JOURNAL OF INFORMATION SYSTEMS
Vol. 25, No. 2
Fall 2011
pp. 145–169

American Accounting Association
DOI: 10.2308/isys-10125

A Meta-Analysis of the Effects of IT Investment on Firm Financial Performance

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ABSTRACT: We use meta-analysis techniques to examine research choices that affect findings with respect to the return on IT investment. Recent research has established that IT investment is substantially related to firm financial performance. We find, however, that the relationship between IT investment and performance varies, depending on how both financial performance and IT investment are measured. Despite criticism of accounting measures as indicators of IT payoff, we find that the relationship is often stronger in studies that employ accounting measures rather than market measures of firm performance. This difference is driven by research that focuses on the process-level impacts of IT investment. Furthermore, the relationship is also stronger when IT investment is measured as IT strategy or spending, rather than IT capability. We discuss the practical implications of the results of our meta-analysis and suggest new directions for future theory development and research.

Keywords: meta-analysis; IT investments; firm financial performance.

I. INTRODUCTION

Over the last two decades, there has been extensive research examining the financial return on information technology (IT) investments. The emerging consensus in recent research is that IT investment payoffs, while positive, are contingent on understanding how these investments affect performance (Sambamurthy et al. 2003) and the contexts and conditions under

The authors thank Paul John Steinbart, the Associate Editor, and two anonymous referees for their careful reviews and constructive suggestions. We also thank Michael Ettredge, James Heintz, Rajiv Kohli, Elaine Mauldin, Theodore Mock, Rajendra Srivastava, as well as participants, discussants, and anonymous reviewers at the 2006 AIS Midyear Meeting for helpful comments and suggestions in the early phase of the paper.

Published Online: November 2011

which IT investment will have a beneficial impact (Clemons and Row 1991; Melville et al. 2004). However, inadequate measurement techniques (Brynjolfsson 1993; Hitt and Brynjolfsson 1996; Robey et al. 2000) and poor quality data sources (Hitt and Brynjolfsson 1996; Robey et al. 2000) still limit researchers' ability to properly appraise IT benefits. Not surprisingly, Melville et al.'s (2004) extensive review of the literature notes substantial divergence in how researchers conceptualize key constructs and their interrelationships.

In this paper, we apply meta-analysis to summarize existing research findings that examine the association between IT investments and firm financial performance. We specifically test whether the measurement of key constructs, namely, financial performance and IT investment, affects the research findings. Consistent with prior literature, we confirm that, on average, IT investment is substantially related to firm performance. Additionally, the relationship is significantly stronger when IT investment is categorized as either IT strategy or IT spending, rather than as IT capability.

We also find that the relationship between IT investment and financial performance is marginally, but significantly, stronger in studies that employ market measures rather than accounting measures of financial performance. However, additional analysis shows a substantial relation between IT investment and process-level accounting measures, counter to the common criticism that accounting measures are backward-looking and unsuitable for measuring intangible benefits. Furthermore, when IT investment is categorized by the extent of IT spending, IT investment is more strongly related to accounting measures; however, when IT investment is categorized as enhancing IT strategy, IT investment is more strongly related to market measures. These differences have important implications for research design.

In designing a study of the payoffs from firm-level investment in IT, researchers must consider five primary issues: (1) the relation between IT investment and firm performance, (2) IT investment measurement issues, (3) firm performance measurement issues, (4) experimental design and other variable measurement issues, and (5) covariate and control variable selection issues. A model of the issues faced when designing a study is shown in Figure 1.

Prior research generally establishes the overall relation between IT investment and firm performance (Area 1 in Figure 1). Studies are built on the notion that there is, or should be, an

FIGURE 1
Areas of Possible Analysis in a Meta-Analysis of IT Payoff Studies

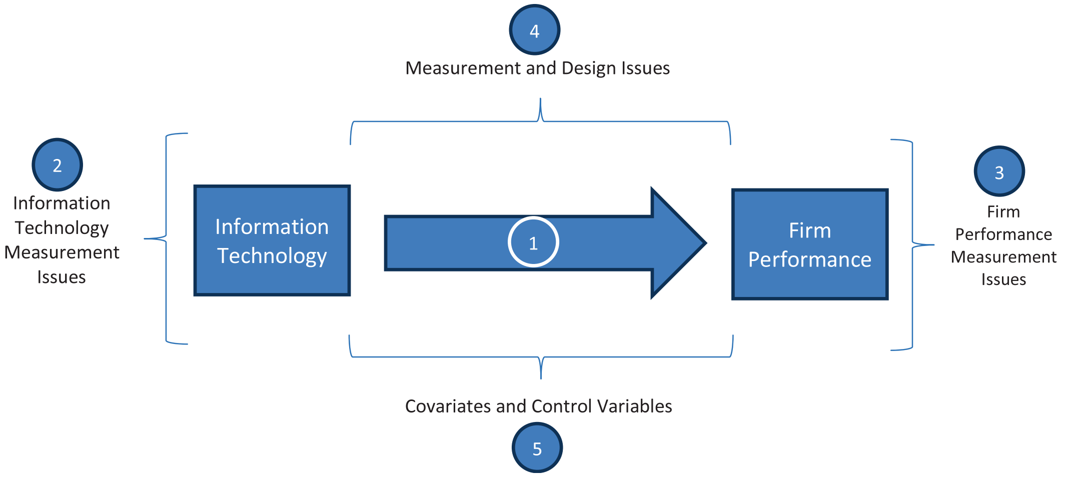

TABLE 1

Elements of the Experimental Design Analyzed Compared to Kohli and Devaraj (2003)

	This Study	Kohli and Devaraj (2003)
1. Relation between IT investment and firm performance	focus of paper—major analysis performed	not tested—no analysis performed
2. Information technology investment measurement issues	major analysis performed	minimal analysis
3. Firm performance measurement issues.	major analysis performed	minimal analysis
4. Experimental design and variable measurement issues.	not tested—no analysis performed	focus of paper—major analysis performed
5. Covariate and control variable selection issues.	not tested—no analysis performed	minimal analysis

increase in firm performance from the appropriate investment in IT. Most studies then focus on the conditions under which IT affects performance, which leads the researcher to other areas of study design. Researchers must choose measures for IT investment (Area 2) and firm performance (Area 3). For example, IT investment has been considered and measured as both stock and flow variables, with and without time lags, individually and in aggregate, among others. Firm performance has been measured using accounting and market measures, financial performance, efficiency, and productivity measures. Performance has been measured at the individual, department, business unit, segment, subsidiary, firm, and industry levels. Researchers must consider all of these choices in addition to the time period, length of performance window, amount of aggregation, etc.

After researchers have determined how IT investment and firm performance will be measured, the focus moves to experimental design and other variable measurement issues (Area 4). For example, the researcher must decide which explanatory variables are necessary and how they are measured, what data are available, which statistical tests to perform, and what results confirm the hypotheses. Finally, researchers must decide what covariate and control variables should be added to the model (Area 5) to rule out alternative explanations, to increase the statistical power of the empirical tests, and to control for known problems for the particular statistical tests being used (e.g., year dummies to control for non-stationarity of the data across time).

As accounting information systems (AIS) research advances, so does the need for meta-analytic studies (Hwang 1996). Meta-analysis[1] is a statistical technique that allows for the aggregation of results across studies to obtain an estimate of the true relationship between two variables in the population, while simultaneously correcting for various statistical artifacts. A meta-analysis of studies on the relation between IT investment and financial performance can examine any one or more of the areas shown in Figure 1. This study examines Areas 1, 2, and 3. An earlier meta-analysis of IT business value (Kohli and Devaraj 2003) examines primarily Area 4, with nominal analysis of Areas 2, 3, and 5. Table 1 compares the areas examined in the two studies.

