Measurement of Information Technology Investment Payoff

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An internship report submitted in partial fulfillment of the requirements for the degree of master of science.

By

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Bachelor of Economics, Shandong University, 1998

2000
Wright State University
I HEREBY RECOMMEND THAT THE INTERNSHIP REPORT PREPARED UNDER MY SUPERVISION BY Qing Wang ENTITLED MEASUREMENT OF INFORMATION TECHNOLOGY INVESTMENT PAYOFF BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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Abstract

This report evaluates the measurements of information technology investments payoff, and recommends a theoretical framework for testing the costs and benefits of Internet e-commerce investments. A number of research studies are referenced to evaluate the accuracy of the traditional, quantitative-oriented measurements and introduce a few contemporary, more qualitative-oriented alternatives. As one of the major types of information technology investments, Internet e-commerce is chosen as a case to evaluate the measurements by applying the theories generated from various research studies. Based on the case analysis, contemporary approaches are justified and adopted to establish a three-step framework of measuring Internet e-commerce investment payoff.
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Introduction

Over the past decades, more and more companies are observed to be heavily investing in information technology (IT). Are these huge expenditures worthwhile? This question has become a major concern for most companies who have already invested or are planning to invest in information technology. The objective of this thesis is to explore the true nature of IT investment and provide theoretical guidance for measuring IT investment payoff.

The first section discusses the impact of information technology on businesses. The focus will be on the relationship between IT investment and its payoff at the firm level. Traditional approaches have extensively studied the IT investment-productivity relationship, where the productivity paradox has been discovered. To explain this paradox and further understand the transition from IT investment to actual productivity and profitability, various theories and hypotheses are presented based on the special features of IT investment. Some contemporary approaches are also introduced.

To provide a concrete example of IT investment payoff analysis, the second section will specifically discuss the implementation of Internet e-commerce technology within firms. Its direct purpose is to establish a framework through which to perceive and actually measure Internet e-commerce technology investment. Many of the insights should help senior managers evaluate or make decisions on Internet e-commerce investments. Indirectly but equally important, a close study of one specific type of information technology will help develop an understanding of the issues involved in evaluating IT investment. Finally, the research findings will be summarized and several conclusions will be drawn.
An Overview of IT Investment and the Productivity Trend

After the steam power era and then the electrical power era, the creation of information technology (IT) may be the most profound source of change to the society, which has brought about a brand new “information technology era”. Economic life is undergoing a series of dramatic changes with the introduction of PCs, workstations, LANs, WANs, Internet, fiber optics, digital and wireless communications. The observation that information technology has ignited an economic revolution is thus widely held.

However, whether IT in reality contributes as much to economic growth and business prosperity as we intuitively feel is being hotly debated in both the academic and business worlds. In addition, the vision of this issue will influence firm decisions on IT investment verses other alternative economic inputs. In this section, many relevant theoretical and empirical research results will be discussed and compared. Since research conclusions are based on certain assumptions and methodologies, much attention is given to their validity to help reach a more accurate evaluation.

What is information technology

When people hear the word “information technology”, they quickly associate it with words such as computers, Internet, e-commerce, systems, database and so on. In a typical technical textbook, information technology is defined as the combination of computer technology (hardware and
software) with telecommunications technology (data, image, voice and networks). In a recent book by Lucas, he emphasizes the database as one component of IT along with computer and network (Lucas, 1999). In addition to the traditional computational and data storing functions, the advance in telecommunication technology has profoundly expanded the technology range to a powerful information process and distribution channel.

As information technology develops, the methods of production are evolving too. One major change of the 20th century in industrialized nations is the emergence of a great volume of white-collar workers. More and more economic resources are transferred to information-handling functions from non-information-handling activities traditionally performed by industrial and agricultural workers. According to Charles Jonscher’s research results, the information work force has grown in approximate proportion to the greater information requirements arising from changes in economic productivity. (Jonscher, 1999)

Jonscher also described the evolutionary phases of the information technology revolution (see table 1). His work enables us to see how changes in information technology have gradually changed the nature of production and economic activities.
Table 1: Three phases of the information revolution

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<th>Measures and timing</th>
<th>Driving technology</th>
<th>Manifestation</th>
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<tr>
<td>1. Growth of</td>
<td>Ratio of information</td>
<td>Production machinery</td>
<td>Mass production</td>
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<td>information</td>
<td>labor to production</td>
<td>(stand alone)</td>
<td>Growth of large clerical</td>
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<tr>
<td>management</td>
<td>costs</td>
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<td>bureaucracies</td>
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<tr>
<td>(1800s-1950s)</td>
<td>Passed 1:1</td>
<td></td>
<td>Growing average firm size</td>
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<td>1960 (USA)</td>
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<td>2. Growth of</td>
<td>Ratio of information</td>
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<td>technology to</td>
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<td>1990 (USA)</td>
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<td>Stable firm size</td>
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<td>3. Integration</td>
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<td></td>
<td></td>
<td>systems</td>
<td>Falling average firm size</td>
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Source: An Economic Study of the Information Technology Revolution, P27 1999

As displayed in phase 1, the emergence of information management is associated with large firm size and the consequent need of clerical paperwork within these firms. From the 1950s, information systems were implemented to support information rather than production labor. In other words, instead of the industrial worker, it is the office worker who uses the computer and
telecommunication equipment in the first place. In the last decade, more advanced information technology innovations enabled the integration of office and factory work. Today we see business to consumer and business to business relationships are tightened tremendously, which is typically represented by the appearance of e-commerce. Some economists believe that such an integration will eventually result in an increase in average firm size (Brynjolfsson, 1989).

