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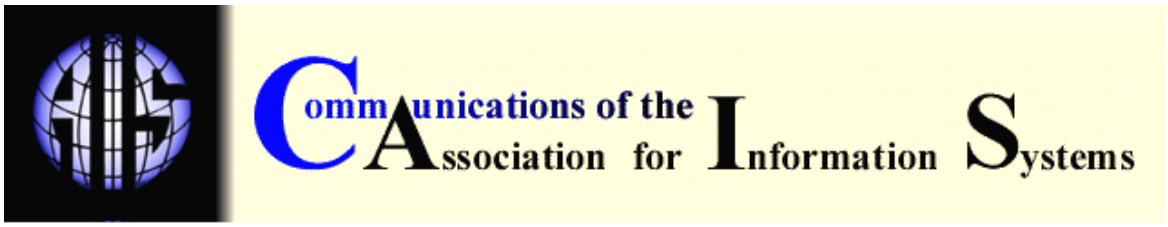

MEASURING PAYOFF OF INFORMATION TECHNOLOGY INVESTMENTS: RESEARCH ISSUES AND GUIDELINES

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ABSTRACT

The business community demands payoff from Information Technology (IT) investment. However, both academic and trade literature report mixed results about the business value of IT. Several research and contextual issues might explain these equivocal results and suggest guidelines for future studies. This tutorial discusses these issues and provides directions for future research in measuring IT payoff.

KEYWORDS: business value, IT payoff, information technology investments

I. INTRODUCTION

Investment in Information Technology (IT) draws debate both among researchers and practitioners. As IT investment increases and other areas compete for investments, measuring payoff from IT investment is no longer just an exercise. It is demanded by stakeholders and expected by senior managers. Organizations assume that each IT investment will yield a payoff and IT departments are expected to demonstrate such payoff. Yet, past studies show equivocal results of the business value of IT as is summed up in these two comments:

> *We see computers everywhere except in the productivity statistics.*
> *Robert Solow, Nobel Laureate in Economics* [Atkinson and Court, 1998]
>
> *...Information Technologies have begun to alter the manner in which we do business and create value, often in ways not foreseeable even five years ago.*
> *Alan Greenspan, Chairman, Federal Reserve Board, May 6, 1999* [Greenspan, 1999]

As researchers, we are perhaps more familiar with the research and analytical issues related to finding payoff from IT. In addition to measuring payoff, practice-related issues can hinder or prevent a true assessment of the business value of IT. For example, poor implementation can negatively affect payoff. Therefore, this tutorial includes an IT payoff implementation process that can improve the ability to obtain higher payoff from IT investments. This process involves understanding the objective of the payoff assessment, risks involved, and complementary

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changes required for implementing a mechanism that leads to an accurate assessment. An inclusive approach to measuring the business value of IT is likely to result in more accurate payoff results.

WHY INVESTIGATE IT PAYOFF?

Providing evidence that IT investments pay off is more significant now than ever. With firms struggling to keep costs under control, the scrutiny of IT investment opportunities for tactical and strategic applications increased. To justify IT expenditures, senior management demands quantifiable payoffs from past investments and justifications for future requests. Such justification is required because there are often competing requests for funding in other business functions. With limited capital expenditure, each investment is tied to the extent of expected payoff.

IT historically labored to find a place at the 'head of the table' and its due respect from other business functions. Often applications were implemented without good assessments of expected payoff. Meanwhile, such comments as Solow's above contributed to a productivity paradox, creating concern among managers that IT investment was not paying off.

It should, however, be noted that most studies showing negative impacts of IT investment are conducted using national economy or industry level data. Similarly, the two comments cited above pertain to productivity at the US economy level. Since findings from economy level investment studies are news-worthy, the perception trickles down to IT investment made at the firm level. As discussed in Section II, we find that fewer firm-level studies exhibit negative outcomes from IT investment.

Nevertheless, academicians need to teach practitioners how to design and conduct studies to measure the business value of IT. They need to develop well-organized IT payoff studies such as those that dispelled the unequivocal results of past studies and then countered the notion that a productivity paradox exists both at the firm-level and the economy-level. [Brynjolfsson and Hitt, 2000; Jorgenson, 2001; Jorgenson and Stiroh, 2000; Kraemer and Dedrick, 2001; Oliner and Sichel, 2000]. This tutorial presents issues and guidelines for firm-level IT research.

OBJECTIVE OF TUTORIAL

The objective of this tutorial is to provide academics with an understanding of the current issues and future research opportunities in firm-level IT payoff and to provide practitioners with an understanding of the process of measuring IT payoff. Payoff pertains to the favorable consequences of a firm's investment in information technology. These consequences are termed as benefits (as in the costs-benefit relationship), or business value. The question in measuring IT payoff is not whether the costs of IT investment exceed the benefits. Rather, the tutorial examines questions such as:

- What are the benefits of IT?
- When, if at all, do benefits occur?
- Where should managers to look to identify benefits?

Through this tutorial we attempt to help researchers answer questions such as:

- What structural variables are likely to affect the outcome of payoff analysis?
- What components of the research design are likely to yield accurate results?
- What are the strengths and weaknesses of different approaches to measuring IT payoff?
- What are some areas of future research?

For practitioners, this tutorial will help in understanding the IT investment process. The tutorial will discuss the complementary changes that are needed to assure that payoff from IT investment

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occurs. Finally, the tutorial suggests a process for implementing an IT payoff mechanism that the authors found useful in practice.

II. WHAT ARE THE ISSUES IN IT PAYOFF?

Key issues in IT payoff research address what to measure and how to measure it, including

- At what level should payoff be measured?
- How do we measure payoff?
- How do different environments affect payoff metrics?
- How do we account for the lag effects of IT payoff?

ISSUE 1: PAYOFF LEVEL

Investments in information technology may occur at the level of a project, firm, industry, or economy. Firm-level studies generally demonstrate a payoff while industry and economy studies show mixed results. Frequently, industry and economy data are obtained from secondary sources. It appears that as we move away from the IT-supported processes, the 'noise' in the measurement increases. Does the source of data influence the payoff from IT investment?

ISSUE 2: PAYOFF METRICS

IT payoff metrics are generally grouped into three broad categories: (1) Profitability, (2) Productivity, and (3) Consumer Value. Profitability measures the benefits appropriated by a firm, productivity measures the marginal benefit of IT, and consumer value focuses on whether the benefits are passed on to consumers. These measures are separate but related and, in fact, research indicates that, while IT has increased productivity and created substantial value for consumers, these benefits do not result in supranormal business profitability [Hitt and Brynjolfsson, 1996]. Yet many studies focus on measuring firm level profitability to assess payoff. In addition, there are other forms of IT payoff such as risk mitigation through investment in public relations websites, testing for adverse impacts (e.g. Y2K), and product disclosure information [Gapenski et al., 1993; Kivijarvi and Saarinen, 1995; Stoneman and Kwon, 1996]. IT investment may result in intangible benefits that may be hard to quantify. Therefore, IT payoff measurement should not rely solely upon the financial impact on the bottom line of the firm.