[1] Meta-analysis can be used to better understand and interpret apparently inconsistent results, while imposing discipline on the summarization process (Lipsey and Wilson 2001). Meta-analysis is rooted in fundamental values of scientific investigation: replicability, quantification, causal, and correlation analysis (Bangert-Drowns 1986; Benbasat and Lim 1993; Hunter and Schmidt 2004). It translates results from different studies to a common metric, allowing exploration of the relation between the characteristics and findings of those studies.

Kohli and Devaraj (2003) examine Areas 4 and 5 in Figure 1 using a set of structural variables, such as sample size, data source, and industry, that discriminate between positive and non-positive IT payoffs. They find that the choice of dependent variable affects the likelihood of positive results, and studies using productivity measures were more likely to report positive results than studies using financial measures. This study builds upon Kohli and Devaraj (2003) by testing whether prior research demonstrates an overall positive statistical relationship between IT investment and financial performance (Area of Analysis 1 in Figure 1). Although substantial recent research (e.g., Kobelsky et al. 2008; Henderson et al. 2010) largely settles the question of IT's contribution to financial performance, there are still questions of how to measure both IT investment and the resulting financial performance. Thus, our analyses should be important to both AIS specialists and business managers.

This study also builds upon Kohli and Devaraj (2003) through in-depth examination of Areas 2 and 3 in Figure 1, considering how payoffs are differentiated based on measurements of financial performance and IT investment. In addition to estimating the true population correlation (Area 1), our meta-analytic procedures allow us to determine if the relation between variables of interest is contingent on how financial performance is measured (accounting versus market) and how IT investment is measured (IT spending, IT strategy, and IT capability). We extend Kohli and Devaraj's (2003) analysis by considering 21 years (1990 to 2010) of firm-level IT payoff studies versus the 11 years (1990 to 2000) in their study. We also focus on the financial measures of firm performance that are more important to AIS specialists and business managers. Thus, this research examines the body of research in this area and provides important information on the relationships between IT investment and firm financial performance that have been found to be the strongest. Researchers can use this to guide empirical strategies for future research. This is our contribution to the AIS literature.

The remainder of the paper is organized as follows: Section II reviews the related literature and offers specific research questions, Section III describes our sample and research design, Section IV discusses the results of empirical tests, and Section V summarizes our findings and presents our conclusion. The technical details of meta-analysis are presented in Appendix A.

II. BACKGROUND AND RESEARCH QUESTIONS

Over the last two decades, results linking IT and firm performance have been mixed. Research by Brynjolfsson and Hitt (1995) effectively ended the debate over the productivity paradox, which questioned the impact of high and increasing levels of IT investment on firm productivity. They find that IT investment, including both IT capital and IS labor expenditures, is significantly positively related to firm productivity in a production function framework. Since then, a number of studies build on that research to show other aspects of the relation between IT investment and firm productivity (see Dedrick et al. [2003] for a summary of this research).

However, the question of IT impacts on firm productivity is different from the question of IT impacts on firm profitability (Hitt and Brynjolfsson 1996). Productivity measures outputs relative to inputs, while profitability indicates potential competitive advantages and returns to shareholders. Hitt and Brynjolfsson (1996) find that IT appears to increase productivity, but has little impact on profitability. Strassman (1997) also describes the lack of correlation between IT spending and financial results, arguing that it is how the firm manages IT that makes a difference. Proving a link between IT investment and firm profitability generally remained elusive until Bharadwaj et al. (1999) showed that IT investments are positively related to Tobin's q values.

Although she does not show a direct link between IT investment and accounting-based measures of firm performance, Bharadwaj (2000) does show that firms with superior IT capability perform better. Perhaps endorsing Strassman's arguments about the importance of managerial ability, she shows that IT leaders have higher return on assets (ROA) and return on sales (ROS), among other accounting-based measures, than a matched control sample. In a similar study, Santhanam and Hartono (2003) relate IT capability to financial performance relative to average industry performance, after controlling for past performance.

More recently, research shows a consistent link between IT investment and firm profitability measures. For example, Kobelsky et al. (2008) relate IT spending to future accounting performance, as well as future risk-adjusted returns. Henderson et al. (2010) use 15 years of IT spending data to show that IT investment is related to market values, residual income, risk, and future abnormal returns.

The examples listed above highlight the range of results linking IT investment to firm performance over our sample period. Several research studies attempt to make sense of the various results of empirical studies. For example, Melville et al. (2004) review the literature and offer an integrative model of IT business value to guide future research. They suggest that future research should recognize the value-generating process whereby IT investments affect business process performance, which in turn affects overall firm performance. Melville et al. (2004) rely heavily on the resource-based view of the firm and economic concepts underlying firm productivity. Dehning and Richardson (2002) provide a similar literature review focusing more closely on issues of direct concern to researchers in the AIS field. They note several conceptualizations of IT investment (i.e., IT spending, IT strategy, and IT capability) that may affect the researchers' approach to examining the link to performance. Yet, neither of these studies provides any new statistical evidence of the link between IT investment and firm performance.

In the only prominent prior meta-analysis of research on this topic, Kohli and Devaraj (2003) synthesized research findings from 66 empirical studies. Unlike a standard meta-analysis, they examine research factors that contribute to finding a positive relation between IT and firm performance, but do not examine an effect size for the relation. They simply code results depending on whether the research found a positive relation between IT and performance.

Kohli and Devaraj's (2003) study finds that researchers are more likely to report positive relationships between IT and performance when using productivity instead of profitability measures, when using larger samples, and when obtaining samples directly from firms instead of secondary sources. This study adds to the literature by addressing the use of firm profitability measures as outcomes of IT investments.

Firm Performance Measures

We focus on measures of firm performance of direct interest to AIS researchers. In particular, we examine market- and accounting-based measures of the return to IT investment (Dehning and Richardson [2002] focus on these two categories in their research summary). Measuring firm performance resulting from IT investment is a major challenge for AIS researchers, and this study empirically examines an important issue in the debate surrounding methodological factors relating to appropriate measures of IT's impact on financial performance. Kohli and Devaraj (2003) combine market and accounting measures, although these measures reveal fundamentally different aspects of firm performance.

Accounting-Based Performance Measures

While accounting measures[2] are widely used in AIS research, they have been criticized because they are often inadequate indicators of the true performance of IT investments. Such measures can be subject to manipulation or distortions for various reasons, such as the different nature of depreciation policies elected, inventory valuation, consolidation of accounts, and standardization in the handling of international accounting conventions. Accounting-based profitability measures often fail to reflect intangible improvements resulting from IT investment, such as faster service, more varied products and services, and better access to business information. Accounting measures also do not include an adjustment for risk, and thus may not reflect firms' changes in risk profiles due to investment in IT. Additionally, accounting measures track relatively short-term performance, which makes longer-term benefits of IT investments harder to detect (Brynjolfsson 1993; Brynjolfsson and Hitt 1996). Finally, a substantial portion of IT spending is expensed, offsetting IT-related reductions in other expenses or enhancements in revenue, and further complicating analysis of potential *short-term* IT-related performance benefits (Henderson et al. 2010).

In their IT value-generating framework, Melville et al. (2004) highlight the important link between IT investment and business process performance. Overall firm performance is simply the consequence of process-level improvements, subject to industry and other competitive factors. This suggests that business process measures are the best direct measure of the impact of IT investment.[3] However, it is often difficult to pinpoint how and when a particular IT investment will affect business processes. For example, an ERP system could affect many different business processes, or the impact on those processes could be delayed until the system is fully implemented and users are trained. In some cases, the changes required by a systems implementation may have a negative short-term impact. Without detailed information about which specific business process is directly affected by a firm's IT investments, researchers are often limited to examining firm-level accounting measures.

