott, 2008) and many authors favor more multi-disciplinary studies to examine the relationship between humans and IS. This group of *entangled* proponents

argues that the current definition of IS does not adequately explain the "digitally mediated" effect of technology on human experience which IS has a responsibility to investigate further (Yoo, 2010, Somers, 2010).

The multi-disciplinary approach of entangled research is reflected in a wide diversity of IS topics published by both journals. The empirical studies include statistical analyses of how IS forces impact a broad range of variables drawn from many disciplines. Throughout this paper examples of different research will be used to illustrate the range of IS topics.

4. Literature Review

Most IS papers include a literature review to help frame the current research effort. The EJIS papers tend to include citations from sources outside of IS research, for example the study *E-business in Latin America and Sub Saharan Africa* (Okoli et al., 2010) included a citation from Wikipedia which would be very unusual in MISQ. Figure 1 shows a map of the most widely cited authors in the field grouped by thematic subject from 2001-2005 (Taylor et al., 2010), and papers in MISQ cited these authors approximately 60%[2] more frequently than those in EJIS.

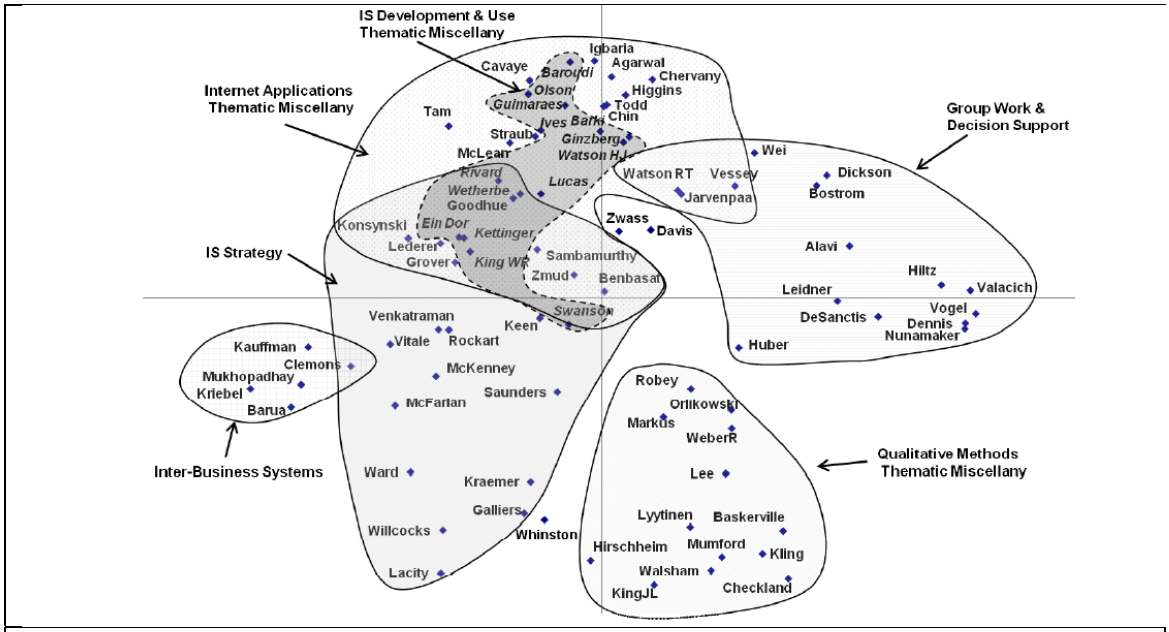

Figure 1. Map of distances between foundational IS authors and thematic subjects (Taylor et al., 2010)

In many cases, the literature review does not heavily impact the use of statistics in the IS paper, unless the focus of the paper is on statistical methods. For example, in *Formative Measurement in IS Research* the authors analyze how the use of structured equation modeling has become widely used in IS research (Kim et al., 2010). The literature review of this paper provides a survey of SEM use and

[2] To count the number of references, the authors' last names were taken from the longitudinal literature review spanning 2001-2005 by Taylor et. al (2010). Common names and words such as Davis, Lee, Weber, King and Watson were removed from this list leaving a total of 55 unique last names remaining. The PDF files of each paper were searched against this list using Adobe Acrobat Professional. The search results were then scanned to ensure citations were listed versus phrases in a document. One limitation of this approach was the double counting of a primary author's inline citation and the bibliographic reference. However, since both journals use similar inline citation formats, the results should be consistent across both journals. A second limitation is the possibility that despite the use of unique names, a citation may have been from another author rather than one of the influential authors cited in the study. Despite these weaknesses in the counting method, there were 1488 results found in the 38 MISQ papers and 917 in the 42 EJIS papers, a large enough difference that, while approximate, provides an interesting insight into the differences between the two journals.

also gives careful attention to both the strengths and weaknesses cited in the literature of this approach. The authors use this review to shape a debate on the use of SEM, and then go on to provide evidence of common missteps and recommendations for how IS research should employ SEM.

5. Research Models and Hypothesis Development

As noted above, IS papers frequently employ a research model. This is important to the discussion of statistics since models indicate constructs, interaction and often the research hypotheses which the statistical results should support. For example, Figure 2 shows a research model for *How Fear Affects Compliance with Computer Security* (left) and a nearly identical structural equation modeling analysis (right) of survey data collected in support of this study (Johnston and Warkentin, 2010).