ISSUE 3: ARE E-BUSINESS ENVIRONMENTS DIFFERENT?

Today companies increasingly join networks of suppliers, customers, and competitors to deliver value to customers jointly. Payoff to each firm is often dependent upon investments made by other organizations. Should measurement of IT payoff differ in e-business environments? At what level should payoff be measured?

Views differ on whether or not e-business brings special measurement needs. Some argue that e-businesses are no different than other forms of IT, only a different type of asset. Others indicate that the metrics of e-businesses are evolving as is the nature of its business enablement. For example, e-commerce, e-government, and collaborative planning, forecasting and replenishment (CPFR) create enhanced collaboration among partners that can expand the payoff from IT investment. Therefore, it is argued, e-business environments should be given special consideration in measuring investment [Barua and Mukhopadhyay, 2000; Straub et al., 2002]. Two issues of *Information Systems Research* deal with developing metrics for e-commerce use among business-to-business as well as business-to-consumers (Volume 13, Issues 2 and 3, 2002).

ISSUE 4: APPROACHING PAYOFF MEASUREMENT

Past studies measured IT payoff from both 'variance' and 'process-oriented' approaches. The variance method takes a positivist approach to assess if the investment paid off by looking for

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variance in one or more dependent variables such as return on assets, profitability, or customer satisfaction. A process-oriented approach investigates the process of how the investment is made and evaluates events that lead to changes in the dependent variables. This approach considers events that lead to the creation of IT assets, the events that translate IT assets to IT impacts, and, finally, the events that converts IT impacts to organizational performance. When the variables for measuring IT payoff are still evolving, the process approach to measure the IT assets, followed by their impacts, may be a reasonable way to assess if the organization benefited from the investment [Soh and Markus, 1995]. This tutorial focuses on process-oriented approaches to IT payoff.

When the process approach is used, other factors that affect the translation of IT assets to impacts are investigated more clearly. The role of management in achieving payoff from IT investment is recognized. Risks that affect payoff can be identified and managed effectively. How should the effects of IT investments be isolated from other sources of investment, such as investment in risk and change management? To do so requires rigorous analytical techniques that some past studies failed to apply. The deployment of IT without an effective strategy is considered a source of mixed results. IT is a tool and when used in the context of a sound business strategy can yield significant payoff. Contrary to general belief, the technology does not need to be very sophisticated for a payoff. Peter G.W. Keen, a prominent thinker in IT management, points out that when all companies can access the same information technology resource, the difference in competitive and economic benefits that firms gain from information technology rests on a management difference and not on a technology difference. Consider the examples of gas stations in the mid-1980's offering customers the ability to pay by a charge card at the pump or some pizza restaurants linking their telephone caller identification facility to a personal computer-based database to retrieve the customers' purchase history and delivery directions as a call came in. How do the investments in management and technology together relate to IT payoff is a key question.

ISSUE 5: LAG EFFECTS

As is evident in the process approach, several steps occur between investment and organizational impact, each of which could result in lag. Accordingly, the data as well as the analysis should be capable of handling the lags. Lag effects require data that spans over a period of time. How long a lag should organizations reasonably expect? The answer will be driven, in part, by the technology deployed, its expected impacts, and when such impacts manifest through the metrics. For example, an investment in an upgrade to an order-entry system is likely to pay off after a lag of a couple of months when the system is deployed, order entry personnel are trained, and system bugs are worked out. On the other hand, an ERP system investment requires extensive changes in organizational processes across many departments, user training, external system interfaces, reporting changes, and more. The lag could be 1 to 2 years in this case. Thus payoff can be realized and measured only after the ERP system is implemented and stable.

It is also important that the frequency of data collection is such that it captures the lag. For example, when the lag between investment and payoff is in weeks or months, the frequency of data collection should be in weeks or months. Gathering and analyzing data in quarters or 6-month intervals can overlook the effect of IT and introduce other confounding factors that might lead to inaccurate payoff outcomes [Kohli and Devaraj, 2002; Mahmood and Mann, 2000].

III. RECENT RESEARCH FINDINGS

MEASUREMENT: META-ANALYSIS OF PAST STUDIES

A recent meta-analysis of structural variables in IT payoff investigated the characteristics of past IT payoff studies and how they relate to the reported outcomes [Kohli and Devaraj, 2002]. Table 1 presents the categories, sub-categories and the dimensions along which past IT payoff studies differed. Many of these variables relate to the research issues discussed above. The 66 studies

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in the meta-analysis and their salient characteristics are listed in Appendix. The meta-analysis suggests that industry sector and data source of the analysis are related to the outcomes of past studies. In particular the study found that manufacturing IT investments were more likely to demonstrate payoff compared with IT investments in service industries.

Table 1. Categories, Sub-categories and Dimensions in IT Payoff Studies

Categories	Sub-categories and Dimensions
Context	• Industry Sector – Manufacturing, Services, Government, Non-Profit [Brynjolfsson and Yang, 1996; Robey and Boudreau, 1999]
Study Characteristics	▪ Sample Size ▪ Aggregation: Month, Quarter, Year [Devaraj and Kohli, 2000] ▪ Duration: Number of Years [Brynjolfsson, 1993; Mahmood and Szewczak, 1999]
Data Source	▪ Firm, Commercial Databases [Brynjolfsson and Yang, 1996; Devaraj and Kohli, 2000]
Variables Employed	▪ Dependent Classification [Robey and Boudreau, 1999]
Data Analysis	▪ Statistical Analysis [Lee and Barua, 1999] ▪ Method: Cross-sectional, Longitudinal [Brynjolfsson and Hitt, 1998; Devaraj and Kohli, 2000; Mahmood and Mann, 1997] ▪ Level of Detail - IT Assets, IT Impact, Organizational Impact [Brynjolfsson and Hitt, 1998; Soh and Markus, 1995; Ward et al., 1996]
Result	▪ Positive, Negative, Neutral, Partial; Percent +ve and -ve significant variables

Source: Kohli and Devaraj, 2002

Consistent with conventional wisdom, the meta-analysis found that larger sample size increased the likelihood of a positive IT payoff outcome. The issue of applying appropriate statistical techniques was raised in research by Lee and Barua [1999]. The meta-analysis did not find a significant relationship between the outcomes of past studies and the statistical analysis employed. Finally, the level of detail in measuring the payoff in past studies had a limited impact on the outcomes. This finding relates to the process approach.

Other measurement issues in firm-level payoff are the choice of dependent variable, the various risks that can affect expected payoff including those arising from IT-led change, and collaboration with business partners. We next discuss these measurement issues.