Market-Based Performance Measures

Accounting-based performance measures are criticized for reflecting past performance, while IT investment is expected to affect future performance. Market-based performance measures,[4] instead, reflect the market's expectations regarding future firm performance. Thus, those measures

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[2] Accounting measures used to assess firm performance, such as income growth, sales growth, and profitability ratios, include: (1) return on assets (ROA), which focuses on the overall performance of the firm, and is measured as operating income or net income divided by total assets (Floyd and Wooldridge 1990; Hitt and Brynjolfsson 1996; Tam 1998a, 1998b; Sircar et al. 2000; Dehning and Stratopoulos 2000); (2) return on equity (ROE), which compares the profits generated by a company to the investment made by the company's stockholders, and is measured as net income divided by the owners' total investment (stockholders' equity) (Alpar and Kim 1990; Hitt and Brynjolfsson 1996; Tam 1998a, 1998b; Rai et al. 1997); and (3) return on sales (ROS), which avoids the effects of differential asset valuation methods across firms, and the impact of new investment and depreciation. ROS represents a firm's ability to generate income from sales revenue, and is measured as net income divided by total sales revenue (Tam 1998a, 1998b; Bharadwaj 2000).

[3] Accounting measures of process performance include process output and quality, inventory turnover, labor hours or number of employees per process output, process cost ratios, selling, general, and administrative (SG&A) expense as percentage of sales, market share, accounts receivable turnover, raw materials turnover, sales per square foot, and similar measures of single or multiple process performance along a firm's value chain (see, e.g., Dehning et al. 2007).

[4] Market-based performance measures enable researchers to examine the market's estimate of the value of the firm and, by inference, the impact of IT on firm value. Market measures include stock price changes (Dos Santos et al. 1993; Im et al. 2001), the market value of common equity (Krishnan and Sriram 2000; Kudyba and Diwan 2002), or Tobin's q (Bharadwaj et al. 1999) that can serve as an estimate for the effectiveness of the firm in foreseeing and rapidly adapting to its changing IT environment. These market measures reflect the expected influence of IT investments on long-term performance. Market-based measures also include short-term market reactions to IT investment announcements, as indicated by abnormal returns and cumulative abnormal returns (CARs).

can capture both tangible and intangible benefits of IT investment, as well as potential delays until firms realize the benefits of IT. Bharadwaj et al. (1999) summarize the advantages of market-based measures as follows:

1. they are the only direct measure of stockholder value;
2. they are widely available for public firms;
3. they reflect all aspects of performance;
4. they can see through manipulations in accounting measures; and
5. they reveal investors' assessment of managers' decisions.

Conversely, market-based measures incorporate all available information about expected performance, as well as firm risk, so it is often difficult to tie performance changes directly to IT investment. There is no formal requirement for firms to disclose their IT spending (Henderson et al. 2010), and information about firm-level IT investment is generally not widely available. Thus, the link between IT spending and market measures is often ambiguous. The only exception is when researchers examine market reactions around firms' IT investment announcements while carefully controlling for other relevant factors (see, for example, Dehning et al. 2003).

Research Choice of Performance Measure

In short, it is not clear that either accounting- or market-based measures better establish the relationship between IT investment and firm financial performance. It seems reasonable to choose performance measures that best reflect the expected impact of the IT investment. When the expected impact is unclear, researchers must employ broad firm-level accounting or market-based measures. Recent research (e.g., Anderson et al. 2006; Kobelsky et al. 2008; Henderson et al. 2010) tends to use both types of measures. However, when researchers employ these broad measures to examine returns to IT investment, they must also consider the potential for endogeneity, since better-performing companies can afford to invest more in IT (Kobelsky et al. 2008).

IT Investment Measures

We also examine how researchers define IT investment, and whether that definition affects the relationship between IT investment and firm financial performance. Melville et al. (2004) describe how IT investment leads to IT assets, which, in combination with other organizational resources, affect organizational performance. However, Rai et al. (1997) attribute researchers' inability to gauge IT payoff in part to the lack of a reliable aggregate measure of IT investment. One explanation for this ambiguity is that there are several dollars of unmeasured IT "hidden" investments for every measured dollar of IT investments. Total IT investment can include hardware, software, networks, systems analysis and design, testing, operation, maintenance, and user training. While some of these costs are captured in IT budgets, costs such as systems analysis and design, operation, and user training require substantial time commitments from system users that are not typically reflected in IT budgets.

Since publicly available information about firms' specific IT investments is very limited, researchers often employ a variety of surrogate measures. For example, IT investment can be measured by the relative importance of IT to the firm or firms within an industry. Dehning et al. (2003) find that the stock market reaction to firms' IT announcements is higher in industries where IT has a transformational[5] strategic role. Additionally, IT investment can be measured as the IT

[5] They discuss three strategic roles for IT in an industry: transform, informate (up or down), and automate, first conceptualized by Schein (1992). They argue that IT is most important when it is used to fundamentally redefine business processes or business models, i.e., transform the nature of competition in an industry.

capability of the firm that results from IT and complementary investment over time. To the extent that the tacit skills related to IT are valuable and heterogeneously distributed across firms, the resource-based view of the firm suggests that these skills can contribute to firms' competitive advantages (Barney 1991). Consistent with those expectations, Bharadwaj (2000) finds that firms with superior IT capability outperform their competitors on various profit- and cost-based performance measures.

In this study, we broadly classify those surrogates for IT investment following Dehning and Richardson (2002):

1. IT spending: IT expenditures for hardware, software, and IT personnel, often measured as a percentage of sales. For example, Bharadwaj et al. (1999) use IT spending information from *InformationWeek* magazine.
2. IT strategy: how the firm intends to use IT (e.g., automate processes), the type of system (e.g., Enterprise Resource Planning [ERP], Supply Chain Management [SCM], or e-commerce, etc.), or when the firm deploys technology relative to competitors (e.g., early movers). For example, Hayes et al. (2001) examined the short-term market reaction to announcements of ERP system investments.
3. IT capability/management: how IT assets are managed, or how much the firm emphasizes the use of IT. For example, Chatterjee et al. (2001) examine market reaction to newly created CIO positions in firms undergoing IT-driven transformation.

Research Questions

As outlined above, we examine whether the relationship between IT investment and firm financial performance is affected by how researchers characterize firm performance and IT investment. Specifically, we use meta-analysis to examine the following research questions:

RQ1: Does the nature of the firm financial performance measure affect the strength of relationship between IT investment and firm financial performance?

RQ2: Does the characterization of IT investment affect the strength of relationship between IT investment and firm financial performance?

RQ3: Does the combination of the characterization of IT investment and the nature of the firm financial performance measure further affect the strength of relationship between IT investment and firm financial performance?

III. METHODS

Identification of the Studies

The first step in a meta-analysis involves identifying studies according to rigorous inclusion criteria. We collected studies by computerized searches of eight specialized databases[6] covering the published literature from 1990 to 2010. We searched for key words: *IT investment*, *payoffs*, *firm performance*, *productivity*, *computers/information systems*, *returns*, and *IT measures* or *evaluation*. We conducted both manual and electronic searches through major information systems, accounting, and management journals.[7] We also reviewed bibliographies of previously published review papers

[6] ABI/Inform, ArticleFirst, Business and Company Resource Center, Expanded Academic ASAP, Factiva, JSTOR, Lexis-Nexis' Academic Universe, and Net Library.

[7] *Communications of the ACM*, *Decision Science*, *International Journal of Accounting Information Systems*, *Information Systems Research*, *Journal of Information Systems*, *Journal of Management Information Systems*, *Management Information Systems Quarterly*, and *Management Science*.

(Barua et al. 2000; Brynjolfsson and Yang 1996; Sircar et al. 1998) to identify other relevant firm-level IT payoff studies. We then set specific criteria for inclusion in this meta-analysis. Our search identified a total of 121 independent studies[8] that describe either a direct or an indirect relation between IT investment and firm financial performance.

Inclusion Criteria

To be included, a study had to describe firm financial performance outcomes resulting from direct or indirect IT effects on firms' business processes. A study must examine either (1) *direct effects* (e.g., improving inventory management, which reduces inventory levels, inventory holding costs, waste, and spoilage), or (2) *indirect effects* (e.g., improving decision making by having more information available from a new IT). A study must also examine financial performance measures: (1) growth (e.g., year-to-year percent change in sales, gross margin, and profit margin), (2) efficiency (e.g., sales per employee, income per employee, accounts receivable turnover, inventory turnover, and asset turnover), (3) profitability (e.g., ROA, ROS, ROE, and market share), or (4) market values or returns.