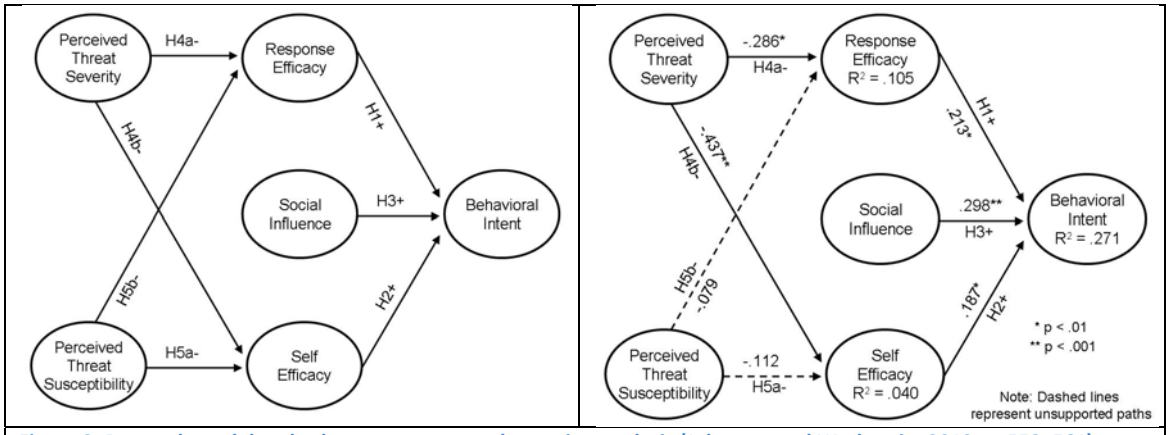

Figure 2. Research model and subsequent structural equation analysis (Johnston and Warkentin, 2010, p. 553, 561)

One important role for research models is to graphically represent the hypotheses. Two to six hypotheses are typical in IS research although one MISQ paper on T*echnology Adoption* developed 11 (Sarker and Valacich, 2010), and one in the EJIS had 15 (Recker, 2010). These hypotheses are then operationalized into a method for collecting data which is statistically analyzed. For example in the study of *How Fear Affects Computer Security* (Figure 2), the authors developed six constructs for their five hypotheses and operationalized them into 24 survey questions.

For papers published in MISQ inclusion of a model is nearly universal, which may reflect this journals perspective (or its reader's penchant) for research which can be conveyed graphically. It is somewhat surprising however, to see models even in papers which do not collect data or present any empirical support.

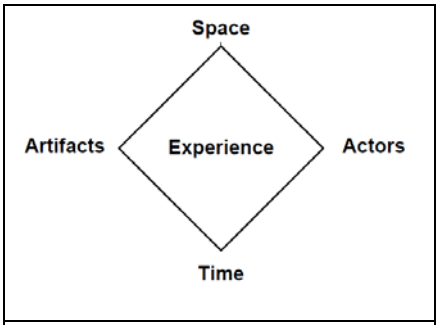

Figure 3. A model for experiential computing (Yoo, 2010, p. 219)

For example Figure 3 is a model from *Experiential Value of IS* (Yoo, 2010). This paper is a review of current IS research which encourages more focus on entangled experiential themes. The model depicts the authors suggested approach to accomplishing this research focus.

6. Data Collection

Surveys are heavily used in IS research as Figure 4 indicates, although many studies employ multiple techniques for data collection –often surveys combined with another method. For example, in the *How Fear Affects Computer Security* study 311 subjects were divided into three different groups each receiving different experimental treatments. Afterwards the subjects completed a survey to assess their attitude towards security compliance (Johnston and Warkentin, 2010). While this study used a 5 point Likert scale on the survey instrument, a 7 point scale is also common and a 3 point scale was used in the *Process Modeling Grammars* survey (Recker, 2010).

Qualitative studies are more common in EJIS than MISQ as Figure 4 indicates. According to the EJIS editorial statement the journal is focused on "theory and practice of IS (de Vaujany et al., 2011)." Consequently, theory and inductive papers are more prevalent in EJIS with 31% using little or no statistics, instead grounding theory in other methods such as a literature review, case study, interviews, or document analysis. MISQ's stated focus is "communication of knowledge" concerning IT (de Vaujany et al., 2011). When qualitative methods were used in MISQ, these often included some statistical analysis of data as only 15% of MISQ papers had no use statistics at all.

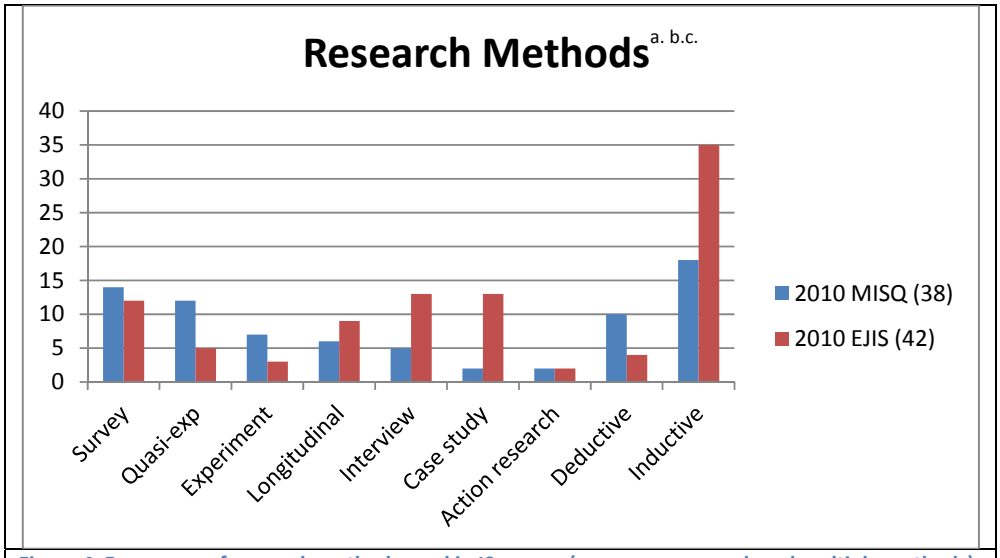

Figure 4. Frequency of research methods used in IS papers (many papers employed multiple methods)

a. When surveys were the primary measure of independent and dependent variables they were classified as quasi-experiments unless they were explicitly described as experiments.
b. Theoretical papers grounded in literature or document coding were classified as case studies if they primarily focused on a small population and/or longitudinal if they covered multiple years.
c. Papers which employed SEM to validate a theoretical model were classified as deductive.