WHAT TO MEASURE: THE DEPENDENT VARIABLE

The quest for appropriate dependent variables continues. Past studies measured different aspects of IT investment in a host of contexts. Future research should develop frameworks that identify the class of dependent variable (productivity, profitability or consumer value), for the type of investment (operational or strategic), and the appropriate set of variables that would manifest the intended and expected IT payoff at the stage of investment (IT asset creation, IT impacts). Table 2 shows a sample table of metrics incorporating part of this framework.

WHAT TO MEASURE: RISKS IN THE PAYOFF PROCESS

To realize payoff from an IT investment, all risks must be measured and managed effectively. Table 3 defines different risks associated with IT investments [Clemons and Row, 1993; Sherer, 2002]. It is important to identify each investment's risk profile and develop risk management strategies to increase the expected payoff. The risk profile can be mapped to the process approach to IT organizational impact and payoff [Soh and Markus, 1995] as shown in Figure 1.

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Table 2. A Matrix of Sample Operational, Managerial and Strategic Variables for Measuring IT Payoff

	Operational IT	Managerial IT	Strategic IT
Investment	Financial Investment in • FTE's (employees) • Equipment • Consulting	Financial Investment and budgeting for • Applications, • Training • Education	Financial Investment and budgeting for • Collaborative technologies • Electronic Data Interchange • ERP
IT Assets	Number of: • Workstations • Automated check-in counters (airlines) • Assembly machines (manufacturing) • Toll processing stations (Toll Road) • Modems (Insurance adjusters in the field) • Information kiosks (Theme parks) • Trainers	Number of: • Process Redesign projects • Extent of Process redesign measured by number of • Person hours invested • Departments involved • Change management initiatives • Managerial Reporting infrastructure such as cost accounting applications	Number of: • Hubs and Routers • Imaging technology • Knowledge based applications • Teams working on strategic systems • Industry and Vendor Partnerships • Decision makers • IT Payoff measurement process
IT Impacts	Number of: • Customers serviced • Hits on the web site • High quality pieces produced • Problems resolved • Returning customers • Customers referred by other customers • Orders processed/day • Sales/Employee • Loan approval days • Rain checks issue • Special orders placed	Number of: • Escalations • Missed deadlines • Extension of Project end dates • Reporting errors • Technology substitution • Mid-project process redesigns • Adverse Event Episode detection (Healthcare) • Product Recalls • Average Length of Stay	• Actual usage by period by user • Extent of integration of IT into corporate decision making such as the number of • Reports requested • Scenarios analyzed
Organizational Impacts	• Profitability • ROI • ROA	• Employee Turnover • Maintenance Expense • Downtime • Mortality Rate (healthcare)	• Market share • Ranking • Industry Awards • Customer Service Rating • Stock price • Financial Rating

Source: [Devaraj and Kohli, 2002]

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Table 3. Information Systems Risks

Risk	Definition
Technical	The technology doesn't work, either because the appropriate technology to provide the necessary functionality is unavailable, or the wrong technology is used, or the software/hardware fails.
Project	The project cannot be completed on schedule or within budget, with adequate performance or in accordance with some measure of project success.
Organizational/ Political	The system is not used effectively because of organizational structure and internal politics.
Financial	The system does not achieve expected benefits
Disaster	The system is harmed by external disasters such as flood, fire, or other natural disasters and terrorism or war
Security	Unauthorized access to systems can result in alteration or theft of information.
Collaborative	The information needed to collaborate is not shared effectively between business partners.
Competitive	Unique ideas, operating procedures, and/or customer information, is acquired by competitors and used to their advantage

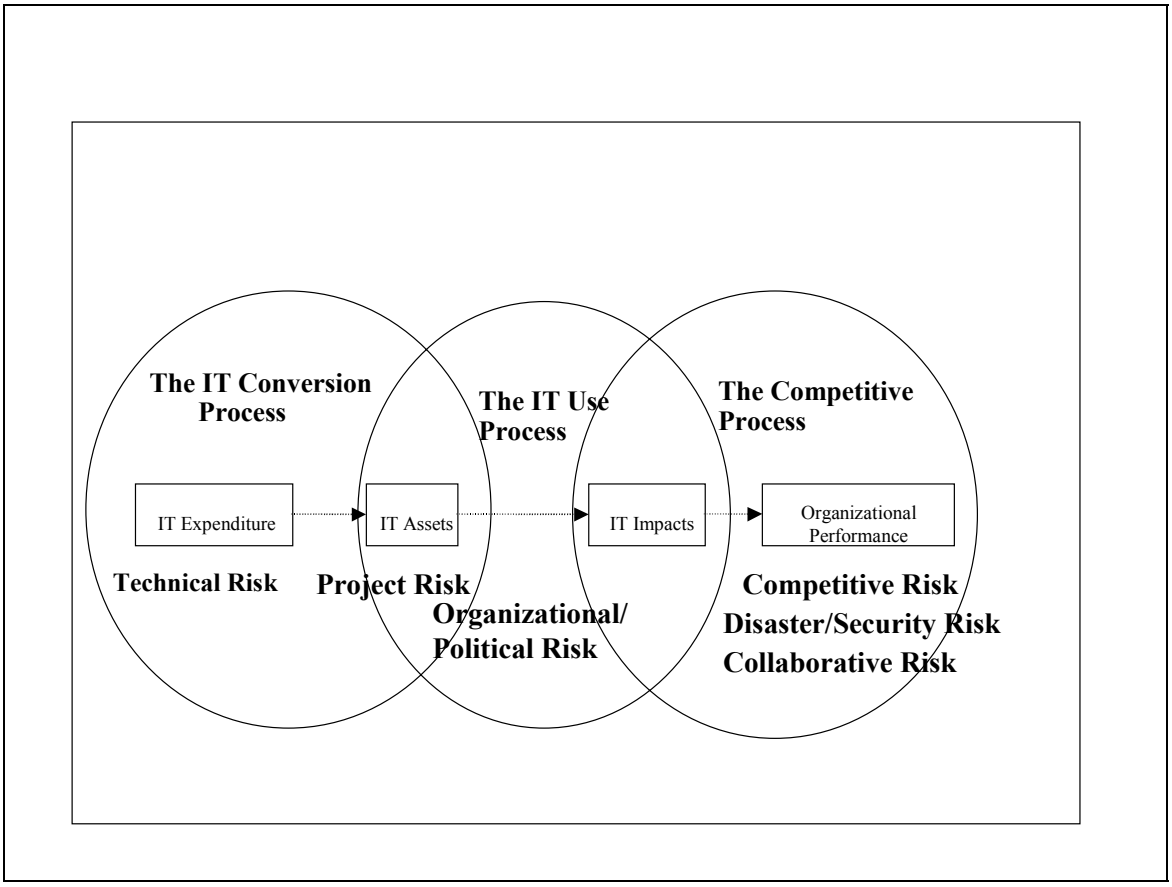

Figure 1. Risks in the IT Payoff Process
(Based on Process Approach to IT Organizational Impact and Payoff from [Soh and Markus, 1995])

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Substantial research is published on identifying and managing risk during the IT conversion process. Table 4 includes some key studies. Yet, project risk continues to plague organizations. In 1999 a Standish group survey of several thousand software development projects found that only 26% were completed on time and on budget; 28% were canceled before completion and 46% were completed over budget and behind schedule, with fewer functions and features than originally specified [Standish Group International, 1999]. Organizational issues are the dominant project risk factors, but they are satisfactorily treated in less than a third of systems development projects [Doherty and King, 2001].