We excluded studies that did not report financial performance measures or only provided general descriptive information (e.g., surveys and case studies). We also excluded studies that examined the relation between IT investment and non-profit or governmental organization performance. Additionally, we excluded studies that relied on secondary data from previous studies already included, and those that used performance as a predictor rather than the dependent variable.

We classified firm financial performance variables as either accounting or market measures—carefully considering those studies with measures that might not obviously fall into either of the two categories. We further subdivided accounting measures into process or firm-level measures. We further subdivided market measures into market values (e.g., Tobin's q) or market returns measures (e.g., annual returns, cumulative abnormal returns [CARs]). We classified IT investment as IT spending, IT strategy, or IT capability. Data were coded independently by one of the authors and another trained rater. The values of the inter-rater agreement statistic (*rho*) were 0.96 and 0.98, respectively, for the firm financial performance and IT investment groups. The mean agreement between raters, when coding was aggregated across the moderator groups, was a *rho* of 0.97. The effective reliability (R) was 0.99, indicating the probability that a similar group of two other raters would reach the same conclusions regarding the variables coded (Rosenthal 1991). Finally, studies must provide the minimum statistical information necessary to calculate effect sizes, either directly or through mathematical transformations described in Appendix A, to allow comparison across studies.

Out of 121 studies, 40 (33.06 percent) studies met the inclusion requirements (36 out of 66 published articles, two of five book chapters, and two of seven conference proceedings). Table 2 lists the included IT payoff studies and their characteristics, such as authors, publication year, sample size, types of performance and IT measures, and related meta-analysis statistical data.

Primary Meta-Analysis Procedures

Meta-analysis involves the quantitative summary of individual study findings across an entire body of research (Bangert-Drowns 1986; Benbasat and Lim 1993; Hedges and Olkin 1985; Hunter and Schmidt 2004). It translates results from different studies to a common metric—termed effect

[8] Canvassing unpublished papers can lead to both strengths and weaknesses in meta-analysis. In principle, aggregating both published and unpublished results adumbrates potential implications of statistically insignificant results, mitigating publication and replication bias. Unpublished studies, however, are likely to exhibit inconsistent research quality, since they have not fully survived peer-review processes.

TABLE 2

Effect Sizes and Sample Sizes of IT Payoffs Studies

Study	Sample Size	Paths	Measures	IT	*r*	*Zr* = *ES*	*v*
Ahituv et al. (1999)	80	Indirect	Market	Capability	0.490	0.536	0.013
Anderson et al. (2006)	731	Direct	Market	Spending	0.540	0.604	0.001
Bardhan et al. (2006)	287	Indirect	Account	Spending	−0.180	−0.182	0.004
Bharadwaj et al. (1999)	631	Direct	Market	Spending	0.310	0.321	0.002
Bharadwaj et al. (2007)	169	Indirect	Account	Capability	0.090	0.090	0.006
Byrd and Marshall (1997)	350	Indirect	Account	Spending	−0.007	−0.007	0.003
Chari et al. (2008)	117	Direct	Market	Spending	0.280	0.288	0.009
Chatterjee et al. (2001)	96	Direct	Market	Capability	0.214	0.217	0.011
Dehning et al. (2006)	1,040	Direct	Market	Spending	0.211	0.214	0.001
Dewan and Ren (2009)	3,100	Direct	Market	Spending	0.008	0.008	0.000
Dos Santos et al. (1993)	97	Direct	Market	Spending	0.022	0.022	0.011
Francalanci and Galal (1998)	250	Indirect	Account	Strategy	0.079	0.08	0.004
Hayes et al. (2000)	76	Direct	Market	Strategy	0.088	0.088	0.014
Hayes et al. (2001)	91	Direct	Market	Strategy	0.033	0.033	0.011
Henderson et al. (2010)	4,378	Direct	Market	Capability	0.075	0.075	0.000
Im et al. (2001)	238	Direct	Market	Spending	0.020	0.020	0.004
Kivijarvi and Saarinen (1995)	36	Indirect	Account	Spending	0.085	0.086	0.030
Krishnan and Sriram (2000)	202	Direct	Market	Spending	0.476	0.518	0.005
Li and Ye (1999)	513	Direct	Account	Spending	0.020	0.020	0.002
Markus and Soh (1993)	295	Indirect	Account	Spending	0.180	0.182	0.003
Mukhopadhyay et al. (1997a)	76	Indirect	Account	Strategy	0.100	0.100	0.014
Mukhopadhyay et al. (1997b)	1,794	Indirect	Account	Strategy	0.039	1.645	0.001
Oh et al. (2006)	193	Direct	Market	Strategy	0.164	0.165	0.005
Prasad and Heales (2010)	192	Indirect	Account	Spending	0.085	0.085	0.005
Prattipati and Mensah (1997)	86	Indirect	Account	Spending	0.013	0.013	0.012
Rai et al. (1996)	210	Indirect	Account	Spending	0.474	0.515	0.005
Ranganathan and Brown (2006)	116	Direct	Market	Strategy	0.309	0.320	0.009
Rao et al. (1995)	65	Direct	Account	Strategy	0.549	0.617	0.016
Ravichandran et al. (2009)	514	Indirect	Market/ Account	Spending	0.000	0.000	0.002
Richardson et al. (2003)	211	Direct	Market	Capability	0.024	0.024	0.005
Shin (1997)	623	Indirect	Account	Spending	0.096	1.645	0.002
Siegel (1997)	293	Indirect	Account	Spending	0.235	1.645	0.003
Sircar et al. (1998)	49	Indirect	Account	Spending	0.494	0.545	0.022
Subramani and Walden (2001)	251	Direct	Market	Strategy	0.435	0.466	0.004
Tanriverdi (2006)	356	Indirect	Market/ Account	Strategy	0.106	0.106	0.003
Teo and Wong (1998)	2,641	Indirect	Account	Capability	0.003	0.003	0.000
Wang et al. (2008)	240	Indirect	Account	Strategy	0.101	0.101	0.004
Wang and Alam (2007)	2,505	Indirect	Market	Capability	0.090	0.090	0.006
Weill (1992)	87	Indirect	Account	Strategy	0.018	0.018	0.012
Zhu et al. (2004)	612	Indirect	Account	Spending	0.552	0.621	0.002
Total	23,891						

size—that allows exploration of the relation between the characteristics and findings of those studies. Following the common practice in meta-analysis (Hedges and Olkin 1985; Hunter and Schmidt 1995), we use Pearson's correlation coefficient r, appropriately standardized and weighted, as the *effect size* we compare across studies.

In principle, meta-analysis reliably aggregates data contained in an unlimited number of related studies, thereby increasing sample sizes and statistical power, and elucidating relationships among key variables. Meta-analysis is particularly effective in reconciling seemingly inconsistent results across studies, and establishing significant relationships among variables in a group of studies whose individual sample sizes are too small to support reliable inferences.

Despite the potential advantages of meta-analysis, there are few meta-analytic studies of IT payoffs. Only Kohli and Devaraj (2003) conduct a meta-analysis of structure variables in similar firm-level empirical research; however, their study does not compute effect sizes necessary to evaluate whether IT investment is statistically significantly related to firm performance across IT payoff studies. This estimate of effect size is an important baseline for future research on the payoffs from investment in IT. Thus, in this study, we compute a standardized correlation effect size between IT investment and firm performance for each individual study. If a study did not report an estimate of r, we made computational adjustments (Hedges and Olkin 1985; Rosenthal 1991) to transform the different statistic to a correlation estimate. The meta-analysis calculations are described in Appendix A.