**IT Investment and Productivity Trend**

As observed by the industrialized nations, IT investment has been escalating at an amazing speed since the 1980s. Taking the U.S. as an example, W. Wayt Gibbs’s 1997 findings show that 43 percent of the firms’ capital budgets in 1996 were spent on computer hardware. This is greater than the expenditures in factories for capital and other types of durable equipment. If software, networks and staff are included, approximately $500 billion was spent on IT (Gibbs, 1997). The result is that employment market shows a strong demand for IT professionals. These facts are undoubtedly a demonstration of strong confidence in the capability of information technology. However, in spite of the IT investment in U. S., growth has been lackluster at about 1 percent annually, according the U.S, government statistics.

To plot a concrete picture of the relationship between IT investment in businesses and productivity trends, a historical review of both issues will be presented in aggregate statistics. The comparison of IT investment and productivity can give us an overview of the relationships between them.
Figure 1 plots the portion of IT investment in total private non-residential investment. Non-IT investments include items such as industrial equipment and various structures. The curve demonstrates a relatively constant increase of IT investment since 1960. In the year 1973, IT investment composed 15% of all investment in businesses. From 1974, this number has been increasing at an average annual rate of 3.8% doubling to 30% in 1991. As the curve displays, the slope becomes steeper between 1982 and 1991. During the 1990s, the amount of IT investment grew even faster. From 1991 to 1999, IT investment in billions of US dollars has increased from 181.4 to 406.9. (BEA. 2000). The overview of IT expenditure exactly verifies the surge of IT input usage in numerous individual companies.

On the other hand, the productivity growth rate is observed to experience a major slowdown since 1974. Figure 2 is a display of the labor productivity trend from 1960 to 1999. The average annual productivity growth from 1960 to 1973 is about 3 percent. While, in the next 20 years till
1995, productivity growth slowed down to 1.4 percent annually. In a few years, such as 1974, 1979, and 1980, productivity growth experienced negative growth. By comparing the slope of the curve before and after 1974, the productivity slowdown is clearly recognized. Only in the last 5 years, has productivity growth started to exhibit a constant increasing rate above 1.5 percent annually (BEA, 2000).

Figure 2: Productivity Trend

Nonfarm Business. Output per hour of all persons 1992=100
Major Sector Productivity and Costs Index.

Figure 3 compares the IT investment growth rate and the productivity growth rate since 1961. Before the mid-1970s, productivity displayed continuous growth while IT investment growth remained at a low level. However, IT investment started to grow tremendously since the late 1970s, when productivity hardly showed any sign of growth. In the 1990s, IT investment began another round of fast accumulation while productivity growth advanced at a 2% annual rate since 1996.
Figure 3: Comparison of IT Investment Growth and Productivity Growth


Note:
1. IT investment include all private investment in computer, peripheral equipment, software and other information processing related investment in US dollars. The IT investment growth rate is annual percentage increase from the previous year.
2. Productivity growth rate is annual percentage increase form the pervious year based on the data from Figure 2.

These statistical analyses do not demonstrate a strong positive relationship between IT investment and productivity growth through the last 40 years. However, given the technological capabilities and strong intellectual support provided by information technology, people would like to believe that IT should be the most powerful stimulus of economic growth. Whether IT investment is the driving force of productivity growth is actually a big debate among both researchers and managers.
The Productivity Paradox

In a 1993 article, Eric Brynjolfsson uses the word “productivity paradox” to describe the fact that growth in IT expenditure has not raised the economy’s aggregate productivity performance, as was assumed it would (Brynjolfsson, 1993). Later, the term was to describe the same situation within firms. Robert Solow, a Nobel Laureate economist, concluded, “PCs are showing up all over the place, except in productivity statistics” (Solow, 1987). Other economists also came to similar conclusions based on their research outcomes.

Roach, who has long been engaged in IT productivity studies, pointed out that IT investment has not generated the anticipated improvements in productivity according to the statistics (Roach, 1991). In Weil’s survey of technology managers in U.K banks, eighty percent of the respondents indicated that IT technology had fallen short of expectations (Weill, 1988). Similar results were reported in a study of Canadian Banking industry, according to Parsons (Parson, 1990).

Since IT investment consumes a great amount of government and business income, it becomes very important for investors to understand whether it can drive economic growth or it turns out to be simply a fashion. As Daniel E. Sichel wrote in his 1997 book:

\[
\text{If information technology is not a magic bullet, however, then future productivity gains would have to come about through more traditional}
\]
means, including increases in saving and investment, intensified research and development, improved education and training, and managerial advances. For these reasons, policymakers, business managers, and the general public must have realistic expectations about how great an aggregate economic boost information technology might impel (Sichel, 1997).

Traditionally, most analyses on the IT investment/productivity issues are based on production theory using the Cobb-Douglas functions; they are often categorized as traditional approaches. Usually, a macro-level analysis applies input-output production models to study the relationship between IT investment and aggregate output. The share of IT equipment in the capital investment, and the return earned by such equipment are often used as indicators of the benefit of IT investments. In most cases, the results generated from this such research demonstrates IT’s incapability in fostering productivity growth. Sichel’s econometric study is typical of the traditional approach.

In his study, Sichel first used a neoclassical framework, and assumed optimal business investment decisions and equal marginal competitive returns for all types of capital investment. In addition, he studied “supernormal returns” (private returns exceeding competitive rates and benefit spillover) and “welfare effects” (depreciated output and consumer surplus) related to IT investment. When measuring the returns, he gave full consideration to all of the computing services and goods, including hardware, software, and computer-related labor. However, telecommunications is beyond the scope of this study.
Results from the neoclassical framework show that between 1987 and 1993 computing services contributed 0.31 points to 2.0 percent annual growth in output. After adjusting for depreciation cost, computing services’ contribution is even less, becoming 0.15 out of 1.6 net output growth. The author explains that computing services’ contribution (one-sixth of gross output growth and one-tenth to net output growth) is a moderate one. However, compared to the dramatic slowdown of productivity, this contribution remains “too small to have reversed the decline” (Sichel, 1997). Therefore, the computer revolution has not resulted in the expected tremendous boost to aggregate productivity growth.