A graphically compelling and innovative example of combining a survey with a secondary method of collect data is the use of MRIs to measure brain activity shown in Figure 5. During an experimental setting participants were asked to rate their perceived *Trustworthiness of EBay Auction Pages* and the region of activity appearing on the MRI was correlated to the degree of trust each subject reported (Riedl et al., 2010). This study is an example of the expanding role of IS research to include other domains which can help increase the understanding of human behavior and IS.

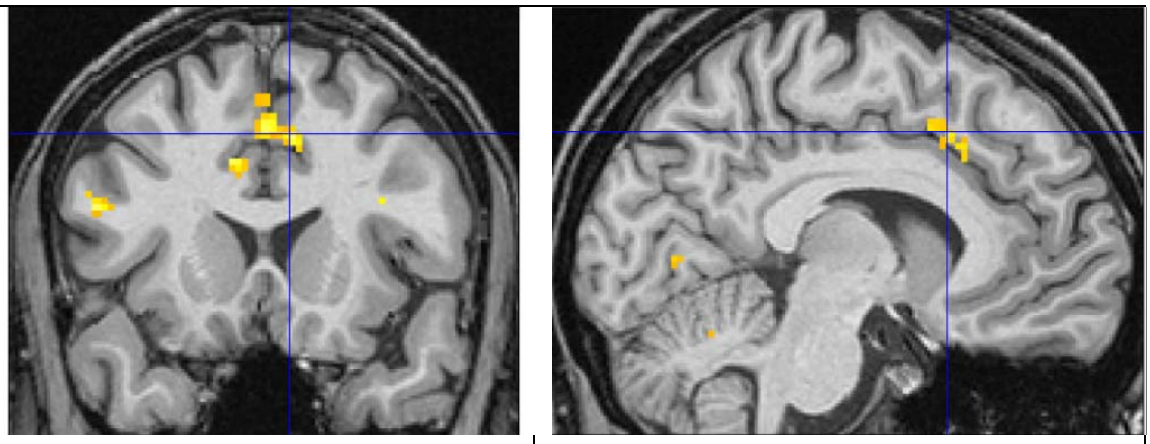

Figure 5. Brain scans with active regions (colored) during trust-related activities (Riedl et al., 2010, p. 413)

Coding is another common method of collecting data. For example in examining the *Key Factors Affecting ERP Benefits*, researchers coded 126 power point slides and transcripts of presentations made by company executives describing their ERP experience at two conferences (Seddon et al., 2010) and then correlated the results to identify key factors. A second example of coding is the effort to measure how organizations were influenced by the *Hottest IT Trends*. In this longitudinal study, researchers' coded articles from 31 years of periodicals to identify the most frequently mentioned IT trends and then coded public information from 108 companies to examine how these trends impacted their performance using a regression model (Wang, 2010).

A data collection method uniquely suitable for IS comes from information systems developed to study research problems. For example in the study *Detecting Fake Websites* the authors developed a software program that used a *statistical learning algorithm* to identify patterns employed in fallacious websites. This program was tested against 900 websites to show it identified a higher percentage of fake websites then other methods (Abbasi et al., 2010).

The use of IS systems to collect data can generate very large sample sizes compared to traditional methods of data collection. For example, in a study of online *Shopbot Vendor Coverage*, over 2 million computer generated data points were collected (Allen and Wu, 2010), and in an analysis of online shopping, the study *Online Store Visit Strategies* had access to data from over 3.5 million visitors per month generating over 60 million page views (Phang et al., 2010). These extremely large data sets give researchers the opportunity to study samples that would be expensive and time consuming to collect manually.

Data Validity

There are many threats to data validity that can cause researchers to reach a false positive (type I error) or false negative (type II error) conclusion (Cook and Campbell, 1979, p. 37-91). Many studies address data validity, for example, by using descriptive statistics to demonstrate the sample represents the population or that no bias existed in different experimental groups. However the one source of error which was most frequently discussed and treated was common method bias which appeared in 28% of the studies (MISQ:10, EISJ:5).

Surveys are prone to common method bias because they ask the same observer (the survey taker) to assess both the dependent and independent variables. This can cause artificial covariance to be

measured which is, in fact, caused by the survey rather than any theoretical constructs the questions attempt to measure (Podsakoff et al., 2003). Because surveys are common in IS research, authors routinely perform validity checks for common method bias.

One method for identifying common method bias used by the study *Software Development Agility* is testing consistency of the survey instrument between objective and perception-based constructs (Lee and Xia, 2010). If there is a poor correlation between the two, this would indicate that the survey suffers from common method bias, although the opposite result does not necessarily indicate absence of bias.