An important question in estimating individual correlations is how to treat multiple correlation estimates if they result from a single study (Rosenthal 1991). The most explicit ways are either to average the correlation estimates or to include all correlation estimates as if they are obtained from different studies (Glass et al. 1981). However, combining correlation estimates from studies that used stochastically dependent samples leads to dependent multivariate distribution of estimated correlations (Hedges and Olkin 1985), which violates assumptions of Chi-square analysis in subsequent analyses (Hedges and Olkin 1985; Hunter and Schmidt 1995). Thus, in those cases, we performed multiple correlation adjustments for stochastically dependent correlations (Hedges and Olkin 1985), resulting in an independent correlation estimate from each study.

Eight of the studies included in this meta-analysis directly reported Pearson correlation effect sizes, while 32 studies reported other metrics.[9] We transformed these statistics to r using standard procedures (Rosenthal 1991). Studies reporting only a significant association (at a certain p, or assumed to be 0.05 if not otherwise stated) were given the minimum r that would achieve that level of significance given the sample size. Studies reporting only that the relationship was not significant were assigned $r = 0$. These standard practices represent a conservative approach and may marginally underestimate overall average effect sizes.

Combining and Comparing Effect Sizes across Studies

First, we transformed correlation effect sizes to Fisher's Z_r to provide an approximate normally distributed metric. We later transformed averaged values of Z_r back into r for reporting (Rosenthal 1991). Multiple results (Z_rs) from the same study were averaged in order to yield one effect size per study in any given analysis, thus avoiding violations of the independence assumptions made when testing significance and computing standard errors. When averaging across multiple studies, we weighted Z_rs by an invariant variance weight; in this case, the sample size of each study minus three (i.e., mean $Z_r(ES) = \sum wZ_r / \sum w$, where $w = n - 3$, and n = sample size for each individual IT payoff study).

[9] In the case of studies that did not report a Pearson correlation, r was computed from adjusted aggregations, Z-statistics, t-statistics, or significance level (p-level).

Combining Estimates of Effect Sizes

We computed the weighted average effect size across studies by weighting each effect size by the inverse of its variance (v). Although effect sizes can be combined by simply averaging them, the more precise procedure is to combine weighted average effect sizes that incorporate variances (v_k) for each effect size (ES_k, where k = number of studies).

We confirm that IT investment is positively correlated with firm financial performance by testing whether the common population effect size (weighted mean Z_r) was equal to zero by comparing the ratio ES^2/v to the Chi-square distribution for one degree of freedom ($\chi^2 = ES^2/v$ for each group). In other words, we tested for a significant main effect for the weighted average effect size (correlation) between IT investment and firm financial performance across studies. We also constructed confidence intervals for the population correlation by first obtaining 95 percent upper and lower confidence limits for population correlation.

Testing for Homogeneity of Effect Sizes

The weighted average effect size represents an unbiased estimate of the population effect size only if single effect size magnitudes are consistent across all studies examined. If single effect sizes do not deviate from each other by more than what is expected by chance, one can conclude that the model of the single effect size fits the data adequately (Hedges and Olkin 1985). However, significant heterogeneity of effect sizes across studies indicates that single effect sizes are not drawn from the same population. In other words, there are important differences in variance among studies, likely due to moderating variables (Hunter and Schmidt 2004).[10]

We address RQ1, RQ2, and RQ3 by testing for the presence of moderating variables. We examine whether groupings based on (1) the nature of the firm financial performance measure (RQ1), (2) the characterizations of IT investment (RQ2), or (3) the characterization of both the IT investment and firm financial performance (RQ3) explain the variation across studies. We systematically examined those moderators by using a procedure analogous to ANOVA (Lipsey and Wilson 1991).

We began by dividing the study into groupings for accounting- versus market-based performance measures and their subcategories. Then, we parceled the heterogeneity among studies into *within* moderator groups and *between*-groups heterogeneity ($Q_{between} = Q_{total} - \Sigma Q_{within}$). Since $Q_{between}$ is distributed Chi-square (with df = number of groups − 1) under the null hypothesis that population effect sizes are equal across moderator groups, we can test whether this grouping significantly explains the variation in the sample. We then tested for the homogeneity of effect size within each moderator group by using Q_{within} *statistics* in the same manner as we originally tested for homogeneity of effect size in the entire sample. To confirm the results, we further examined the pair-wise differences between weighted average correlations for different moderator groups by means of linear combinations using orthogonal polynomials (Hedges and Olkin 1985).

Next, we subdivide the sample studies using groupings based on the characterizations of IT investment, and repeat the process until we achieve within-group homogeneity of effect size. If effect sizes for final partitions were homogeneous within classes but heterogeneous between classes, a comparison was made between effect sizes for different classes within each group by means of linear combinations using orthogonal polynomials (Hedges and Olkin 1985). Finally, we considered the interaction between IT investment and performance measure categories to test whether combinations further affected *between*-group heterogeneity.

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[10] The term "moderating variable" has a different interpretation in meta-analysis than in archival and behavioral research. In meta-analysis, moderating variables explain the heterogeneity in the weighted average effect size.

Considering the sensitive nature of the Chi-square test (due to high statistical power generated by the large number of studies in the meta-analysis) in detecting even the slightest violations from within-group homogeneity of individual correlations (Hedges and Olkin 1985; Hunter and Schmidt 1995), Hunter and Schmidt's (1995) 75 percent rule was used as another validation of the results obtained based on Hedges and Olkin's (1985) approach. In actual meta-analyses, there is always attenuation and false variation due to bad data and unknown and uncontrolled artifacts, and it is never possible to correct for all artifacts that cause variation across studies.

Outlier Analysis: Effect Size Outliers and Extreme Values

We conducted two outlier analyses: (1) based on correlation magnitudes, and (2) based on sample sizes. The presence of high correlation values, considering the high sensitivity of the Chi-square test, can induce systematic variance that, in fact, is not meaningful (Hunter and Schmidt 1995). Large sample sizes affect weighted averages and can cause the entire meta-analysis to be defined by one or a few studies (Hunter and Schmidt 1995). Small sample sizes are not a concern because the negative bias in the distribution of r is stabilized by transforming to Z_r.

To estimate the relative stability of unbiased effect size magnitudes, we used a schematic plot analysis (Light et al. 1994) to indicate outliers and extreme values for the entire sample. We identified three outliers: two based on the magnitude of correlations and one based on sample size. The two studies with high correlations used structural equation modeling analyses based on survey data, which tends to produce higher correlations. We note, however, that the large sample would be considered modest in most accounting research. This argues for more research with larger samples, but we recognize that larger samples of IT investment data are hard to obtain.

We follow the customary procedure for dealing with outliers by conducting analyses both with and without the outliers (Williams and Livingstone 1994). In addition to identifying the studies in our sample, Table 2 reports the sample sizes, individual correlations, weighted mean correlations, and effect sizes of each study.[11]

IV. RESULTS

Table 3 shows that the weighted average correlation between IT investment and firm financial performance for the entire sample is 0.282 ($Z_{significance} = 44.651$, $p < 0.01$, 95 percent C.I. = 0.270 – 0.293). The magnitude of this average effect size indicates the presence of a significant main effect of firm financial performance across the full sample of studies ($\chi^2 = 6242.768$, $p < 0.01$). However, Hunter and Schmidt (2004) have shown that the changes in meta-analytic results due to the removal of extreme sample sizes are not surprising because the weighted average always gives greater weight to studies with large sample sizes.

To avoid bias due to sample size and correlation outliers, we also conducted the analysis with extreme values removed. In this case, the weighted average correlation between IT investment and firm performance is 0.115 ($Z_{significance} = 16.820$, $p < 0.01$, 95 percent C.I. = 0.102 – 0.129). Although the correlation is substantially smaller, the magnitude of this average effect size still indicates the presence of a significant main effect for the reduced sample ($\chi^2 = 645.926$, $p < 0.01$). In both cases, the correlations are clearly greater than zero, confirming that there is a significant relationship between IT investments and financial performance (Area 1 in Figure 1). In addition, the results show that each weighted estimate of the population correlation had relatively narrow 95

[11] To avoid bias due to sample size and correlation outliers, our final sample size is 37. Those three studies are: Mukhopadhyay et al. (1997a), Shin (1997), and Siegel (1997).

