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A Comprehensive Model of Information Technology
Value Creation in the Supply Chain

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Abstract

Investments in Information Technology (I.T.) continue to grow, yet there continue to be doubts regarding the economic benefits of I.T. This paper researches prior work into what constitutes I.T. value and how I.T. creates value.

Two general approaches predominate the literature on researching I.T. value - the micro economic production theory approach and the firm level process oriented approach. The micro economic production approach investigates the impact of multiple inputs (such as I.T. investment) on some output measure (such as productivity) using economic production theory techniques. This approach implicitly assumes usage of the I.T. investments. Because this approach fails to consider the usage of I.T. within the business, it lacks explanatory power in identifying how I.T. impacts firm level results.

The firm level process oriented approach provides an explanation of how and why I.T. value is created because it considers I.T. usage in the business. This paper focuses on the process oriented approach and reviews prior work in this area. A comprehensive model of I.T. value building on prior work is presented.


ISRL Categories: AD0517, AF0401.01, AM02, AD0102.

Introduction

Investments in Information Technology (I.T.) in the U.S. exceeded $500 Billion Dollars in 1995 and are expected to continue to grow. (U.S. Commerce Dept, Bureau of Economic Analysis). The magnitude of this investment is enormous yet there continues to be doubt regarding the anticipated economic benefits of I.T. (Barua, et al, 1995). Organizations are spending more and more on I.T. and there is little to show for it in the output statistics... empirical studies undertaken by I.T. researchers have yielded mixed results (Soh and Markus, 1995).

Over the last decade the “I.T. Productivity Paradox” fueled a quest for economic analysis to determine a link between I.T. investment and productivity, and I.T. investment and profitability of a firm (Brynjolfsson, 1993; Brynjolfsson and Hitt, 1996,98; Dewan and Kraemer, 1998; Berndt and Malone, 1995; Lee and Barua, 1999).

Prior research failed to find convincing evidence that I.T. investment is always associated with superior performance (Weill 92). Recent findings by Brynjolfsson and Hitt (1998) suggest that I.T. investment is associated with increased output (thus refuting the so called “I.T. Productivity Paradox”), but I.T. investment has not been associated with increased business value. Mixed empirical results are an invitation to seek better theory (Soh and Markus, 1995). In fact, there is little consensus about the nature of I.T. value, or whether I.T. is capable of creating value... nor has a comprehensive framework of I.T. business value emerged (Mooney, et al, 1996).

Statement of Problem

HOW is value created through the investment and usage of Information Technology ? Understanding this, how can the organization create value using Information Technology (I.T.) within the firm, and across firms in the supply chain ? (The transactions within and across firms constitute the supply chain.)

The Concept of I.T. Value

Value is a multi-dimensional concept which has both social and economic dimensions. The social dimensions of value consist of expressive characteristics which are generally intangible and sensory based. The economic dimensions consist of tangible and economically based characteristics (Babbie, 1995). The concept of I.T. value within a business is generally accepted as having instrumental characteristics (tangible / economic). These are evident in prior studies considering the many forms of I.T. value (as the dependent variable), such as return on assets (ROA), profitability, inventory turnover, capacity utilization, productivity improvement, market share, shareholder value, etc (Weill 1992, Barua 1995, Strassmann 1990, and others). As an economic instrumental concept that is applied within a business process approach, I.T. value may be described as: the economic impact realized through a firms’ usage of I.T in the supply chain.
There is a distinction between “value of I.T.” and “value derived from I.T”. Both are economic instrumental characteristics of I.T. value. The latter clearly implies usage. In the former case, “value of I.T.” often can be interpreted as the asset cost – or economic investment.

Two general approaches predominate the literature on I.T. value - the micro economic production theory approach and the firm level process oriented approach. The micro economic production approach investigates the impact of multiple inputs (such as I.T. investment) on some output measure (such as labor productivity or profitability) using economic production theory techniques (Mukhopadhyay and Cooper, 1993; Brynjolfsson, 1993; Brynjolfsson and Hitt, 1996,1998; Lee and Barua, 1999). This approach implicitly assumes usage and fails to consider the context of I.T. within the firm, hence it lacks the explanatory power to describe the sources of I.T. value (Lee and Barua, 1999).

The firm level process oriented approach provides an explanation of how I.T. value is created through an analysis of the I.T. impacts on organizational processes. Impacts on performance resulting from I.T. usage can be explained through a chain of relationships from I.T. investment, deployment of I.T. assets, to usage of those I.T. assets resulting in economic impacts (Lee and Barua, 1999). Mooney, (1996) suggests that the process oriented studies provide the ability to move beyond correlational evidence to explanations of how I.T. produces value.

Usage of I.T. is a necessary but not sufficient explanation for firm level impact (Soh and Markus, 1995). I.T. usage has two aspects - one is effective utilization in the “task, technology fit” (Goodhue, 1995), and the other is satisfying the objectives of the business processes.