More thorough approaches to common method bias analysis are described by Podsakoff, et al. (2003) and often cited by authors who to perform bias checks. For example, in *Technology Adoption Modeling and Analysis*, the following steps were taken:

1. One-factor test and partial correlation procedure: "All the variables of interest were entered into a factor analysis to check if a single factor emerges from the factor analysis and if one single factor accounts for a majority of the covariance in interdependent and criterion variables. Neither of the two conditions was true (Venkatesh and Goyal, 2010). "

2. Check for meaningful relationship: "The first factor from the unrotated factor matrix was entered into a linear regression model as a control variable to check if a meaningful relationship among the variables of interest exists. We found that this condition was indeed satisfied (Venkatesh and Goyal, 2010)."

The first test seeks to determine if one common factor accounts for the majority of the variance, while the second is a partial correlation procedure to identify whether the variance in the statistical analysis comes from different measureable sources, and can usually be compared in a theoretically supportable ratio of covariance between factors (Podsakoff et al., 2003).

An alternative approach is partial least squares regression (PLS), which is a form of structured equation modeling that combines features from principal component analysis and multiple regression to measure covariance (Hervé, 2007). For example, in *Transactive Memory Systems*, the authors:

> "[R]an a PLS model with a common method factor and calculated each indicator's variances as explained by the principal construct and by the method. Our results show that the average variance of indicators explained by the construct is .799, while the average variance explained by the method is .006. Furthermore, all of the method factor loadings are not significant. Therefore, we conclude common-method bias is not a threat to the validity of our study (Sue Young et al., 2010)."

The single PLS test verified no single factor accounted for the majority of variance and different ratios of variance were present in the model, from which the authors' concluded, there was no threat of common method bias.

7. Statistical Analysis Methods

In this section I review the data analysis methods commonly used in IS research, primarily emphasizing methods unique or different to other disciplines outside IS, especially the growing use of SEM. As Figure 6 indicates, a wide range of methods are used to analyze data such as correlation, t-tests, analysis of variance (ANOVA), regression, factor analysis and complex multivariate methods (ANCOVA, MANOVA, MANCOVA).

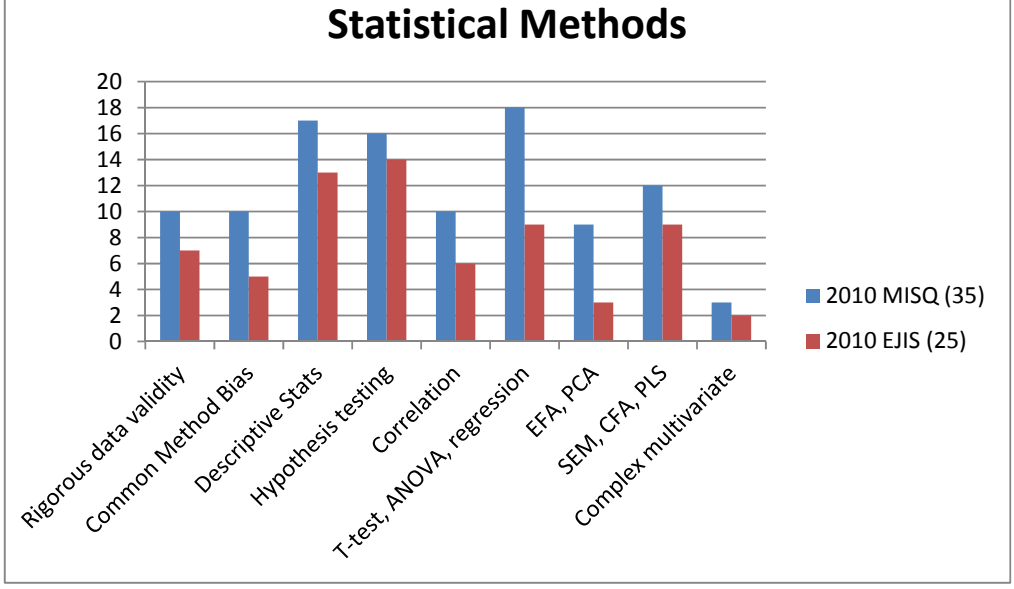

Figure 6. frequency of statistical methods used in IS papers reviewed

Most of the papers were inductive research, presenting some new model, although approximately 30% were deductive and included more in depth analysis of the hypotheses. The high number of inductive papers is likely a reflection of the fast pace of change in the IS field and also the expanding range of topics being investigated.

	Avg Study Size	# SEM only [a]	% used SEM	% Theoretical [b]	% Surveys
MISQ	404	3	32%	16%	37%
EJIS	383[c]	5	24%	36%	29%

Table 2. Summary of study size used in IS papers reviewed

a. Studies did not use any other statistical method except SEM
b. Theoretical papers were those with no use of statistics, percentages are from total papers published for the year
c. Average does not include one study with over 2 million computer generated data points.

As previously noted, surveys are common in IS research, and the average number of respondents for surveys in MISQ was 327, and 246 for EJIS. For all methods, the average sample population was 400 although this number is largely meaningless since the standard deviation was twice as large. Smaller sample populations ranging between 50 and 200 were common for interviews or case studies.

A widely used approach for statistical analysis is a factor analysis or component reduction to synthetically combine values from questions used to measure different variables. For example, the study *Relationships in Outsourcing* was an exploratory study into how relationships affect business outsourcing. The results in Table 3 report the principal component analysis values (Bharadwaj et al., 2010).