TABLE 3

Primary Analysis of Weighted Effect Size (Correlation)

Summary Statistics for Overall Effect Sizes	All Studies	No Outliers[a]
Number of Sampled Effect Sizes	40	37
Total Sample	23,891	21,181
Integrated Effect Size	0.282	0.115
$Z_{significance}$	44.651	16.820
Q_{within} (χ^2)	6242.768***	645.926***
95 Percent Low	0.270	0.102
95 Percent High	0.293	0.129

*, **, *** Significant at the 0.10, 0.05, and 0.01 levels, respectively.
p-values are for two-tailed tests of significance.
[a] Outlier adjusted sample—adjusted sample size outlier and correlation outliers removed.
This table shows integrated effect size (weighted average correlation) and related statistics for all studies and without outliers. Number of sampled effect sizes equals the number of studies; Total Sample equals the combined number of observations for all studies; Integrated Effect Size equals the weighted average correlation between IT investment and firm financial performance; $Z_{significance}$ equals the significance of the relation between IT investment and the firm financial performance measure; $Q_{within/between}$ are measures of heterogeneity within and across groups; and 95 percent low and 95 percent high are the confidence interval limits for the integrated effect size.

percent confidence limits, corroborating the accuracy of the estimation and stability of the average correlations.

Table 3 also shows that the assumption of within-group homogeneity of effect sizes was rejected; both Q_{within} values are significant ($p < 0.01$). This validates our search for moderators, i.e., groupings that can explain the variance, as outlined in RQ1, RQ2, and RQ3. We, therefore, first examine whether the nature of firm financial performance variables used in IT payoff studies affects the level of correlation between IT investment and firm financial performance.

Analysis of Firm Financial Performance Moderator (RQ1)

Panel A of Table 4 shows the results for analysis comparing market and accounting measures of firm financial performance. The weighted average correlations (i.e., integrated effect size) indicate that IT investment is a significant predictor of firm financial performance for each measurement type, although there are modest differences in results for the two firm financial performance measures. Market returns are leading indicators of accounting returns that impound the expected future benefits of IT investment. Thus, as we noted earlier, some researchers argue that market measures better reflect the impact of IT investment. The results in Panel A confirm that argument, although the difference between the two financial performance measures is small. The relationship between IT investment and firm financial performance is marginally stronger for market measures ($r = 0.119$, $k = 20$) compared to accounting measures ($r = 0.099$, $k = 19$). The between-group homogeneity test ($Q_{between}$) shows that the magnitude of the average correlations for each moderator group were different from each other ($Q_{between} = 2.045$, $p < 0.10$), indicating that the financial performance measurement type marginally affects the magnitude of average correlation between IT investment and firm financial performance. The critical ratio (2.05) suggests that the estimate population correlations for market performance indicators are marginally, but significantly, different from those of the accounting performance indicators ($p < 0.10$).

The results in Panel A of Table 4 suggest that the answer to RQ1 is qualitatively positive: *the nature of the firm financial performance measure (i.e., accounting versus market-based*

TABLE 4

Market versus Accounting Measurements Moderator Analysis (RQ1)[a]

Panel A: Overall Market versus Accounting Measures Analysis[b]

	n	Total Sample	Integrated Effect Size	$Z_{significance}$	$Q_{within}/_{between}$	95 Percent Low	95 Percent High
Market	20	15,023	0.119	14.631	369.445***	0.103	0.135
Accounting	19	7,028	0.099	8.255	287.788***	0.075	0.122
$Q_{between}$					2.045*		

Panel B: Market and Accounting Measure Subcategories Analysis[c]

	n	Total Sample	Integrated Effect Size	$Z_{significance}$	$Q_{within}/_{between}$	95 Percent Low	95 Percent High
Market Values	10	10,554	0.145	15.017	281.882***	0.127	0.165
Market Returns	10	4,469	0.056	3.740	62.129***	0.027	0.085
$Q_{between}$					12.016***		
Process-Level	13	5,194	0.117	8.415	259.454***	0.090	0.144
Firm-Level	10	2,563	0.092	4.486	62.943***	0.052	0.132
$Q_{between}$					34.619***		

*, **, *** Significant at the 0.10, 0.05, and 0.01 levels, respectively.
p-values are for two-tailed tests of significance.
[a] Outlier adjusted sample—adjusted sample size outlier and correlation outliers removed.
[b] Two studies (Ravichandran et al. 2009; Tanriverdi 2006) use both market and accounting measures.
[c] Four studies use both process- and firm-level measures: Prasad and Heales (2010), Rai et al. (1996), Wang et al. (2008), and Weill (1992).
Panel A compares market and accounting measures of firm financial performance. Panel B compares subcategories of market measures (market levels and market returns) and accounting measures (process-level and firm-level). n equals the number of studies; Total Sample equals the combined number of observations for all studies; Integrated Effect Size equals the weighted average correlation between IT investment and firm financial performance; $Z_{significance}$ equals the significance of the relation between IT investment and the firm financial performance measure; $Q_{within}/_{between}$ are measures of heterogeneity within and across groups; and 95 percent low and 95 percent high are the confidence interval limits for the integrated effect size.

performance measures) does affect the relationship between IT investment and firm financial performance. Although support is found for RQ1, the results also indicate that the association between IT investment and accounting measures is not as weak as expected.

However, Panel A of Table 4 also shows significant heterogeneity remains within the partitioned groups (Q_{within}) across studies with both market ($Q_{within} = 369.445$, $p < 0.01$, $k = 20$) and accounting ($Q_{within} = 287.788$, $p < 0.01$, $k = 19$) measures. Hunter and Schmidt's (1995) *75 percent rule* also confirms the results of the previous analysis using a Chi-square test approach (not shown). We, therefore, next examine whether subcategories of those measures can affect the relationship between IT investment and firm financial performance.

Panel B of Table 4 presents results for two categories of market measures: market values and market returns, and two categories of accounting measures: process-level and firm-level measures. First, Panel B shows that the integrated effect size for market values ($r = 0.145$, $k = 10$) is more than twice as large as the integrated effect size for market returns ($r = 0.056$, $k = 10$). The between-group homogeneity test ($Q_{between}$) also confirms that the magnitudes of the average correlations for these two groups were different from each other ($Q_{between} = 12.016$, $p < 0.01$), indicating that the type of market measure significantly affects the magnitude of average correlation between IT investment and firm financial performance. While this suggests that researchers find a stronger relation between IT investment and firm financial performance using market value measures (e.g., Tobin's q, Ohlson model analyses), it can also represent the lower correlations in general when research examines market returns rather than market levels.

Panel B also shows the highest integrated effect size for process-level firm measures (r = 0.117, k = 13) compared to firm-level performance measures (r = 0.092, k = 10). In allocating studies to these subcategories, we observed that a number of studies use both process-level and firm-level performance measures. As discussed earlier, a number of researchers have emphasized the direct link between IT investment and process-level performance (Melville et al. 2004), and these results confirm that link. IT investment is strongly related (weighted average correlation = 0.117) to process-level firm financial performance measures. This result indicates that IT investment is significantly related to firm-level performance measures, which again confirms that even firm-level accounting measures can provide reliable measures of IT payoffs. The between-group homogeneity test ($Q_{between}$) also confirms that the magnitudes of the average correlations for these two groups were different from each other ($Q_{between}$ = 34.619, $p < 0.01$), indicating that process-level measurement type significantly affects the magnitude of average correlation between IT investment and firm financial performance.

Panel B of Table 4 also shows that significant heterogeneity (Q_{within}) remains within the partitioned market and accounting measures groups. This suggests that these measures could be further subcategorized; however, sample size limits restrict further analysis. To provide additional insight into potential moderators, we next examine whether the categorization of IT investment (i.e., IT spending, IT strategy, or IT capability) affects the relationship between IT investment and firm financial performance.