The IT investment decision is a critical issue for businesses. To assist their decision making process, studies on the disaggregated level of the firm are more relevant. Firm level analysis provides closer observations about how efficiently IT is being applied and what the resulting welfare effects are; effects that have eluded aggregate analysis. One example of the firm-level analysis using traditional approaches is the research done by Gary W. Loveman. He uses a data set containing data from 1978 to 1984 at the business unit level for U.S and Western European manufacturing companies.

Similar to other research, Loveman applied production theory and quantitative methods to model the relationship between IT and productivity. In this case, the author uses the Cobb-Douglas production function with both IT and non-IT related factors as the independent variables, and he performed a regression analysis. The central finding is that for this sample model, IT capital stock had little, if any, marginal impact on output or labor productivity growth; whereas, all the
other inputs into production—including non-IT capital—had significant positive impacts on output and labor productivity. In short, profit-maximizing firms in this sample would have been better off investing their marginal dollar in non-IT factors of production.

Any research method will be built on certain assumptions, use certain methodologies and data, and generate limited results and implications. The research on the IT investment and productivity reflects the situation. The next section of the report investigates why the productivity paradox exists.

Explanation of the paradox

Given the sluggish productivity growth in spite of the IT investment explosion, senior managers may become confused about how much should be invested in IT and the expected pay-off. To assist business decision-making on IT investment, more is needed than just the statistics generated from certain approaches. In reality, there are as many studies explaining the limitations of the traditional approaches to studies using them to reach conclusions.

Many explanations of the paradox actually stem from the special nature of information technology itself. Information technology is not only an innovation of technology; it is a very unique type of technology distinguishable from steam, diesel, electrical, or nuclear technologies. In the other four technology systems, the high power levels are embodied in machinery, which is basically used to substitute for manual work. Information technology does not possess a high
power level to manipulate massive physical objects. Instead, information technology presents electronic power, which employs information, utilizes intellectual labor, and generates knowledge. This feature suggests that traditional labor-productivity focused approaches that are used to capture the capability of those “powerful” technologies might not work well with information technology.

As introduced earlier, information technology integrates physical equipment, intangible pieces of information, and intellectual property. A typical information system implemented in firms is used to collect, process, store, and disseminate information to support decision-making, control, analysis, and for visualization. In this context, information becomes a special economic commodity. Its creation and spread largely relies on physical equipment, such as computer hardware and peripherals. However, its value is independent of the existence of the physical component of IT. The central value of information lies in its assistance in generating correct knowledge for efficient operations within the firm. In addition, it can be reused, spread, and spilled over easily, which benefits economic activities through its efficiency, quality and variety.

Given these intangible features of information, it becomes very hard to translate all the value into numbers. Moreover, since the value of information is self-determining, it does not necessarily come with physical inputs. Whether the firm is able to benefit sufficiently from the supposed value of information is largely determined by IT investments and management approaches.
Based on IT’s unique characteristics, many clarifications and hypotheses are presented to solve the productivity paradox. Most of them focus on why the rate of return earned by IT investment does not show up in statistics (Banker, Kaufman, Mahmood, 1993; Mahmood, Szewczak, 1999). There are mainly four categories of explanations:

1. Improper measurement

Traditional approaches, such as Sichel’s study discussed earlier, have a large reliance on quantitative methods. However, given information’s unique characteristics, much of the invested IT might have resulted in something intangible and hard to measure. Thus, it is very possible that the measured return is less than the actual return. In addition, this kind of analysis requires a large amount of data to produce accurate and representative estimates in aggregate or firm-level studies. Nonetheless, even the most basic data of output and IT input is hard to find, let alone the data that are used to control for exogenous factors. These limitations often greatly reduce the effectiveness of quantitative models.

In the last section, Gary W. Loveman’s firm-level analysis was reviewed. Yet the author himself expresses strong concerns about the methodologies he applied. He wrote:

There’s no doubt that the sample used in this study is not representative and is drawn from a difficult time period. The exclusion of nonmanufacturing firms ignores the majority of firms and employment and thus fails to consider this performance in industries such as financial services, for which the gains may have been substantial.
Regression techniques are in principle, appropriate, but the model specifications are sufficiently imprecise and the data sufficiently noisy for the econometrics to be incapable of extracting the true relationships. (Loveman, 1994)

2. Improper management

One type of improper management is reflected by underestimating the true cost of IT investment and overconsuming information. According to a 1995 report, large companies spend nearly $4000 every week to maintain each personal computer (Forrester Research, 1995). This number is far beyond a normal manager's estimate of the costs. Mahmood and Szewczak’s research show that managers overconsume information because there are no explicit measures of information value.

Another type of improper management is very normal in companies. In short, it is a mismatch of the chosen IT investment and the existing organization structure and strategy. Since information is a type of intellectual property, it has to be properly integrated with a structure to exploit its value effectively. Yet, in many companies IT investments fail to unite with the business strategy, human resource management and resource allocation. This is an apparent factor leading to the insignificant productivity growth from IT stock. Interviews conducted by Loveman (1994) show that inadequate organizational structures and poor capital budgeting are the two interrelated central problems that have limited the returns from IT.
3. Time lag

The time lag hypothesis argues that it takes a long time for companies to learn how to integrate information technology into their organizational structure. New technologies always need a period of time to be mastered and used effectively within a firm. These factors determine that there will be a time lag between IT’s first investment and the start of earning higher rates of return. Paul David uses an analogy to explain this reason. He observes that it took over 40 years after the first electric motor was installed before managers designed plants to take advantage of this technology (David, 1989). Similarly, IT may exhibit the same phenomenon. Therefore, a comparison of current costs to current benefits could give misleading information that IT investment is incapable, even though firms would eventually earn competitive or better rates of return on these investment in a long term.