Variable item	*Reliability (Cronbach's alpha)*	*Convergent validity (correlation of item with total score item)*	*Discriminate validity (Factor loading)*
Successful relationship	0.645		
1		0.477	0.859
2		0.477	0.859
BPO outcome	0.789		
1		0.378	0.442
2		0.300	0.356
3		0.644	0.768
4		0.572	0.684

Table 3 Reliability, validity and factor scores for variables reported. Circled values fall below normally accepted thresholds but were kept in this study because of its exploratory nature (Bharadwaj et al., 2010).

The three values circled fall below desired values for statistical reliability. For example, Cronbach's α is a measure of scale reliability and should be greater than or equal to .7 (Field, 2009, p. 674-685), convergent validity a common method bias correlation should be greater than or equal to .333 and factor loading scores should be greater than or equal to .5 (Bharadwaj et al., 2010). The authors acknowledge these measures fell below the desired thresholds, but because their study was an exploratory one, keep them for their analysis.

Once a set of synthetic variables have been formulated and shown to be reliable and valid, they are often entered into a regression. The regression model uses the coefficients of each predictor variable to measure the effect on the dependent variable and report the contribution of each variable and the explained variance resulting from the model (Field, 2009, p. 209-261).

For example, in *Market Value of Voluntary Disclosures*, the authors developed Equation 1, a complex regression model of variables from different sources to measure market value changes between different firms to analyze the overall explained variance (Gordon et al., 2010).

$$\text{PRC-3M}_{it} = \beta_0 \times \text{Intercept} + \beta_1 \times \text{Dis}_{it} + \beta_2 \times \text{BVPS}_{it} + \beta_3 \times \text{EPS}_{it} + \beta_4 \times \text{LnAst}_{it} + \beta_5 \times \text{Neg}_{it} + \Sigma\beta_k \times \text{Year}_{it} + \Sigma\beta_j \times \text{Indus}_{it} + \varepsilon_{it}$$

PRC-3M_{it} = stock price of firm *i* for year *t*, 90 days after fiscal year close
Dis_{it} = 1 for a generic disclosure of information security, 0 otherwise
BVPS_{it} = book value of equity divided by No. of shares outstanding for firm *i* for year *t*, year-end
EPS_{it} = earnings per share (basic excluding special items) for firm *i* for year *t*, year-end
LnAst_{it} = log of assets for firm *i* for year *t*
NEG_{it} = 1 if EPS is negative for firm *i* for year *t*, 0 otherwise
Year_{it} = 1 if current year, 0 otherwise

Equation 1. Pooled cross sectional regression equation to compute market value (Gordon et al., 2010)

While regression analysis is very common, many studies are beginning to perform structured equation modeling in addition to or instead of regression. Structured equation modeling is a wide range of methods which includes PLS, confirmatory factor analysis, path analysis, covariance and correlation matrixes among others (StatSoft, 2010). Although a relatively new approach to statistical analysis, SEM "has become the preferred data analysis tool for empirical research in IS" (Kim et al., 2010) and 35% of papers used some form of SEM (MISQ:12, EJIS:9).

An example which illustrates the elegance of SEM is the *Software Development Agility* study (Lee and Xia, 2010) where a PLS model was used to analyze the data. As previously stated, PLS combines both factor analysis and regressions across multiple constructs. There is an undeniable appeal to the concise simplicity of Figure 7 which depicts the regression coefficients and factor analysis results directly onto the research model.

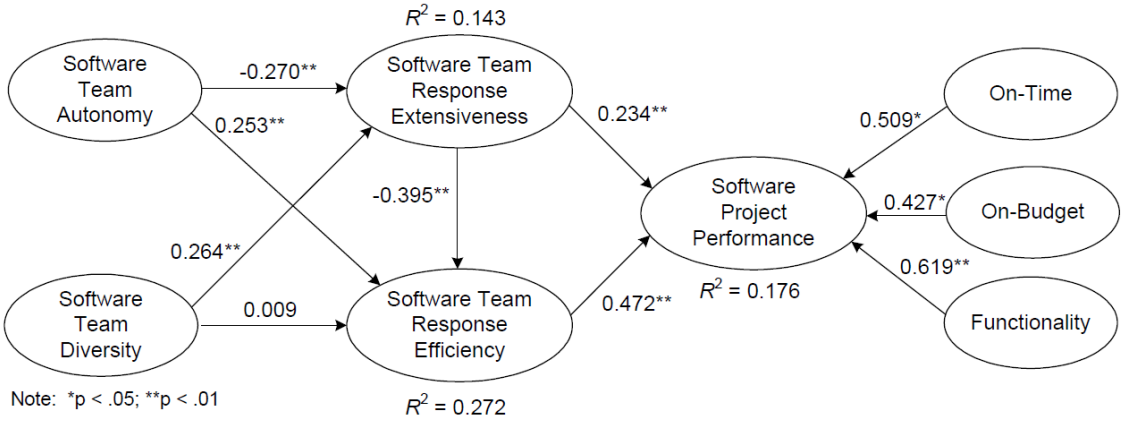

Figure 7. PLS model used in *Software Development Agility* (Lee and Xia, 2010)

Another example which illustrates the benefit of SEM is the *Effects of Emotions on IT* study, which used two identical SEM models each with different independent variables to measure their effect on IT usage. The authors' hypothesis was respondents in a positive mood would be motivated by different emotions than those in a negative mood. By using the same model and changing one variable they were able to visually and statistically demonstrate how one moderated a positive effect and the other a negative effect. To control for the possibility of common method bias, the authors also conducted ANOVA tests to confirm their results (Beaudry and Pinsonneault, 2010).