Table 4. Studies of Risk in IT Conversion and Use

Type of Risk	Studies
Technical	Humphreys [1989]; Linger [1999]; Charette [1989]; Musa [1987]; Sherer [1992]
Project	Barki [1993]; Boehm [1989]; Doherty [2001]; McFarlan [1981]; Ropponen [2000]; Schmidt [2001]
Organizational/ Political Risk	Lucas [1981]; Baronas [1988]; Baroudi [1986]; Ives [1984]; Ginzberg [1981]; Mumford [1979]; Mumford [1997]; Castle [2001]; Cummings [1989].

Organizational issues also affect IT use. Little research deals with measuring the impact of investment in change management on IT payoff. Most of the IT payoff studies consider the IT investment as a "black box", with little consideration for complementary changes that must accompany IT investment to minimize risk.

WHAT TO MEASURE? CHANGE MANAGEMENT

Part of the information systems investment process involves adoption of new solutions, which requires organizational change. Accounting for the complementary changes within the organization is believed fundamental to understanding how IT adds value and reduces risk [Powell and Dent-Micallef, 1997]. The use of change management techniques such as change agents or facilitators and effective change communication strategies can help assure the full potential payoff from an information systems investment [Sherer et al., 2002]. These tools can help manage user expectations, promote user involvement, and overcome resistance to change. Effective change managers assess the preferences and expectations of stakeholders, and use communication tools and facilitators to meet or alter these expectations. Change management can help organizations achieve full value from their information systems investments.

While past studies looked at complementary changes in business processes and human capital [Davern and Kauffman, 2000] and reporting structure [Barua et al., 1996], few studies considered complementary change management initiatives. Change management is the process of reducing resistance to change and increasing support/commitment for it, whether that be a change in process, structure, technology, reward systems, management practice, or culture [Castle and Sir, 2001]. Change management activities such as effective communication, creation of internal sponsors, and user feedback can affect IT payoff as shown in Table 5. These activities must be linked with payoff metrics such as increased user satisfaction, decreased implementation time and cost [Sherer et al., 2002]. Figure 2 shows a framework for assessing the impact of change management initiatives on payoff from IT investments and potential metrics for each component.

WHAT TO MEASURE: COLLABORATIVE RISK AND IT PAYOFF

Measuring payoff in e-business environments introduces new complexity because payoff results from activities within more than one organization. Success of collaborative information technology depends upon motivation of *all* partners. While IT investment may affect all collaborating organizations, all partners may not realize equal payoff from their investments. For example, retailers initially resisted checkout scanners that could greatly improve inventory practices in the distribution channel because they felt that their bargaining power would be eroded [Clemons and Row, 1993]. Total payoff from collaborative technology may require complementary changes

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Table 5. Impact of Change Management Initiatives on IT Payoff

Change Management Initiatives	Impact on IT Payoff
Creating internal sponsors	Enhanced impact of IT assets Reduced implementation time
Communication	Lower implementation costs Reduced implementation time
Surveys and Focus Groups	Enhanced use of upgraded systems Reduced implementation time/cost
Pilot studies and client satisfaction surveys	Increased client satisfaction
Providing client feedback through web sites	Reduced implementation time
Partnerships with help desk	Increased client satisfaction
Scheduling applications	Reduced implementation time Increased client satisfaction
Communications targeted to project completion	Reduced time to complete project

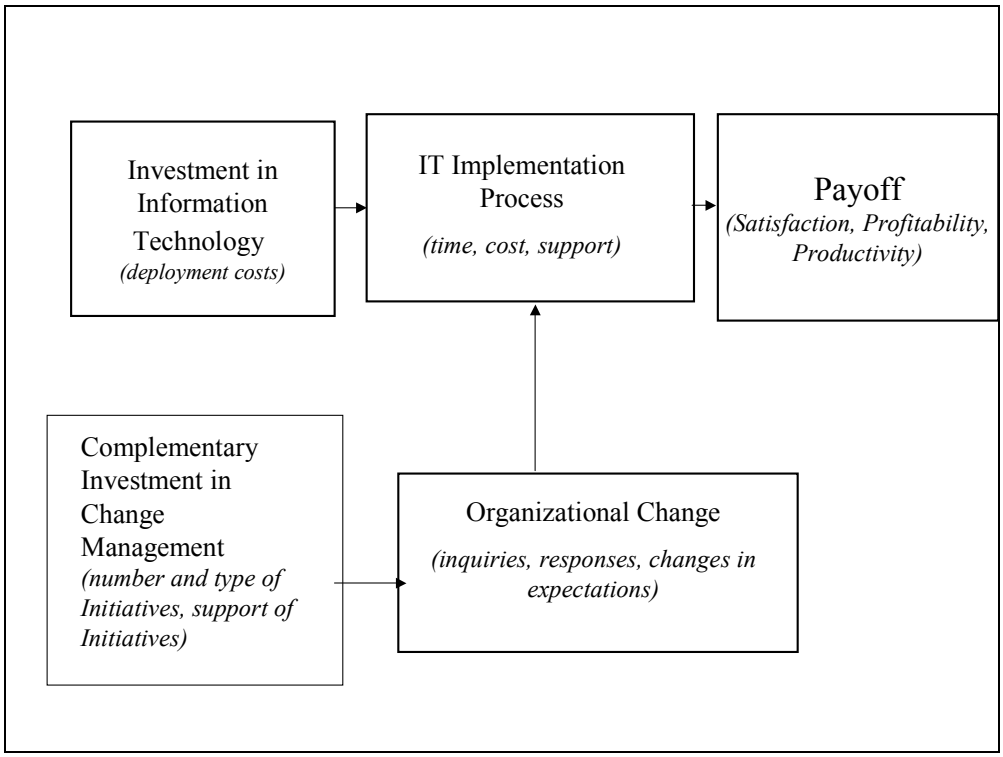

Figure 2: Impact of Investment in Change Management on IT Payoff
(Source: Sherer et al. 2002)

in business processes of *all* partners. Collaborative, planning, forecasting, and replenishment (CPFR) systems are a collaborative approach to increase product availability while reducing inventory across the value chain. Both retailers and manufacturers must be willing to share demand and supply forecasts to synchronize their value chains. Payoff from these systems involves reduction in inventory carrying and stock out costs but requires changes to business and collaborative processes that must be implemented by all parties [Roberts et al., 2001]. Research is needed to understand the motivators and processes that must accompany collaborative systems to reduce collaborative risk and increase payoff from them.