4. Redistribution

The redistribution effect refers to the fact that IT can generate a great deal of private benefit to firms without adding to overall output. (Brynjolfsson, 1993). This is especially true in the financial services industry. According to Sichel’s findings, computers are primarily being used to redistribute profits among traders rather than to generate greater output of financial services. The effect is that it produces large private returns and small social returns.
There are other explanations which are discussed in a broader context instead of just examining the returns earned by IT investment. For example, one opinion says that there are other factors offsetting the potential growth brought about by IT inputs, so that overall growth appears sluggish. Alternatively, another opinion observes the small share of computers in overall capital stock, and argues that the overall economic growth would be limited by IT’s modest size relative to all other capital.

Although the efforts to solve the productivity paradox do not provide a firm conclusion that IT is worthwhile as a type of investment, they have demonstrated the imperfectness of traditional approaches and provided other valuable insights on this issue. For example, given IT’s special features, other measures besides quantitative ones should be adopted. Also, good or bad management could make a great different in realizing the value of IT. These are very useful pieces knowledge in helping firms further understand the feature and function of information technology, and fully exploit its value.

New Approaches and Insights

Through their research, many scholars have realized that the study of the IT investment-productivity relationship is still at an immature stage. (Banker, Kauffman, Mahmood, 1993; Lucas, 1999). Traditional approaches of measuring such returns have not been very successful in detecting the full value of IT investment within firms. In addition, since the 1990s, information technology has evolved to an upper phase characterized by the integration of office and
production technologies. Consequently, information technology has become more complex and difficult to handle in terms of measuring the return of the investment and deciding a proper budget plan for it.

To assist firms in making better decisions, fresh insights and approaches have been introduced. Many of these ideas have broadened the vision on the true value brought about by IT investment to the firm, and generated new frameworks for measuring such values. Various methods have been adopted besides quantitative ones, which are much closer to firm level analysis. Numerous results from this research have turned out to be contrary to the traditional ones, which may explain why companies continue to invest large sums in IT.

Traditional approaches focus on the quantitative return or productivity that IT has contributed to the economy or firm. Contemporary approaches first reexamine any improvement (including various forms of qualitative returns as well as quantitative ones) that IT investment can bring to the firm. They use the term “value” and have tremendously broadened the range of “return”.

Lucas (1999) argues that information technology produces value in many different dimensions. Not all types of value can be embodied quantitatively and show up in financial returns. Customer loyalty, due to a convenient online product investigation network, is very hard to detect quantitatively. Not implementing an ATM system may make a bank less competitive than its rivals and thus lose its market share. Faster access to certain information provides greater intellectual support to decision making, which can help businesses succeed by making better
strategic decisions or avoiding potential losses (Lucas, 1999). There are countless contributions made by IT investment. In explaining the productivity paradox, the special features of information technology are found to be important. Because information technology often generates intangible benefits to the firm, and many benefits cannot be observed in a short term period, the true value brought to the firm cannot be reflected simply by current financial returns or by calculating output per unit of input in the monetary form.

To approach the different dimensions of value produced by information technology, Lucas develops an IT Investment Opportunities Matrix. In this matrix the generally defined IT investment is divided into different categories. Each category of IT investment has different features in terms of its measurability and potential return. The following examples of some categories indicate how complex and multidimensional IT investment can be.

1) Infrastructure, such as Wide Area Network (WAN), enables the firm to take on new opportunities in the long run.

2) Required managerial control, such as the Occupational Safety and Health Administration system, generates almost no return, but possibly avoids fines for noncompliance.

3) No other way to do the job, such as air traffic control, which has to rely on a computerized system.

4) Systems that can generate direct return, such as just-in-time production systems, are not hard to measure and have the highest possibility of returns.
5) Systems that mainly generate indirect returns, such as computerized reservation systems used in travel agencies. Such systems obviously provide customers with more convenience, and increase the company's competitive advantage in the long run, but it is very hard to measure their contribution.

6) Competitive necessities, such as bank ATMs and e-commerce. This type of investment is a necessity for companies to be competitive and retain market share. In the mean time, it generates other benefits. For example, the Chairman of Nationsbank indicated that by installing a few hundred ATMs, about 150 branches were closed, which brought about a substantial cost reduction (Lucas, 1999).

Banker, Kauffman and Mahmood (1993) argue that there is no single approach to measure IT investment returns, because the issue is too multidimensional to allow a simple analysis. Therefore, all possible measures such as quantitative, qualitative, and process measures should be used in combination.

Given the various types of IT investment, most studies only focus on one specific type of IT investment. Elizabeth Towell points to the importance of intangible benefits from innovative Internet applications. In an earlier survey conducted with her co-researcher, over 85% of IT managers were found to have adopted the Internet, and about 20% strongly believe that they would realize significant business value from Internet investment. Most IT managers are unable to evaluate the contribution of Internet investment to their organizations. Towell argues that the use of Internet access in an organization is not a solution to a single problem or opportunity, and
thus should not be evaluated in an isolated situation. Internet plays a three-dimensional role, generating three levels of values, namely, business value, strategic value, and enterprise value. Usually, only business value is counted in financial measures. Towell argues that cost and benefit relationships should be considered for all three levels. For example, enterprise costs (e.g. training needs and employee dissatisfaction), and enterprise benefits (e.g. information empowerment of employees for decision-making) should be compared. On the basis of some case studies, she believes that a successful utilization of the Internet is able to show positive returns in all three dimensions of value.

Likewise, Chrys de Almeid and Elizabeth Kennick provide a framework for measuring the value of “CARVE”, a decision support system supporting the mortgage-backed securities at Morgan Stanley. Similarly, this is a framework for measuring different dimensions of payoffs at the knowledge worker level, business process level, and firm level. The authors maintain that senior management should not make investment decisions simply based on firm level macro measures. They should pay more attention to benefits which are subtle and indirect or which may be substantive over the long run.