For studies which used SEM analysis, there was rarely justification for choosing one SEM technique over another. Cynically, it is possible to suspect that familiarity with a method or software program played a stronger influence than any theoretical rationale for the choice. One notable exception was the study *Process Modeling Grammars* which carefully justified the SEM analysis. First a confirmatory factor analysis using LISREL was done because this was "preferred to exploratory factor analysis in cases with strong *a-priori* theory, a focus on theory testing and pre-validated scales." Then a SEM analysis was used because it was "particularly appropriate for testing theoretically justified models (Recker, 2010)." More studies which use SEM analysis should follow this example and explain the rationale for choosing a specific SEM technique

Another weakness of papers using SEM is their lack of consistency in analysis and reporting. For example, eight papers relied solely on SEM analysis and had little or no additional supporting statistics (see Table 2). This seems like a poor choice as using another statistical analysis technique such as correlations, t-tests, component analysis or regression would give the SEM results more significance and offer readers unfamiliar with SEM a better context for the results.

For reporting results, several goodness of fit indexes are used to explain the SEM significance, but authors rarely justify which indexes are reported (or omitted). One exception is the results of *Process Modeling Grammars* study depicted in Table 4. Ten different indexes are reported along with their suggested values. This table is easy for the reader to see the SEM fits the data well across many indexes. It would generally benefit most papers using SEM analysis to include multiple fit indexes and their suggested values. These papers would also be stronger contributions if they reported fit indicators even if they were below the suggested values and included an explanation for why the model was still considered a good fit despite (for example, some indicators are considered less reliable than others).

Fit index	*Suggested value*	*Determinants model alone*
GFI	>0.900	0.941
AGFI	>0.900	0.913
NFI	>0.900	0.985
NNFI	>0.900	0.986
CFI	>0.900	0.989
SRMR	< 0.050	0.0451
RMSEA	< 0.080	0.0625
χ^2 (*df*, *p*)	—	253.003 *(81,0.00)*
χ^2/df	approx. 3	3.123
R^2 for ItU	—	0.413

Table 4 SEM fit indexes for *Process Modeling Grammars* (Recker, 2010)

While SEM is becoming very popular as a statistical method, there is still a debate over what value it has in IS research. As with any statistical method, improper use can falsely identify effects that have no theoretical justification. To demonstrate the risk of faulty models, in *Formative Measurement in IS Research* the authors created four SEM models, two of which were theoretically incorrect. Both the correct and incorrect models had comparable goodness of fit measures (Kim et al., 2010) which illustrates the potential risk of type I errors from SEM analysis.

Although complex methods such as SEM are used frequently it is fitting to highlight two examples of very basic methods which were the primary statistical analysis employed in a study, lest one incorrectly conclude complex methods are required for IS research.

T-tests: in the study *Detecting Fake Websites* pair-wise t-tests were the primary method used to compare the performance of learning systems against the lookup tools. The results for one of the hypotheses is shown in **Error! Reference source not found.** which indicate three of the four systems (left hand column) outperformed the look up tools (top row) (Abbasi et al., 2010).

	H1a – Overall Accuracy			
System	Sitehound	EarthLink	IE Filter	FirePhish
SpoofGuard	< 0.001	< 0.001	< 0.001	< 0.001
Netcraft	< 0.001	< 0.001	< 0.001	< 0.001
EBay AG	0.109*	0.066	< 0.001*	< 0.001*
AZProtect	< 0.001	< 0.001	< 0.001	< 0.001

Table 4. P-values for pair wise t-tests classification accuracy versus lookup systems (Abbasi et al., 2010)

Because of its versatility t-tests are a very powerful analysis method which is also well known and understood. Since the authors were comparing a large number of results from different tests, the t-

test was sufficient to show that the means from each group were from different populations (Field, 2009, p. 324-345).

Correlation: in the study *Key Factors Affecting ERP Benefits* the correlations shown in Table 5 were the primary statistical method used to measure consistency between rater codings of presentations to support the hypotheses (Seddon et al., 2010). Correlations are a powerful method to demonstrate that a result is very unlikely to happen if there was not a corresponding effect in the population (Field, 2009, p. 166-196). Since this data was originally collected from a non-quantitative source, this was an effective method of supporting the hypotheses.

	Sapphire 2003 Data				
	Inter-rater correlation post reconciliation (Gamma statistic)	Percent of the 60 presentations containing evidence supporting H1–H6 (and project go live)			
Hypothesis		Mentioned as a factor (SoE = 1)	Clearly identified (SoE = 2)	Strong Evidence (SoE = 3)	Total % (SoE = 1, 2, or 3)
(a)	(b)	(c)	(d)	(e)	(f)
1. Functional fit	0.96	13	44	37	94
2. Overcoming organizational inertia	0.97	18	26	28	73
3. Integration	0.99	18	33	44	94
4. Process optimization	0.99	25	47	14	86
5. Improved access to information	0.98	18	14	12	43
6. On-going projects	1.00	28	40	7	75
Project go live	1.00	9	38	32	78

Notes:
1. "SoE" stands for strength-of-evidence. Definitions of SoE = 0, 1, 2, and 3 are given in Table 4.

Table 5. Correlation of presentation codings by two researchers in support of ERP key benefit hypotheses (Seddon et al., 2010)

However, it is fitting to conclude by highlighting one of the most complex statistical methods encountered in *Polynomial Modeling and Response Surface Analysis*, a study which used confirmatory regression analysis and response surface models as depicted in Figure 8. Note the convex surface on the left hand shape which depicts a negative moderating effect of the behavioral intention variable and the concave surface on the right hand model which depicts a positive moderating effect (Venkatesh and Goyal, 2010). Although this is a visually interesting result, it is difficult to interpret compared to better known techniques (three pages were used to explain the results). The authors also note the method has several limitations. For example, it can only be used with three variables, two of which must be closely related.