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HOW TO MEASURE: USING ACTIVITY ANALYSIS TO REALIZE BUSINESS VALUE

The process-oriented approach to IT payoff assessment clearly demonstrates the importance of understanding the process changes that must support payoff. When opening up the "black box" of IT investment, we need to understand and measure the necessary complementary changes. Activity based analysis provides a framework for analyzing these changes and assigning responsibility to ensure that they do, in fact, occur. Methodologies such as activity based costing allow firms to identify activities, prioritize improvements, evaluate performance, and improve decision outcomes [Greenwood and Reeve, 1992; Moravec and Yoemans, 1992; Turney, 1991]. Payoff from IT investment occurs when decision makers use the information to induce changes in work activities. IT alone does not create benefits; it is the management process that uses IT to create benefits [Brynjolfsson, 1993; Keen, 1991]. If specific responsibility for achieving proposed benefits is not assigned to individuals with authority to reorganize and restructure to exploit those investments, the projected benefits will not occur. Activity based analysis provides a framework for evaluating IT investments [Sherer et al., 2002]. When making an IT investment, affected activities across the value chain should be identified. Responsibility can then be assigned to a cross functional group of stakeholders with authority to ensure that these activities do change. Figure 3 provides an overview of an activity analysis framework that can be used to realize value from IT investments [Chowdhury et al., 2001]. A strategic planning document is used to communicate the complementary changes throughout the organization. All stakeholders help identify change priorities. Activity analysis is then performed to identify the changes, and the impact of the IT investment. Responsibility for each activity change is assigned to responsible parties.

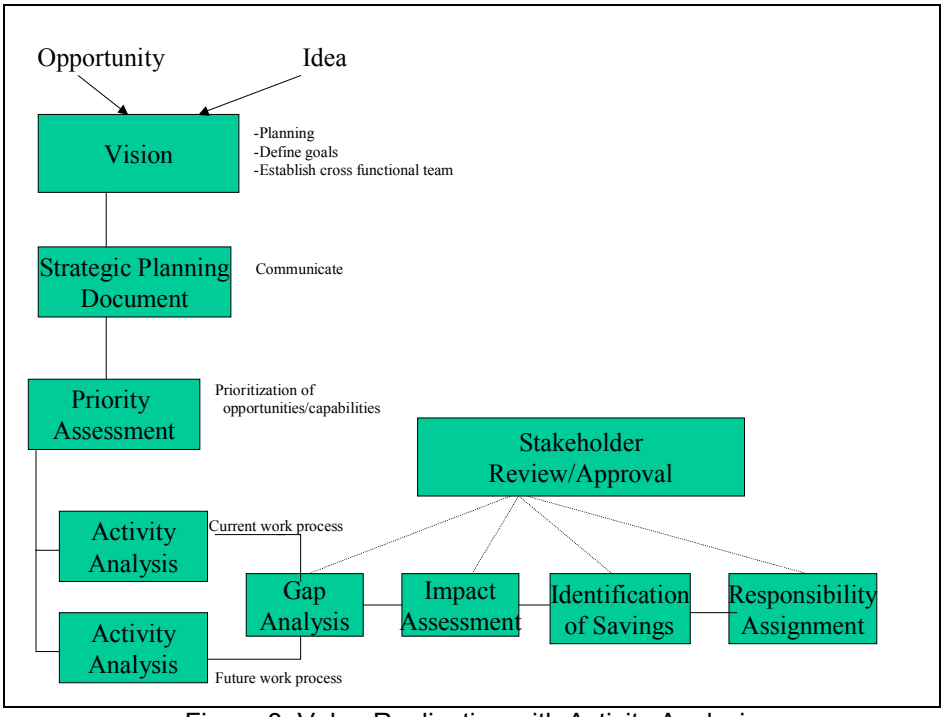

Figure 3. Value Realization with Activity Analysis
(Source: Chowdhury et al. 2001)

HOW TO MEASURE: INFORMATION TECHNOLOGY JUSTIFICATION MODELS

The purpose of IT justification models is to convert the relationship between IT investment and anticipated payoff into a logical or mathematical form, while accounting for other factors that might affect the measurement along the way. The primary objective of a model is to isolate the surplus profits that can be attributed to the investment. The complexity of these models increases

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as other factors are added to either the cost or benefit side of the equation. In addition, certain justification models may be more appropriate given various organizational imperatives such as upgrading existing technology, investing in IT infrastructure, or acquiring new IT applications. Technology justification models can vary from intuition-based cost-benefit analysis, and breakeven point, to financial and economic models such as Net Present Value (NPV), Economic Value Added (EVA), and Real Options to statistical models such as regression analysis. Cost-benefit analysis often requires substantial data collection and analysis of a variety of costs and benefits. Yet, a rigorous analysis is not always necessary. For example, if the number of complaints decline substantially following implementation of a Help Desk, gathering detailed data and performing sophisticated analysis may not be required because the benefits are obvious. However, most IT investments and their benefits involve greater complexity and require a detailed cost-benefit analysis. This analysis involves explicitly spelling out the costs and benefits in a formula such as Equation (1) for an investment that improves productivity.

$$P = \{(\Sigma (H_b - H_a) * W)\} - \{C_h + C_s + C_l\} \quad (1)$$

(Benefits) (Costs)

where

P = Payoff
H_b = hours before implementation
H_a = hours after implementation
W = average wage rate
C_h = hardware costs
C_s = software costs
C_l = labor costs

A variation of cost-benefit analysis called Information Economics accounts for intangibles and uncertainties in information systems investments. In addition to determining costs and benefits, it ranks and scores intangibles and risk factors associated with the investment [Wen and Sylla, 1999].

The time value of investment is represented in Net Present Value (NPV). The NPV uses a discount factor (DF) to assess the value of the investment. Determining an appropriate DF is usually the challenging part of the calculation because it involves a forecast of future returns. In some companies, the discount factor is set by administrative fiat.

While NPV provides information about the time value of the investment, it does not take into account the risks or opportunities created by stopping, decreasing, or increasing investment in the future. Investment in real world scenarios is more complicated than a yes or no decision to invest. Given additional information about how IT investments yield payoff, management has the option to increase or decrease investment any time after the first phase of investment. The Real Options approach helps managers understand the potential payoff from IT investments in a multi-phase investment scenario [Benaroch and Kauffman, 1999; Benaroch and Kauffman, 2000]. Often, it is worth the risk to continue investing in IT initiatives, even if the immediate return is minimal, because of the potential of a portion of the payoff in the future. Traditionally, these situations challenged investors in Research and Development or high-risk ventures such as oil drilling. In the IT context, failure to make an investment in the network infrastructure, such as laying cable, can severely restrict a company's competitive capability to add computer applications and provide new services. Even when it is possible to retrofit infrastructure to adopt new applications, the valuable time lost in upgrading can put a company at a competitive disadvantage. The operationalization and prevalent use of Real Options in IT investment analysis is limited by the appropriateness of using Return on Assets (ROA) in meeting the assumptions of Real Options and difficulties in approximating the discount factor in IT investments [Tallon et al., 2002]

Statistical approaches, something that IS faculty are most familiar with, apply statistical analysis to understand the relationship between the investment and payoff. Most commonly, the first step is to examine the correlation table listing the strength of relationship between the investment (independent) variables, and the payoff (dependent) variable. In the next level of payoff analysis, the extent of the contribution of each item is related to performance by constructing a regression

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equation [Devaraj and Kohli, 2000]. The regression equation analyzes the contribution of the various factors that are hypothesized to lead to a payoff.