Analysis of IT Investment Moderator (RQ2)

Table 5 shows results after partitioning the studies into three classifications of IT investments. Again, the integrated effect sizes (weighted average correlations) indicate that IT investment is a significant predictor of firm financial performance for all three categories: IT spending, IT strategy, and IT capability. Results of the between-class homogeneity test ($Q_{between}$) indicate significant differences among the IT investment classes ($Q_{between}$ = 48.627, $p < 0.01$). This suggests that categorization of the IT investment also significantly affects the magnitude of the average correlation between IT investment and firm financial performance. Furthermore, the correlation between IT investment and firm financial performance is stronger with the IT strategy (r = 0.180) than with the IT spending categorization (r = 0.139) or IT capability (r = 0.039) classification.

The results also show that the estimated effects of the three categorizations of IT investment vary in precision. The IT spending confidence interval (0.122 to 0.155) is relatively narrow compared to the IT strategy (0.134 to 0.224) and the IT capability (0.013 to 0.065) confidence intervals. This suggests variation in the way that IT strategy and IT capability are categorized in the research. The 95 percent confidence interval does not include zero for any of the classifications, indicating that the true population correlation is non-zero. The critical ratios (40.32 and 27.33, not shown) indicate that the correlations for the IT spending and IT strategy categories are statistically different from that relationship for IT capability.

The results in Table 5 indicate that the answer to research question RQ2 is also positive: *the categorization of IT investment does affect the relationship between IT investment and firm financial performance*. Although IT strategy has a stronger average relationship with firm financial performance, these three characterizations are not independent. It seems likely that firms that emphasize an IT-related strategy are also likely to have higher IT spending and IT capability. For

TABLE 5

Type of IT Investment Moderator Analysis (RQ2)[a]

	n	Total Sample	Integrated Effect Size	$Z_{significance}$	$Q_{within/between}$	95 Percent Low	95 Percent High
IT Spending	20	13,678	0.139	16.268	525.514***	0.122	0.155
IT Strategy	11	1,801	0.180	7.631	45.403***	0.134	0.224
IT Capability	6	5,702	0.039	2.950	26.379***	0.013	0.065
$Q_{between}$					48.627***		

*, **, *** Significant at the 0.10, 0.05, and 0.01 levels, respectively.
[a] Outlier adjusted sample—adjusted sample size outlier and correlation outliers removed.
p-values are for two-tailed tests of significance.
This table compares the relation between IT investment and firm financial performance for three categories of IT investment used in the literature. n equals the number of studies; Total Sample equals the combined number of observations for all studies; Integrated Effect Size equals the weighted average correlation between IT investment and firm financial performance; $Z_{significance}$ equals the significance of the relation between IT investment and the firm financial performance measure; $Q_{within/between}$ are measures of heterogeneity within and across groups, and 95 percent low and 95 percent high are the confidence interval limits for the integrated effect size.

example, Kobelsky et al. (2008) show that firms with a transform strategy spend more on IT. Henderson et al. (2010) then show that firms that spend more on IT have higher future abnormal returns, suggesting that much of the general relationship between IT investment and firm financial performance is driven by firms with an IT-based strategy.

Using the same analytical procedures as in the firm financial performance measure moderator analysis, we find that within-class tests of homogeneity (Q_{within}) of individual correlations still indicate significant heterogeneity within the partitioned classes. Q_{within} values vary across studies with IT spending ($Q_{within} = 525.514$, $p < 0.01$, $k = 20$), IT strategy ($Q_{within} = 45.403$, $p < 0.01$, $k = 11$), and IT capability ($Q_{within} = 26.379$, $p < 0.01$, $k = 6$).[12] We, therefore, next examine—to the extent that sample size allows—whether the characterizations of both IT investment and the nature of the firm financial performance measure affect the relationship between IT investment and firm financial performance.

Analysis of Combinations of IT Investment and Firm Financial Performance Moderators (RQ3)

Table 6 presents results for combinations of IT investment and firm financial performance measures. The breakdowns in this table are again limited by sample size, especially for the IT capability measure. Thus, we could not confidently examine the subcategories of firm financial performance measures. Nevertheless, the results present some interesting insights.

First, IT spending is more strongly related to accounting measures than to market measures. The integrated effect size for the combination of IT spending and accounting measures is substantial (0.180). The integrated effect size for IT spending and market measures, while also significant, is one-third lower (0.120). We attribute some of this difference to the substantial relationship between IT investment and process-level measures shown in Panel B of Table 4. Additionally, research shows that the link between IT spending and market measures is not linear. Henderson et al. (2010)

[12] Hunter and Schmidt's (1995) 75 percent within-group homogeneity rule confirms these results.

TABLE 6

Combination of Type of IT Investment and Firm Financial Performance Moderator Analysis (RQ3)[a]

	n	Total Sample	Integrated Effect Size	$Z_{significance}$	$Q_{within}/_{between}$	95 Percent Low	95 Percent High
IT Spending and							
Market	10	11,048	0.120	12.704	305.456***	0.102	0.139
Accounting	11	3,144	0.180	10.128	223.296***	0.145	0.213
$Q_{between}$					8.893***		
IT Strategy and							
Market	6	1,083	0.236	7.866	21.089***	0.179	0.292
Accounting	6	1,074	0.096	3.122	18.946***	0.036	0.155
$Q_{between}$					11.140***		
IT Capability and							
Market	4	2,892	0.069	3.718	19.884***	0.033	0.105
Accounting	2	2,810	0.008	0.432	1.189[ns]	−0.029	0.045
$Q_{between}$					5.307**		

*, **, *** Significant at the 0.10, 0.05, and 0.01 levels, respectively; [ns] indicates not significant.
p-values are for two-tailed tests of significance.
[a] Outlier adjusted sample—adjusted sample size outlier and correlation outliers removed.
This table compares the relation between IT investment and firm financial performance for the interaction between three categories of IT investment used in the literature and two categories of firm financial performance measures. n equals the number of studies; Total Sample equals the combined number of observations for all studies; Integrated Effect Size equals the weighted average correlation between IT investment and firm financial performance; $Z_{significance}$ equals the significance of the relation between IT investment and the firm financial performance measure; $Q_{within}/_{between}$ are measures of heterogeneity within and across groups; and 95 percent low and 95 percent high are the confidence interval limits for the integrated effect size.

suggest that the relationship between IT spending and market measures is not linear, but instead driven by the highest IT spenders.

Second, the IT strategy categorization is more strongly related to market measures than to accounting measures. The integrated effect size for the combination of IT strategy and market measures (0.236) is almost 2.5 times higher than for IT strategy and accounting measures (0.096). IT strategy is a broad measure of IT investment and seems to match well with broad market measures of firm financial performance.

Third, IT capability categorization is only modestly related to market measures and not significantly related to accounting measures (the confidence interval includes zero). The combination of IT capability and performance measures has the lowest effect sizes. Theory, such as a resource-based view of the firm, suggests that IT capability should be a major factor in achieving firm financial performance through IT investment. However, these results suggest the link is limited. Although the sample size is limited, we also interpret the difference between theory and empirics as a measurement issue. There are no widely used standard measures of IT capability.

In summary, the IT spending categorization is more strongly related to accounting measures, and the IT strategy categorization is more strongly related to market measures. We believe that the differences are driven in part by the link between IT and process-level measures. Thus, we recommend that researchers first attempt to establish a link between IT investment and process performance before moving to broader firm-level accounting and market measures. We also expect that results would be stronger when research combines information about both IT spending and IT strategy when considering the nature and potential impact of IT investments.

V. DISCUSSIONS AND CONCLUSIONS

Our meta-analysis of IT payoff studies synthesizes the results of empirical studies conducted over the past 21 years to address questions of importance to AIS researchers. In particular, we examine if study characteristics systematically moderate the relationship between IT investment and firm financial performance. Consistent with recent research, this study confirms that IT investment is positively related to firm financial performance across studies and across years. This study also suggests that the way researchers measure both IT investment and firm financial performance affects the strength of the relationship between IT investment and firm financial performance.