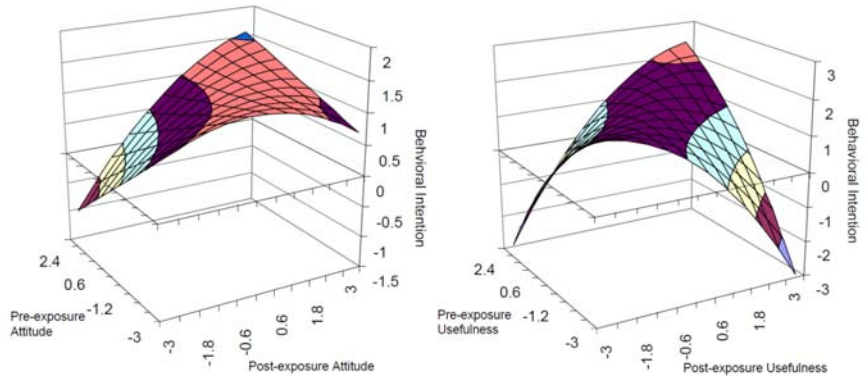

Figure 8. Polynomial response surface models to visualize relationships (Venkatesh and Goyal, 2010)

Conclusion

This paper reviewed the 38 articles published by MISQ, and 41 by EJIS from 2010 to identify the 60 papers which used statistics and these were examined in detail. While statistics are common in all research, this paper has focused on characterizing the unique and interesting trends of IS research. These include the following:

- A positivist epistemology dominates the field, and this drives the use of models and hypotheses in IS research.
- There is a core group of authors who have developed well defined subjects. However, the topics of research change frequently and there are growing efforts to better understand human and IS interaction.
- IS studies commonly use empirical methods although theoretical contributions are more common in EISJ than MISQ.
- There is a wide variety of research methods used, and most IS research is inductive due to the rate of change in topics.
- There is a heavy reliance on surveys for data collection, and consequently common method bias is one of the most widely addressed threats to validity.
- A wide variety of statistical methods are employed for data analysis, from simple correlations, t-tests, factor analysis and regression to more complex multivariate analysis.
- The use of SEM is an important statistical tool common in IS studies, although recommendations to this approach have been noted.

In summary, the use of statistics is indispensable for the analysis of IS research and this paper has discussed how they are widely used in IS research published in top journals of the field.

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Appendix A Detail of Statistical Methods Used in IS Articles

MISQ Article	N	**S**urvey, **E**xperiment, **Q**uasi-exp, **C**ase study, **I**nterview, **A**ction research, **L**ongitudinal	Dataset description	Rigorous treatment of data validity	Descriptive Stats	Hypothesis testing	Correlation	t-test, ANOVA, regression, non-parametric equivalents	EFA, PCA	CFA, SEM, PLS	Complex multivariate techniques, non-parametric equivalents	**D**eductive or **I**nductive
(Seddon et al., 2010)	126	Q,L	Coding of PowerPoint slides & transcripts			1	1					I
(Liqiong and Poole, 2010)	445	E	Stimuli and response	1				1	1	1	1	D
(Sarker and Valacich, 2010)	321	Q, S	Stimuli then Group & individual questionnaires	1	1	1	1	1		1		D
(Mani et al., 2010)	120	S	Survey of 120 organizations & coding of documents	1				1	1	1		D
(Riedl et al., 2010)	20	E	Stimuli and response compared to activity in MRI brain scan	1	1	1	1					I
(Dou et al., 2010)	124	Q, S	Computer task followed by questionnaire		1	1		1				I
(Wang, 2010)	109	Q	Coding of news publications and IT budgets		1	1	1	1				I
(Smith et al., 2010)	89	C, S, I	Multiple surveys of government agencies + focus groups									I
(Yoo, 2010)	0		Review of current IS research to distills themes									
(Abbasi et al., 2010)	900	E	Different software tests against 900 websites		1	1		1				I
(Venkatesh and	1143	S	Survey of employees in one	1	1	1		1			1	I

Goyal, 2010)* CMB			company to assess IT adoption									
(Johnston and Warkentin, 2010)	311	E	Power of fear treatment on IT behavior using 3 groups	1			1	1	1	1		D
(Taylor et al., 2010)* trends in IS	100	L	Author citation analysis to identify historical research trends		1				1			I
(Puhakainen and Siponen, 2010)	16	A, I, S	Effectiveness of security training		1							I
(McKinney Jr and Yoos Ii, 2010)	60	L	Taxonomy of IS terms extracted from journals									I
(Bulgurcu et al., 2010)	464	Q, S	IS policy compliance attitudes (good treatment of survey development, CFA, CMB & SEM)	1					1	1		
(Chen et al., 2010)	174	S	Survey of IS strategies and agreement by executives		1	1			1			D
(Kim et al., 2010)	4	E	Comparison of different formative measurement (SEM) methods							1		I
(Morris and Venkatesh, 2010)	2794	S	Survey of ERP's effect on Job Satisfaction		1	1	1	1	1			I
(Gordon et al., 2010)	796	Q, L	Keyword search of SEC filings and subsequent analysis		1	1	1	1			1	I
(Siponen and Vance, 2010)	1449	S	Survey of security questions			1		1		1		D
(Anderson and Agarwal, 2010)	594	S, E	Survey and experiment of home computer users security practices	1	1	1		1		1		D
(Xinxin and Hitt, 2010)	88	Q	Unit sales and average transaction prices of digital cameras		1	1	1	1				I
(Nevo and Wade, 2010)	0		Theoretical model of IT assets to benefits distilled									