Sanjay Singh reports on an empirical study involving 51 North American companies which tests various measures of Executive Information System (EIS) success. Direct measurement of EIS benefits is often difficult to attain since they are generally intangible and difficult to quantify. In addition to traditional measures of EIS, such as user acceptance and satisfaction, a service quality measurement called GAP is computed by analyzing the difference between the factors
motivating development of an EIS and the actual support provided to those factors by the system. The results of hypothesis testing and GAP analysis suggest that EIS are being used to support the implementation and control aspects of the strategic management process and that improvement is needed in supporting organizational objectives, environmental scanning, and strategy formulation.

Another notable feature of some type of IT investment is that it will not fully demonstrate its value in a short-term. As Lucas indicated in the IT Investment Opportunities Matrix, IT infrastructure is such a type of investment. A typical firm invests 1.7 percent of revenues on average over five years in IT infrastructure. This amount is 43 percent of the firm’s total IT investment. As the author points out, it is not very likely that a typical firm will gain a return of more than 40 percent of the IT budget. Apparently, IT infrastructure is not something that will be consumed in the short-term. However, it is able to provide the organization with many opportunities using advanced technologies for taking initiative in competition. It also provides the company with strong flexibility for handling unexpected events. In short, a great part of the returns will only show up in the long-term. Noticing this feature, a large-scale study of 25 companies for three industries and four continents are conducted. The overall results suggest that infrastructure does provide firms with opportunities (Weill, Broadbent and Butler, 1996). Another study of the Intranet (Internet within an organization) based on a survey of 41 companies show that 78 percent have positive returns in the long-term. (Meta Group Research, 1999)
These new approaches and insights on measuring IT investment returns are very specific and concrete. They are not as quantitative as the traditional models, but they do provide valuable approaches and important evidence on certain issues. Following the method of these contemporary studies, a study on e-commerce and its payoff to firms will be carried out in the next section.

**Internet E-commerce Payoff Measurement**

Today, electronic commerce is frequently mentioned in both the business community and the academic world. Though it only came into being in the late 1990s, its rapid growth and fundamental change in the way of doing businesses has attracted tremendous attention. To provide a concrete example of how to evaluate the IT investment payoff, Internet e-commerce is chosen for a close investigation.

*An Introduction of Internet E-commerce*

The emergence of Internet electronic commerce has proven to become a significant contribution of the continuous advancement of information technology. In 1969, ARPA net, the precursor of the Internet was brought up to the world. Twenty years later in 1989, the World Wide Web software and HTML language were invented at the University of Illinois. Since then, the Mosaic browser and Netscape Navigator browser have been released in 1993 and 1994. Immediately after all the necessary technology became available, some innovation takers started the first trial
of Internet e-commerce. Aggressive companies like Dell, Cisco and Amazon stepped into the new way of doing business in 1995. During the next five years, due to the liberalization within the telecommunication sector and the development of network technologies, such as fiber optic and digital subscriber, the Internet availability to businesses has tremendously expanded. As a result, numerous Internet-based companies emerged. In addition, more and more traditional businesses are also pursuing e-commerce to stay competitive.

In order to investigate and estimate the value of e-commerce related investment, it is essential to define e-commerce in the first place. Since e-commerce is in its infant stage, definitions vary greatly depending on the source. These are some current definitions. The 1997 OECD working paper presents a relatively complete description of e-commerce by showing a topology of definitions. A narrow scope only includes business-to-customer and business-to-business electronic transactions, which usually are based on open networks. It is also the youngest form among all types of e-commerce. A broader definition will include the activities in supporting the electronic infrastructure, such as all types of equipment and access providers. The broadest definition adds all other electronic transactions, typically including Electronic Fund Transfers and Settlements (EFT) and all credit/debit card transactions. These forms of e-commerce have existed for decades (OECD, 1997).

In this paper, the scope of e-commerce will follow the narrow definition. In other words, the focus will be on business-to-customer and business-to-business electronic transactions based on open networks. Open networks are often referred to in comparison with closed networks. The
The infrastructure for Internet e-commerce encompasses an extensive range of information technology components. Hardware, software, networks and supporting technologies are all
required. However, such an infrastructure is not only used for e-commerce purposes in most cases. This fact is especially true for physical investments such as PCs, routers and servers. This can be related to previously discussed opportunities that IT infrastructure can provide. Therefore, e-commerce can be regarded as an opportunity for fully exploiting the IT infrastructure investment. To be noted, when estimating the cost of e-commerce, the total cost of the hardware can not simply be assigned to e-commerce.

*Measuring Internet E-commerce*

Various contemporary studies in measuring IT investment have identified the difficulties of fully capturing the value of these investments (Mahmood, Szewczak, 1999). There are quality and other intangible or indirect values, which are difficult to quantify. There are also long-term benefits, which will not be evident at the time when the information technologies are invested.

As far as Internet e-commerce investment is concerned, through the survey of business news (Gleckman, 1993; Violino, 1999), the three major impacts it brings to firms are cost, customer relationships, and competitiveness. Among these, the latter two are usually hard to measure. In other words, customer relationships and competitiveness constitute the typical indirect or intangible values gained from e-commerce, which is obviously a great portion of all the benefits. In addition, because it is a new and immature product, large samples of data are hard to gather. Thus, statistical analysis and general trend study based on large samples can hardly be performed.
to provide systematic evidence. Any framework of estimating investment payoff needs to take these problems into account.

The research results of many studies indicate that one key advantage of e-commerce versus traditional commerce is the better service quality it brings to customers rather than a lower price of the product or service it delivers. (Keen, 1992; OECD, 1999). Traditional approaches usually use the price of a product or a type of service to count for the actual value of them. However, the price indicator can not fully reflect quality and efficiency. We can tell that shopping online provides more convenience to people who do not have enough time to go normal shopping, even if they are charged the same price for the same product. This perspective partly explains why IT investment does not show distinct benefits in monetary output. Therefore, output price should take quality factors, such as timesaving, lower transportation cost, into account to improve the effectiveness of using it as an indicator.