Prior research varies in how firm financial performance is conceptualized and measured. We categorize measures of firm financial performance as either market-based or accounting-based. Researchers often argue that market measures have a theoretical advantage since they are forward-looking and, therefore, reflect expected future benefits of IT investment. On the other hand, market measures are broad measures of performance easily confounded with other factors, such as differences in risk, changes in competition, and changes in the information environment. Accounting measures are often criticized as both backward-looking and unsuited for measurement of intangible benefits. Our results show that the correlation between IT investment and market measures is marginally greater than the correlation with accounting measures in general. That result changes, however, when we subdivide accounting measures into process-level and firm-level measures. Comparing process-level accounting measures to market measures, we find that the relationship between IT investment and firm financial performance is substantially stronger for process-level accounting measures than for market measures. These results support research (Melville et al. 2004) that emphasizes the link between IT investment and business process performance.

Prior research also varies in how IT investment is conceptualized and measured. Following Dehning and Richardson (2002), we examine three different measures of IT investment. We find that all three are positively related to firm financial performance, although IT capability appears less precisely defined than the other categories and has the lowest relation with firm financial performance. IT strategy and IT spending are similarly related to firm financial performance, although the integrated effect sizes are nominally higher for IT strategy studies. The IT spending studies typically have larger sample sizes, which also improves precision. However, the availability of IT spending data is limited, since firms do not separately report IT expense or IT capital expenditures in financial statements.

Implications for Researchers and Practitioners

Part of the reason that IT payoff research has been eagerly embraced by AIS scholars and practitioners is its applicability to organizational efforts to improve financial performance. Our results imply that future research (1) could be aided by better IT investment data, and (2) should consider the contexts that enhance or detract from that relationship (consistent with calls from other literature review studies). Additionally, when data are available, researchers could also benefit from using multiple categories of IT investment and firm financial performance measures to shed more light on IT payoffs.

Additionally, the results suggest that researchers should consider the IT value-generating framework (Melville et al. 2004) when linking IT to firm financial performance, especially when detailed knowledge of the IT investment is available. Our results show that IT spending is more strongly linked to accounting measures, ostensibly through the link to process-level measures.

Broader measures of IT investment, such as IT strategy, can be linked to broader market measures of firm financial performance (e.g., Tobin's q). Thus, researchers should consider the nature of the IT investment when selecting the appropriate financial measure of firm performance.

Limitations

We acknowledge several limitations of this study. In testing moderating effects, we were constrained by the limited number of studies for measurement classes. In all meta-analytic work, but especially when there are relatively few studies for some levels of the moderators, one must be cautious in drawing inferences from these results. In this case, further primary research is necessary before questions about moderators can be definitively answered.

A second limitation is that this study focused mainly on published research of academic journals and conference proceedings. It may only convey editors' and reviewers' views of valid IT investment measurements, rather than those of all IT payoff researchers. In fact, a major issue in meta-analysis has been the question of representativeness of the studies included in the meta-analysis. This has been referred to as potential source bias, availability bias, or publication bias. It has long been alleged that published studies have larger correlations and effect sizes than those that are unpublished, partly because the former are better designed, but also partly because editorial reviewers have a substantial preference for studies with statistically significant results.

Conclusions

Although there have been several conceptual reviews regarding the application of IT investments to organization settings, no study to date has quantitatively synthesized, tested, and compared the measurement variations in the IT investment to firm financial performance relationship. In addition, this study performs a unique analysis of the pattern of results as a function of moderating effects of various studies' characteristics across the population of all available IT payoff studies. Thus, we identify the dimensions of IT that are related to particular dimensions of performance with more certainty. Studies examining IT spending are more likely to find evidence of the impact on performance in accounting-based measures. Studies examining IT strategy are more likely to see evidence in market-based measures, and studies examining IT capability face the likelihood of more uncertain outcomes.

Finally, this meta-analysis suggests that AIS researchers should focus on more specific questions regarding the nature and underlying mechanisms of the relationship between IT investment and firm financial performance. Focused research can thereby attempt to clarify the more specific circumstances and means by which IT investment contributes to business value.

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APPENDIX A

Detailed Procedures of Meta-Analysis

A.1 Computing Effect Sizes

We are interested in the overall association between IT investments and firm financial performance, drawing on the entire extant literature. Therefore, we first summarize the reported results for each paper and calculate the mean correlation coefficient (r) effect size. After assessing each paper's main results, we record the reported effect size or statistic. Since all of the papers report a statistic, rather than directly reporting an effect size for the association, we need to convert the various statistical measures into correlation coefficient r effect sizes using previous studies' methodology (Rosenthal 1991; Lipsey and Wilson 2001). We then transform these r effect sizes into standardized (Zr) values, and multiply the Zr values by their corresponding variance weight (n – 3) to arrive at the mean r effect size (i.e., mean Z_r $(ES) = \sum wZ_r/\sum w$, where $w = \text{n} - 3$; n = sample size for each individual IT payoff study). All calculations appear in Table 3.

A.2 Converting Statistics to Effect Sizes

The studies included within the meta-analysis employ a variety of test statistics to measure the association between IT investments and firm financial performance. These test statistics include t-statistics, Chi-square, F-test scores, p-values, and Z-statistics. To convert these statistics into r correlations, we apply the effect size formulas from prior studies (Rosenthal 1991; Lipsey and Wilson 2001), which are as follows:

t-statistic:

$$ES_r = \frac{t}{\sqrt{t^2 + df}}. \quad (1)$$

Chi-square statistic:

$$ES_r = \sqrt{\frac{x^2}{n}}. \quad (2)$$

F-statistic:

$$|ES_r| = \frac{\sqrt{F}}{\sqrt{F} + n_1 + n_2 - 2}. \quad (3)$$

p-value:
First converted to t-statistic, then converted to r using Equation (1).

A.3 Computing the Mean Effect Size

We measure the mean effect size r using the inverse weight variance method (Rosenthal 1991; Lipsey and Wilson 2001). This technique standardizes the effect size r of each study as Z-values, as follows:

$$ES_{Z_r} = 0.5\log_e\left[\frac{1+r}{1-r}\right]. \quad (4)$$

Standardizing the effect sizes as Z-values eliminates problems of the standard error formulation inherent in product-moment correlation. To incorporate the impact of sample size in the analysis, we compute the variance weight, w_{Z_r}, of each study by subtraction (n − 3) and multiply the weight by the standardized Z-value correlations. We then determine the mean Zr effect size using the following equation:

$$\overline{ES_{Z_r}} = \frac{\sum(w_{Z_r} * ES_{Z_r})}{\sum w_{Z_r}}. \quad (5)$$

Finally, to interpret the results of this meta-analysis, we convert the mean Zr effect size back into standard correlation form as follows:

$$\overline{ESr} = \frac{e^{2ES_{Z_r}} - 1}{e^{2ES_{Z_r}} + 1}. \quad (6)$$

To test for significance, we use the following formula (Rosenthal 1991; Lipsey and Wilson 2001), which assesses significance based upon the Z-value tested at the 0.05 significance level:

$$Z = \frac{|\overline{ESz_r}|}{SE_{\overline{ES_{Z_r}}}}. \quad (7)$$

A.4 Test for Homogeneity of Variances

We conduct a homogeneity analysis to determine whether the variety of proxies for performance measures actually capture the same construct. The result of the Q-test is compared to a critical Chi-square value, where the degrees of freedom are defined as the number of studies less one, to determine whether to reject the null hypothesis of homogeneity. The homogeneity test (Q) provided by previous studies is computed as follows:

$$Q = \sum(w_{Z_r} ES^2_{Z_r}) - \frac{\left(\sum w_{Z_r} ES_{Z_r}\right)^2}{\sum w_{Z_r}}. \quad (8)$$