			from literature									
(Sue Young et al., 2010)	743	S, Q	Survey to measure value of knowledge management systems	1					1	1		I
(Galbreth and Shor, 2010)	0		Mathematical models of software markets to study malicious attacks									I
(Beaudry and Pinsonneault, 2010)	249	S, Q	Survey to measure emotions on IT use at 2 banks					1	1	1		D
(Lee and Xia, 2010)	399	S, Q, C, I	Survey of agile software project managers					1		1		D
(Mingers and Walsham, 2010)	0		Theoretical paper on IS ethics									
(Strong and Volkoff, 2010)	92	A, I	Interviews on enterprise software to identify IS misfits			1						
(Spears and Barki, 2010)	228	Q, I,	Survey to measure IT controls effect	1	1	1	1			1		D
(Wattal et al., 2010)	176	L, Q	Study of web 2.0 impact on presidential candidates		1			1				I
(Dimoka, 2010)	15	E	MRI scans to correlate trust with brain activity		1	1		1				I
(Mudambi and Schuff, 2010)	1587	L	Effectiveness of Amazon.com product reviews		1		1	1				

EJIS Article	N	**S**urvey, **E**xperiment, **Q**uasi-exp, **C**ase study, **I**nterview, **A**ction research, **L**ongitudinal	Dataset description	Rigorous treatment of data validity	Descriptive Stats	Hypothesis testing	Correlation	t-test, ANOVA, regression, non-parametric equivalents	EFA, PCA	CFA, SEM, PLS	Complex multivariate techniques, non-parametric equivalents	**D**eductive or **I**nductive
(Rodon and Sese, 2010)	48	C, I, L	Interviews to develop theory of inter-organizational IS									I
(Bharadwaj et al., 2010)	65	S	Critical competencies for successful outsourcing		1	1	1	1				I
(Lee and Panteli, 2010)	2	C	Case study at 2 firms to identify strategic conflicts									I
(Arnold et al., 2010)	207	S, Q	Impact of risk on supply chain information sharing	1	1	1				1		D
(Reggiani et al., 2010)	111	C	Complexity analysis of airline network			1		1				I
(Recker, 2010)	529	S	Survey of process modeling grammars to develop theoretical model (good reporting of SEM results)						1	1		I
(Kartseva et al., 2010)	1	C, I	Control patterns in corporate network to derive software model									I
(Phang et al., 2010)	2562	Q	Click stream data to derive shopping demographics		1	1		1				I
(Al-Debei and Avison, 2010)	0	L	Theoretical paper on IS in BPM									I
(Sila, 2010)	319	S, Q	SEM to test relationships of IS on performance	1		1	1	1		1		D
(Berente et al., 2010)	68	I, C	Interviews at NASA to study ERP implementation									I

(Blanco et al., 2010)	108	E	Visual presentation of product images online	1	1	1					1	I
(Zappavigna and Patrick, 2010)	24	I, C	Compare 2 methods of parsing grammar to discern IS requirements		1	1		1				I
(Banker et al., 2010)	100	L, Q	IT Audits to measure cross organizational IT impact	1				1		1		D
(Seltsikas and O'Keefe, 2010)	270	C,I, A	Electronic ID themes		1							I
(Collins et al., 2010)	0	E	IS model to test decision support pricing analysis									I
(Connolly et al., 2010)	6661	S	Quality of Irish government revenue website	1			1	1				I
(Allen and Wu, 2010)	2200000	E	Effect of shopbots on vendor pricing strategy		1	1	1	1				I
(Huang et al., 2010)	3	C, I	IT Governance steering committees in SMEs									I
(O'Reilly and Finnegan, 2010)	31	C, I	Theory of e-market performance			1	1					I
(Wastell, 2010)	0	L	Theory of IS research direction									I
(Kreps, 2010)	0	L	Poststructuralist interpretation of social network sites from lit review									I
(Busquets, 2010)	34	L, C	Orchestrating Smart Business Networks									I
(Reid et al., 2010)	45	I	Women in IS				1					I
(Lu and Ramamurthy, 2010)	277	Q, L	Analysis of IT leaders from COMPUSTAT database and InfoWeek500 listing		1	1		1			1	I
(Conboy, 2010)	4	C, I	Budget control impact on IS project failure		1	1						I
(Posey et al., 2010)	529	S	Self-disclosure in multicultural social networks	1						1		I

(Thomas and Bostrom, 2010)	22	I, S	Team technology to improve collaboration		1	1						I
(Okoli et al., 2010)	316	S	Survey of SME eBusiness in developing countries							1		D
(Beynon-Davies, 2010)	0	L	Unified theory of IS entanglement									I
(Sarker et al., 2010)	141	S	Survey of offshore Indian IS work life conflict	1	1	1				1		I
(Kettinger and Li, 2010)	0	L	Conceptual model of data, information and knowledge									I
(Recker, 2010)	19	I	Process modeling syntax		1							I
(Wei and Wang, 2010)	181	S	Constructs that drive supply chain reconfigurability							1		I
(Meissonier and Houze, 2010)	1	A	IT conflict resolution theory									I
(Pallud and Monod, 2010)	106	C, I, S	Evaluating users IS experience in museums		1	1			1			I
(Deng et al., 2010)	289	S	Effects of user experience with IT on continual usage						1	1		I
(Klaus and Blanton, 2010)	41	I	User resistance in ERP									I
(Somers, 2010)	0		IS identity crisis									I
(Iannacci, 2010)	0	C	Information as infrastructure									I