IV. GUIDELINES FOR PRACTICE AND RESEARCH

Based upon the above discussion and issues in the literature, we present some guidelines for practitioners and researchers. Although most readers of this tutorial are academic researchers, we hope that practitioners will benefit from these guidelines as well. In addition, we expect that some academic researchers will work with organizations to help determine IT payoff.

GUIDELINES FOR INSTITUTING IT PAYOFF INITIATIVES

Guideline 1. Understand the Objective of IT in the Organization

As an assessment of IT commences, it is important to understand why the information technology investment was made. What was the primary objective of the technology? Was the IT expected to improve productivity, or profitability, or consumer value? While all three can be related, usually there is one primary influential objective. It is important to recognize the role of IT early because that determines the metrics as well as the lag after which a payoff can be expected.

Guideline 2. Understand the Role of the IT Investment

What type of IT will the investment support? If the IT investment is strategic and has long term goals, the data collected should enable analysis incorporating a longer time frame. Longitudinal data allowing for the lag will be needed so that sufficient time is allowed for the strategy to take effect. In case of new technologies, advanced analysis, such as Real Options, might be appropriate for strategic long-term analysis. Conversely, investment in expanding an existing system might need cross-sectional data for which metrics may be well-established.

Guideline 3. Consider Complementary Changes

Recent studies have reiterated the critical role of complementary changes as a pre-requisite to IT payoff success. Complementary changes vary depending upon the complexity and depth of the IT deployment. Complex IT requires technological training and testing as complementary organizational change, whereas an upgrade to the email system affecting every IT user will require a timely and deliberately redundant communications process as a complementary change. Only then can the deployment be expected to be smooth and IT payoff to occur.

Guideline 4. Examine and Mitigate Potential Risks

Great expectations from IT investment can turn into organizational nightmares if the potential risks are not managed. Some complementary changes discussed in Guideline 3, when not addressed, can pose potential risks. As organizations become net-enabled and outsource their operations, the IT risks extend beyond their premises. The end customers will reward or penalize the vendor based upon complete service experience, regardless of whether the vendor outsourced their IT operations. 3 in Section III lists several categories of risks, many of which affect IT payoff. Assigning responsibility for benefits realization can help minimize risks.

Guideline 5. Don't Overlook the Human Element

Academic and industry literature in the past decade indicates that the technical issues for technology deployment are largely worked out. It is the organizational issues, generally involving the human element, that remain the key determinant for the success of an IT investment. Researchers should realize that people affected by an assessment of IT value are apprehensive if their productivity is the subject of measurement. Timely and accurate communication strategy can lower the resistance from those who can make a difference in the success of an investment.

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Guideline 6. Prepare the Infrastructure

Investment in IT is often intimately linked to an appropriate and stress-tested IT infrastructure assumed to be in place. For example, on-line banking is successful when the bank's information systems are integrated. While it is difficult to justify investment in infrastructure because it is often not tied to specific benefits, infrastructure is a critical enabler of future investment in creating applications, products, and services. Yet, it often is overlooked, resulting in organizational unpreparedness to respond to a changing competitive landscape.

Guideline 7. Examine New Payoff of Previous IT Investment

With proper infrastructure and some creativity, the IT investment in systems can enable applications not envisioned at the time of deployment. For example, by integrating systems, bank ATMs can now dispense event tickets and accept credit card applications. Without the IT infrastructure, many new online and ATM banking services would be impossible. One way to examine new payoffs from previous IT investments is to exploit the past data gathered and gain insights into customer preferences, product improvements, and creating new products or services.

Guideline 8. Refine the Process of IT Investment

As is the case with most processes, the IT investment process should be occasionally examined and refined for continuous improvement and feedback from past iterations. This guideline assumes that there is a deliberate process in place to make the investment. Devaraj and Kohli (2002) present a 4-phase process (Figure 4) to implement IT payoff initiatives. Each phase draws from feedback loops so that the next iteration can be improved. The refinement also applies to the human learning of what works in ensuring that IT is targeted and implemented so that it results in a payoff.

V. CONCLUSION AND AREAS OF FUTURE RESEARCH

This tutorial points out that firm-level IT payoff research can be affected by several research design and measurement issues. Researchers should pay special attention to the objective of IT investment, and the strategic nature of IT once implemented because these factors determine the choice of metrics. Since the effectiveness of IT investment depends upon complementary changes and investments made by the firm, failure to examine these changes can generate additional risks. Among the critical complementary investments are organizational change and infrastructure issues, which when properly managed can result in unanticipated additional benefits.

We provide a list of suggested research issues that we believe continue to be important topics for research. In addition, we also further elaborate on two specific areas where past research can inform future work.

Some suggested topics for future research include:

1. Frameworks for businesses to decide where and when to invest in IT
2. Assessing payoff lags for various types of IT investments
3. Investigating how (i) employee training and (ii) process redesign affect the IT payoff
4. Relating task-technology fit and usage to impact of IT on the firm
5. Examining IT payoffs in service quality as well as customer satisfaction, and then examining change in market share. In other words, consider dependent variables other than financial variables.
6. Determining how IT investment contributes to the firm's value as measured by variables such as Tobin's q or stock value
7. Expanding IT payoff research from reactive and exploratory to proactive and prescriptive; i.e. preferred approaches for future investments