At the current stage, the price of electronically sold products does not show a significant gap in comparison with regularly sold products (Chait and Glass, 1997). However, the advantage of e-commerce exists in the fact that it can remove time and location constrains inherent in traditional commerce (especially in retail), and provide greater varieties. It is apparent that customers tend to choose what brings more convenience and variety. However, the quality features are difficult to capture empirically. Many quality improvements and greater choice possibilities for customer are beyond the current price statistics. It is possible that if such gains were measured, industry productivity statistics would show a notable change. As far as a firm is concerned, increased
revenue and market share can reflect quality improvements, though they do not necessarily translate into profits. As seen by all, more and more enterprises are resorting to e-commerce today. A key reason is that they have realized that e-commerce can significantly improve quality, and better quality helps establish healthy and long-lasting customer relationships, which finally leads to more sales, revenue and a larger share of the market. A 1999 survey from Information Week including 500 companies, indicates that on average, 21 percent of their total revenue is drawn from e-commerce transactions, and 81 percent of IT executives believe that improved customer satisfaction and repeat business is a key contributor to their business benefits (Violino, 1999).

The competitive impact brought about by e-commerce is even harder to measure. It is often combined with business innovation and strategy, and can be reflected in the firm’s ability to generate innovative ideas and product and service improvements, willingness to take greater risks, business expansion, flexibility and adaptability to new and unexpected situations, etc. These elements are essential to the success of businesses, but usually show up in the long run. Meanwhile, they are not directly related to the scope of quantitative input-output productivity measures. Their value is represented by the fact that they are important factors in determining the company’s ability to achieve pecuniary benefits, which eventually falls in the productivity or financial return scope. Due to the indirectiveness and long-term effect, it is almost impossible to use traditional quantitative models to depict the benefit of competitiveness brought by e-commerce investments. In addition, as Lucas’s IT Opportunity Matrix indicates, e-commerce is
becoming a competitive necessity of companies. Thus, the cost of not implementing e-commerce should also be taken into account.

Besides the difficulties inherent in e-commerce, there are also a few practical problems. The young age of e-commerce is one of them. Internet investment for e-commerce is only five years old. E-commerce still constitutes a small percentage of all business transactions. Systematic statistics on e-commerce implementation are scarce. Also, when focusing on an individual firm, a few years of e-commerce implementation cannot demonstrate all the benefits in the long run. Meanwhile, the majority of firms which perform e-commerce are small businesses. Even the famous Amazon.com only had 151 employees in 1997 (SEC, 1997). In addition, many of those firms are not publicly traded, making it difficult to track the relevant data for studying investment payoffs.

Another notable problem is that traditional commercial activities are seen to blend with Internet e-commerce since more businesses have started to implement e-commerce together with old ways of doing business. Thus, e-commerce activities may not be clearly separated from traditional activities in the company account. This will, at least to some degree, affect the accuracy of relevant data and measurement of e-commerce benefits.

To summarize, the impact of e-commerce within firms is multidimensional. Pure quantitative measures, such as return on investment or labor productivity are not adequate for tracking intangible benefits. Moreover, at the embryonic stage of e-commerce, the amount, range, and
accuracy of relevant data are insufficient to carry out a complex empirical study. It is for this reason that the scope of this study is restricted to establishing a theoretical framework to integrate each and every possible economic impact brought by e-commerce, where various quantitative, qualitative and process methods should be adopted when applicable.

Internet E-commerce Payoff

The motives for firms to engage in e-commerce generally fall into three categories: cost reduction, better customer relationships, and increased competitiveness. They are related to each other and all will eventually contribute to the goal of gaining benefits to the firm. To evaluate the overall payoff of Internet e-commerce, all three sources of benefits should be tracked and combined. Meanwhile, new costs of investment will also emerge. Just as with benefits, the costs could also be tangible and intangible. Under these circumstances, a cost/benefit analysis could be applied as the theoretical background. Many researchers have used it to evaluate other types of IT investments for its capability of measuring intangible benefits. Traditionally, a cost/benefit analysis is very quantitative-oriented; however, subjective judgment and utility measures are introduced to animate qualitative evaluations.

A critical issue in measuring costs and benefit is that a time lag must be integrated into this framework. For example, the various costs and benefits do not happen at the same time. Also, some benefits and costs come as a lump-sum at one specific time, while others extend to the
future. Therefore, when comparing the costs and benefits, a short-term vision will probably be misleading, because of the ignorance of some components that will only show up in the long run.

Based on cost/benefit analysis, three steps are recommended in evaluating e-commerce payoff to the company. The first step is to identify all the costs and benefits possibly involved in the e-commerce application. A complete consideration of each and every possible cost/benefit item is the heart of this framework. The second step is to measure all the identified items. Certainly, the difficult task is to translate each intangible cost/benefit into quantitative or qualitative terms, or a combination of both. In measuring them, a time factor should be considered to adjust the short-term and long-term difference between those cost/benefit items. Finally, the generalized cost and benefit will be compared at two levels.

Step 1: Identify all costs and benefits

Generally, the costs of e-commerce application will be tracked along two lines: tangible and intangible costs. The tangible costs are those associated with purchasing the technology and human intellectual support, including capital and labor expenditure. Typical capital costs include computers, servers, routers, e-commerce support software, and Internet line leasing fees. Labor costs basically fall into technical support staff and logistic support staff. The regular salary, benefits and training costs for the staff all belong to this category, because they are directly reflected in monetary terms in the company’s account. There could be other types of costs
depending on the specific e-commerce application. For example, business to customer e-commerce dealing in tangible goods will induce shipping costs.