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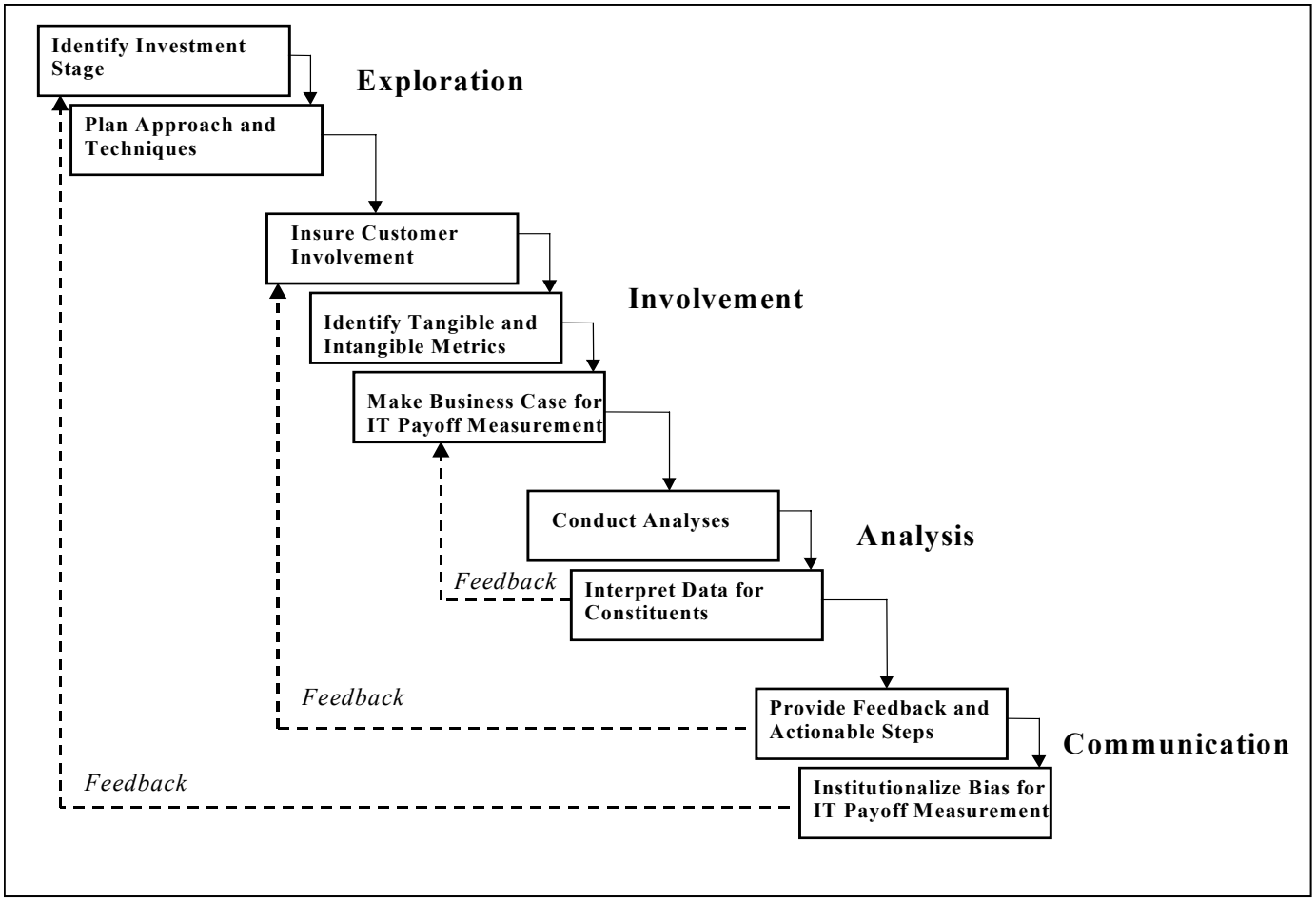

Figure 4: The 4-phase EIAC Model for Instituting IT Payoff Initiatives
(Source: Devaraj and Kohli, 2002)

IT Payoff in Developed vs. Developing Economies

A potential area of future research in IT payoff is to examine the differences between IT payoff in developed and developing economies. While limited technology and constricted financial resources constrained IT deployment, creative investments were made in developing nations. For example, many developing nations with no land-based telecommunications infrastructure spent heavily in wireless systems, whereas developed economies (such as the US) with significant investments in land lines were relatively slow in using wireless. Similarly, several developing nations bypassed the mainframe computing era because they computerized their operations when the client-server technologies were available.

Given such differences, should IT payoff in developing economies be measured differently because investments were made following 'lessons learned' from those that invested in the past? Do limited financial resources lead to creative ways of deploying and measuring IT investment?

IT Payoff in E-business Environments

Past research on IT investment payoff should provide a basis for answering questions regarding payoff of investments in new e-business environments. These environments provide some

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different technologies and relationships that may affect payoff. Future research in this environment is needed to measure payoff from

- Collaborative commerce
- Collaborative, Planning, Forecasting, and Replenishment (CPFR) systems
- Developing new e-business products and services
- Click and mortar versus dot.com enterprises
- Click and mortar versus brick and mortar businesses
- e-Business infrastructure investments
- Mobile e-business technologies

In addition, we need frameworks and evaluation methods for e-business investments, comparisons of payoff from e-business and traditional IT investment strategies and tools, and assessments of how information technology can be used to achieve cost leadership in this environment.

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APPENDIX I: IT PAYOFF STUDIES AND THEIR CHARACTERISTICS

Studies	Data Source	Method	Payoff Coding	Dependent Variables
1. Ahituv, Lipovetsky and Tishler, [1999]	Computerworld, Fortune	Longitudinal	1	Output; Labor Productivity
2. Alshilash, A.*, [1997]	Survey of Saudi Arabia firms	Cross-sectional	1	Degree of IT Use, Organizational Functions
3. Barua and Lee, [1997]	MPIT Database	Longitudinal	1	Output; Labor Productivity
4. Barua Kriebe1 and Mukhopadhyay, [1995]	MPIT Database	Longitudinal	1	Capacity Utilization; Inventory Turnover; Quality
5. Barua, and Whinston, [2000]	Hoover's Online	Longitudinal	2	
6. Bergnon and Dexter, [1999]	Firms	Longitudinal	1	Adoption Benefit; Process Savings
7. Bharadwaj, Bharadwaj and Konsynski., [1999]	Information Week 500	Longitudinal	1	Tobin's q
8. Bresnahan and Brynjolfsson, [2000]	CI Infocorp, Compustat, Survey	Longitudinal	1	value added to firm
9. Brynjolfsson and Hitt, [1993]	IDG; Compustat	Longitudinal	1	ROI
10. Brynjolfsson and Hitt, [1995]	IDG; Compustat	Longitudinal	1	Sales; IT Capital; IT Labor
11. Brynjolfsson and Hitt, [1996]	IDG; Compustat	Longitudinal	1	Sales; IT Capital; IT Labor
12. Brynjolfsson, and Hitt, [2000]	CI Infocorp, Compustat, IDG	Longitudinal	1	Capital, Labor, Computer elasticity
13. Byrd and Marshall, [1997]	IDG Computerworld Premier 100	Cross-sectional	2	ROI, ROS, Revenue Growth
14. Chen, W*, [1996]	Computerworld Premier, COMPACT	Cross-sectional	1	ROA, ROS, ROE
15. Cline*,[1999]	Railroad firm	Longitudinal	1	
16. Devaraj and Kohli, [2000][b]	Firms	Longitudinal	1	Revenue; Quality
17. Devaraj and Kohli, [2000][a]	Firms	Longitudinal	1	Revenue; Quality
18. Dewan and Min, [1997]	IDG; Compustat	Longitudinal	1	Sales; IT Capital; IT Labor
19. Francalanci and Galal, [1998]	LOMA; A. M. Best Insurance Reports; Compustat; 10K Reports of Publicly Traded Firms	Cross-sectional	2	Income per Employee; Ratio of Total Operating Expense/Premium Income