Among intangible costs, learning and adjustment costs associated with implementing the technology constitute a significant component. The learning cost exists in everyday business practice, but does not often appear on the financial account. Learning costs happens at two levels. One is at the employee level. It takes a long time for employees to acquire necessary skills and know-how to fully utilize a newly implemented e-commerce and maximize the potential payoff. Even the training costs will not represent all the learning process. The other is at the organizational level. Likewise, an organization needs to adjust its existing systems, structures and culture to the new e-commerce solutions. Learning costs are hidden in this process. Some typical examples could be: Internal customers and users of the Internet system complain about the system when they feel uneasy to use it, due to it being time-consuming, confusing or there is no significant output from it. Managers are not clear about how much they can get from it and in what way they can make the best use of it. Another source is the new transaction costs peculiar to e-commerce application. Since on-line activities imply potential risks for any involved party, not being trusted represents loss of profit. The company must identify the intangible sources of costs to get a complete picture of it.

To be noted, many companies who engage in Internet e-commerce already possess a great deal of IT infrastructure, such as computers, servers, WWW browsers. To implement e-commerce, there is no need for extra heavy capital investment. Instead, the use of e-commerce helps fully
exploit the value of these existing IT investments. This can be regarded as an extra benefit of e-commerce. This helps explain the long-term benefits of IT investment, such as the flexibility it brings to the company.

The benefits of e-commerce applications will be captured through three major sources: cost reduction, better customer relationships, and increased competitiveness.

Cost reduction is the most important tactical benefit of conducting e-commerce. Usually, e-commerce displays strong strength in reducing sales costs, procurement costs, delivering costs and low-skilled labor costs. Many statistics can prove this. Examples are showed in table 2 and table 3.

Through online ordering system and online after-sale service, costs in physical establishment (e.g. shopping stores), selling and purchasing order, inventory carrying, distribution of intangible goods (software, financial service, travel, etc), and related labor are tremendously trimmed down. Depending on the line of business, there could be other specific cost reductions because e-commerce has streamlined the traditional way of doing business to a great extend. To be noted, cost reduction through e-commerce is applicable to companies who implement e-commerce to replace their existing traditional business system. For companies who start as an e-commerce doer, such as Amazon.com, cost savings compared to similar business would rather be considered as one of its competitive advantage.
Table 2: Cisco’s e-commerce customer support cost savings

<table>
<thead>
<tr>
<th>Cost Source</th>
<th>US $ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product manual printing cost</td>
<td>270</td>
</tr>
<tr>
<td>Software distribution</td>
<td>130</td>
</tr>
<tr>
<td>Telephone technical support</td>
<td>125</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>525</strong></td>
</tr>
</tbody>
</table>

Meeker, 1997

Table 3: E-commerce impact on various distribution costs

<table>
<thead>
<tr>
<th></th>
<th>Airline tickets</th>
<th>Banking</th>
<th>Bill payment</th>
<th>Software distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional system</td>
<td>8.0</td>
<td>1.08</td>
<td>2.22 to 3.32</td>
<td>15.00</td>
</tr>
<tr>
<td>Telephone-based</td>
<td>0.54</td>
<td></td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Internet-based</td>
<td>1.00</td>
<td>0.13</td>
<td>0.65 to 1.10</td>
<td>0.20 to 0.50</td>
</tr>
<tr>
<td><strong>Saving(%)</strong></td>
<td><strong>87</strong></td>
<td><strong>89</strong></td>
<td><strong>71 to 67</strong></td>
<td><strong>97 to 99</strong></td>
</tr>
</tbody>
</table>

OECD, 1999

E-commerce’s improvement in customer relationship is especially evident in business to customer type. First, customers have an open store to visit at any time. It is easy to access, saves time and provides a great variety of choices. The better quality of service can make a big difference in the degree of customer satisfaction. Second, an open store avoids geographic
restrictions and can be accessed by millions of people around the world. Apparently, it becomes much easier for the company to attract new customers and expand its influence. Third, on-line transaction also improves the accuracy of placing orders, customer support and product distribution. For example, Cisco managed to reduce the order placing error rate to 2 percent through the replacement of e-commerce to fax and phone in order placing. In evaluating e-commerce payoff, it would be deficient if these benefits were not identified.

E-commerce is able to increase business competitiveness in many ways. Cost reduction and excellent customer service can both be strong competitive advantages for a company. The ability of e-commerce to bring customers and business partners closer can greatly increase the efficiency of business processes. Through the Internet, design by demand becomes possible and customer preference is easy to gather. This presents a typical transformation of traditional commercial activities. The company’s flexibility and adaptability to new and unexpected situations are increased by quick response to real-time information. E-commerce also makes a company’s globalization easier to manage because of its ability to overcome geographical constraints. Additionally, as e-commerce grows, companies who do not implement it could face a severe competitive disadvantage. The potential opportunity cost of not doing it has to be identified, too.

Step 2: Measurement of identified items
In measuring all the cost and benefit items, the company’s financial statement usually can reflect all the tangible components, such as capital cost, and cost reduction compared to their old system. Intangible and indirect components are the critical issues to investigate. Among these, some can roughly be measured in available numbers (e.g. market share reflects customer relationships), while others will rely on subjective judgment.

The learning cost is one of the most difficult items to measure. However, companies will notice its impact without a doubt. Both theory and empirical results show that the adoption of a new technology tends to lower productivity in the short-term, even though it raises productivity greatly in the long run. The shape of the learning cost curve is represented by curve P in figure 1. The curve is increasing at a diminishing rate, indicating more learning costs will happen in the short-term than in the long run.

Learning costs vary in different companies. They are largely determined by management capability, organization and employee adaptability, which in general can be called learning ability and speed. Some empirical research studies found that IT capital intensity is positively
correlated with learning ability and speed, because companies with faster learning ability tend to accumulate more IT capital (Ahn, 1999). However, this is not adequate and accurate for measuring learning costs. Senior managers should be consulted.

Among the benefits, customer relationships and competitiveness are indirect. Better customer relationships should eventually be translated into sales and revenue. The strategic effect of competitiveness should lead to business expansion, more innovations and continuous development. Since their benefits are indirect, measuring revenue, productivity and profitability in the short-term may not completely capture all the benefits they generate. Therefore, a long-term, for example, a 3-year, 5-year or 10-year cumulative measurement of tangible benefits should be kept.

Step 3: Cost and benefit comparison

Costs and benefits need to be compared in order for one to decide whether the Internet e-commerce investment has paid off. Nonetheless, all the measures are not identical in monetary terms and only part of the costs and benefits can be pooled and compared. These are usually direct and short-term factors at a tactical level. Part of the indirect and intangible items such as customer satisfaction can also be quantified to monetary terms and join the comprehensive comparison. However, the learning costs, customer and competitive impacts can only be accurately measured in the long run at a strategic level.
Summary and Conclusions

Investment payoff analysis has long been utilized at the firm level to assist in decision-making. Traditional approaches, such as regression analysis, production functions, and return on investment, have been very useful in measuring productivity and profitability of many traditional capital investments such as machinery and vehicles. As information technology investments increase, greater attention has been given to the power of the new driving force. A number of empirical studies have utilized the traditional approaches to test IT investment and its contribution to productivity and profits. However, in Eric Brynjolfsson’s word, a “productivity paradox” was discovered. Until recently, IT expenditures did not show up in terms of a positive impact on the economy’s aggregate productivity performance as was assumed it would.

In justifying the presence of the productivity paradox, the empirical results from the traditional methodology are questioned. The root cause lies in the special features and functions of information technology and the way it is transformed to productivity and profitability. The traditional methodology fails to capture all of them, and thus the results and conclusions from it may be incomplete and inaccurate. This fact suggests that it is essential to understand the unique nature of information technology to measure its payoffs.

In brief, information technology is not a technology which supplies physical power, but rather intellectual support. The efficiency in business processes, knowledge support, and better quality can not be directly translated into traditional numeric measures. This is a mismeasurement.
problem that is inherent in the traditional approaches. Since information technology can lead to profound changes in organizations, there is quite an elaborate process for IT investments to integrate with existing systems, where the mismanagement problem arises. This also points to the problem of time lags between investing and reaping the benefits.

The dominate explanations of the productivity paradox, namely, mismeasurement, mismanagement, and time lags, also provide valuable insights into how to build better ways to capture intangible benefits and long-term effects. Many contemporary approaches are beginning to take these issues into account. They are a number of valuable theories and frameworks for providing a better understanding of IT investment and measurement. A few are worth mentioning:

1. Information technology produces value with several different dimensions.
2. Information technology is becoming a part of the business strategy.
3. Tracking indirect and intangible values of information technology is a critical step to approach a more accurate estimate.
4. There is no single solution to measure various dimensions of IT investment benefits in different business environments.
5. The level of business activities makes a difference when measuring the costs and benefits of IT investments; such as the business value, strategic value, and enterprise value as suggested by Elizabeth Towell.
Contemporary approaches usually do not use an aggregate analysis; they focus on a specific type of IT investments, industries, and firms. In addition, many methodologies include non-quantitative measures, such as qualitative and process measures. The result is that the contemporary approaches are multidimensional. Empirically, a number of applications have identified a positive relationship between IT investments and productivity or profitability. Still, no one can assert that these contemporary approaches will produce accurate results, although they appear to be an improvement over the more traditional approaches to conducting cost/benefit studies.

Applying theories and methodologies of contemporary approaches, Internet e-commerce was chosen as the object in the investment payoff analysis. Studying the nature of e-commerce and the process of investment-payoff transformation turns out to be a critical step in defining a way to obtain actual measurements. E-commerce has profoundly changed a series of business activities, including sale, marketing, procurement, product design, distribution, etc. The extensive influence makes it a part of the business strategy and even a competitive advantage. These complicated impacts of e-commerce are certainly not easy to be measured. Plus, a longer term is needed for observation, so that relevant data can be accumulated and brought to the analysis.

The Internet e-commerce was found to have powerful impacts on business activities in three dimensions: cost, customer relationships, and competitiveness. The payoff analysis should be centered on these impacts, because they are the differences made by e-commerce. Among the
three, customer relationship and competitiveness constitute the typical indirect or intangible components. Therefore, effective measures must be developed to capture them.

The solution for the Internet e-commerce case is decidedly based on a cost/benefit analysis. Various quantitative, qualitative, and process methods should be encouraged whenever they are applicable in evaluating a particular cost or benefit. The purpose of this report was not to provide empirical results, but rather to establish a theoretical framework for evaluating Internet e-commerce. The main reason for not conducting an empirical study was lack of relevant data. However, future empirical tests of the framework can be performed when e-commerce and related investigation become more mature and visible to the public.

A three-step testing framework is recommended. Briefly, it includes the identification of each cost/benefit, the translation of each item, and the comparison at different levels. The objects are the costs (tangible and intangible costs) and benefits (cost reduction, better customer relationship, and increased competitiveness). The detailed analyses of this Internet e-commerce framework again suggests the necessity of capturing the full impact of IT investments.

As far as the framework itself is concerned, the analyses and methods in each step are based on the special features of e-commerce and the way it works in real world applications. This attests to the validity of the framework foundation. Admittedly, since no empirical study is involved, its ultimate remains to be demonstrated.
In today’s competitive business environment, companies must make better decisions on IT investments and know how to get the highest returns from it. Senior managers who are in charge of information technology systems must make efficient overall business strategies to be successful. A thorough understanding of the characteristics of information technology investments is the basis for managers to make correct decisions.
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