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Studies	Data Source	Method	Payoff Coding	Dependent Variables
20. Grover, Segars and Fiedler, [1998]	Survey of Firms	Cross-sectional	2	IT Diffusion; Perceived Extent of Process Change; Perceived Productivity Improvement
21. Harris and Katz, [1991]	Life Office Management Association (LOMA) Database	Longitudinal	1	Premium Income
22. Haynes, M, Thompson, [2000]	Banking World	Longitudinal	1	ATM adoption
23. Hitt and Brynjolfsson, [1996]	IDG Surveys; Compustat II; Bureau of Economic Analysis; Council of Economic Advisors	Longitudinal	2	Sales Revenue; Labor Productivity; Total Factor Productivity
24. Kelley, [1994]	Firms	Cross-sectional	1	Production Hours; Setup Hours; Machine Hours
25. Kivijarvi, and Saarinen, [1995]	Talouselama Magazine, Survey	Cross-sectional	2	
26. Kohli and Devaraj, [2000]	Firms	Longitudinal	1	Revenue
27. Koski, [1999]	The Federation of Finnish Electrical and Electronics Industry (SETELI)	Longitudinal	2	Sales Revenue; Labor Productivity; Total Productivity
28. Kudyba, and Diwan, [2000]	CI Infocorp	Cross-sectional	1	Revenue
29. Kwon and Stoneman, [1995]	Firm Surveys; Lotus Datastream	Longitudinal	1	Value added to firm
30. Lee and Barua, [1999]	MPIT Database	Longitudinal	-1	Output; Labor Productivity
31. Lee and Perry, [2000]	CI Infocorp	Longitudinal	1	Gross State Product
32. Lehr and Lichtenberg, [1998]	Bureau of Labor Statistics (BLS) Federal Productivity Measurement Program, CI Infocorp	Longitudinal	1	Productivity; Labor Costs
33. Li and Ye, [1999]	Compustat; InformationWeek; US Dept of Labor's US Industrial Outlook	Longitudinal	1	Return on Assets; Return on Sales
34. Lichtenberg, [1995]	IDG, InformationWeek; Computerworld	Longitudinal	1	Revenue
35. Loveman, [1994]	MPIT Database	Longitudinal	-1	Output; Labor Productivity
36. Lubbe, Parker and Hoard, [1995]	Firms Survey	Longitudinal	1	Computerization Index; Operating Expense Ratio

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Studies	Data Source	Method	Payoff Coding	Dependent Variables
37. Mahmood and Mann, [1993]	Computerworld Premier 100; Compact DISCLOSURE database	Longitudinal	1	ROS, ROI; Growth in Revenues
38. Mahmood and Mann, [1997]	Computerworld Premier 100	Longitudinal	1	ROS; Growth in Revenues
39. Markus and Soh, [1993]	Federal Reserve Bank	Longitudinal	1	Profitability
40. Mayberry-Stewart*, [1996]	Dornfest Hospital database	Longitudinal	2	IT Performance (Application and Technology intensity)
41. McKeen and Smith, [1993]	Firm	Longitudinal	1	Revenue; CPU time; Employees
42. Menon and Lee, [2000]	State Healthcare Database	Longitudinal	1	Costs
43. Menon, Lee and Eldenberg, [2000]	State Healthcare Database	Longitudinal	1	Costs
44. Mistry and Johnston, [2000]	Fed Reserve Bank	Longitudinal	1	Labor Costs, Revenue
45. Mukhopadhyay, Barua, Kriebel, [1995]	Firm	Longitudinal	1	Inventory Turnover; Costs; Production Volume
46. Mukhopadhyay, Lerch and Mangal, [1997]	Firm	Longitudinal	1	Labor Hours; Number of Transactions; Type of Transaction
47. Mukhopadhyay, Rajiv and Srinivasan, [1997]	Firm	Longitudinal	1	Total Output; On-time Output; Labor Hours
48. Panthawi*, [1999]	Firms in Thailand	Longitudinal	2	Firm Performance
49. Papp, [1999]	Fortune, other	Longitudinal	0	Financial Performance
50. Peffers and Dos Santos, [1996]	Federal Deposit Insurance Corporation (FDIC); Federal Reserve Board of Governors; Conference of State Bank Supervisors	Longitudinal	1	Market Share; Performance before Taxes
51. Prasad and Harker, [1997]	Wharton Financial Institutions Survey	Cross-sectional	2	Productivity; Profitability
52. Prattipati and Mensah, [1997]	Computerworld Premier 100	Cross-sectional	1	Management Output; Economic Value Added (EVA)
53. Ragowsky, [2000]	Survey	Cross-sectional	2	Executive Perception
54. Rai and Patnayakuni, [1997]	InformationWeek; Compustat	Cross-sectional	2	ROA; ROE

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Studies	Data Source	Method	Payoff Coding	Dependent Variables
55. Rai, Patnayakuni, Patnayakuni, [1996]	InformationWeek; Compustat	Cross-sectional	2	ROA; ROE
56. Rao, Pegels, Salam, Hwang, and Seth, [1995]	Mail Survey; Compustat	Cross-sectional	0	ROA; Long-term debt to equity
57. Siegel, [1997]	US Census Bureau	Longitudinal	1	Total Factor Productivity
58. Stoneman and Kwon, [1996]	Firm Surveys Centre for Urban and Regional Development Studies, UK	Longitudinal	1	Gross Profit
59. Strassman, [1990]	MPIT Database	Longitudinal	0	Return on Management, Value added
60. Tam, [1998]	Asian Computer Directory (ACD)	Longitudinal	2	Operating Costs; Computer Capital; Non-Computer Capital
61. Tam, [1998]	Asian Computer Directory (ACD); PACP and Global Vantage Databases; Asian Development Bank	Longitudinal	2	ROA; ROE, ROS
62. Teo and Wong, [1998]	Survey of Managers' perception	Cross-sectional	2	Competitive Performance; Productivity; Management Performance
63. Van Asseldonk, Huirne and Dijkhuizen, [1988]	NRS Royal Dutch Cattle Syndicate (Netherlands)	Cross Sectional	1	Milk Fat and Protein Production; Calving Interval
64. Wang*, [1997]	Taiwan firms	Cross-sectional	1	Firm Performance
65. Weill, [1992]	Firm Surveys; Interviews; Site Visits	Longitudinal	1	Sales Growth; ROA; Labor Productivity

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Studies	Data Source	Method	Payoff Coding	Dependent Variables
66. Xia*, [1998]	Survey	Cross-sectional	1	Effectiveness of IS function/Business Processes, Organizational Performance

Note: With the exception of Cline (1999), all longitudinal studies used multi-firm data also referred to as panel data.
1 Positive, - 1 Negative, 0 Neutral, 2 Mixed or Partial (some positive, some negative)

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