**Multiplicity of Approaches to I.T. Value**

Venkatraman (1994) presents an enterprise level economic framework which focuses on I.T. enabling business transformations and relates I.T. value to the organization through two dimensions. The first dimension describes the range of I.T. potential benefits, and the second is the degree of organizational transformation. I.T.’s potential value increases as I.T. enables organization transformations through five levels. Benefits from I.T. are marginal if only superimposed on existing organization conditions (Venkatraman 1994). These five levels are summarized in table 1 below:

<table>
<thead>
<tr>
<th>Levels of I.T. Enabling Business Transformation</th>
<th>Description and Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Localized Exploitation</td>
<td>Productivity improvements</td>
</tr>
<tr>
<td>2. Internal integration</td>
<td>Product design (reduce time to market) focus is on technical interconnectivity instead of process interdependence</td>
</tr>
<tr>
<td>3. Business Process Redesign</td>
<td>Design for Manufacturability within a firm, redesign processes with a focus on business process interdependence</td>
</tr>
<tr>
<td>4. Business Network Redesign</td>
<td>Supply chain management</td>
</tr>
<tr>
<td>5. Business Scope Redefinition</td>
<td>New business transformation</td>
</tr>
</tbody>
</table>

Table 1, Venkatraman’s Levels of I.T. Enabling Business Transformation, 1994


Common elements of I.T value are the form of I.T. impacts (for example, productivity improvements, 2 Weill and Broadbent (1998) consider a fourth and separate type of investment – infrastructure investment – which enable future application and technology investments for the firm. In Weill’s prior work this type of investment was included with the Informational investments.
elimination of tasks, cost reductions, to supporting the development of a new product or channel for distribution, reducing time to market in product development, to better decision making…) and the scope of impact (for example, within the four walls of the firm as in Venkatraman’s levels 1-3 above; or the greater reaching impacts of I.T. on the supply chain within an industry – Venkatraman’s levels 4 and 5.)

I.T. Value’s Evolution into a Firm Level Issue

In 1937 Coase recognized the transaction cost as a key element of analysis within and across firms. There is a cost associated with transacting business between firms and a different cost for transacting business within the firm. This observation is still relevant today as I.T. is utilized to minimize transaction and process costs, and accelerate the exchange of information across the supply chain. Williamson (1976) extends this and considers “information impact” and the acquisition costs of information as an additional element of transacting business.

These early findings identify two fundamental elements in considering I.T. value in relation to transaction costs – information gathering in and around the business transaction, and carrying out the transaction itself.

Porter’s Value Added Chain

Porter’s value chain analysis is one the earliest frameworks considering the role of I.T. in supporting and 1 Historically, I.T.’s role in adding value in the context of the firm’s supply chain has been to seek out the recurring, repetitive transactions and automate the informational component of them thereby increasing their speed, accuracy and/or timeliness – initially within a firm (payroll, time and attendance, labor reporting, inventory, etc…..) and then across firms - (order entry, accounts payable, purchasing, accounts receivable and so on….). Here in begins to emerge some competitive differentiators in the usage of I.T. - best in class practices would do these transactions very well, with a minimum amount of data entry, minimal or no rekeying, and integration between upstream and downstream activities needing the information. Last in class practices would involve frequent rekeying, poor integration between upstream and downstream users of the information, unreliable data transfer, and poor information content causing a great deal of human intervention to transact business. Clearly, these differences in usage need to be discerned to understand the impact of I.T. Understanding the usage of I.T. is critical to knowing how I.T. value is realized through its support, or failure to support the business processes.

creating competitive advantage (Mooney, 1996). The framework allows analysis into how I.T. may affect nine specific activities. Five of these address production and distribution activities: inbound logistics, operations, outbound logistics, marketing and sales, and service. The other four address support activities: human resources, procurement, firm infrastructure, and technology / product development (Porter, 1985).

Porter’s framework can be extended to identify opportunities for inter-organizational supply chain management improvements. Evans and Wurster (1997) recognized the different, but distinct life cycles that information and the product have along the value chain. I.T. has the capability of creating value for both the information value chain and the product value chain.

This is significant because Porter’s framework and Evans and Wurster’s extension provides a holistic view to analyze I.T. value for a firm. Information can flow throughout the supply chain independently from the flow of the product. Exploiting this can lead to a deconstruction of the traditional value chain for many service and goods providers (Evans and Wurster, 1997). This suggests that I.T. has the potential within the supply chain as both a competitive weapon and a competitive threat for a firm.

Prior Work and Development of Models of I.T. Value

Soh and Markus’s synthesis of a process theory for I.T. value cites five prior research models on I.T. value - Lucas (93), Grabowski and Lee (93), Markus and Soh (93), Sambamurthy and Zmud (94), and Weill (92). Common elements of these models are synthesized into a process theory structure to explain how I.T. creates value2 and suggest new lines for empirical research.

1 Historically, I.T.’s role in adding value in the context of the firm’s supply chain has been to seek out the recurring, repetitive transactions and automate the informational component of them thereby increasing their speed, accuracy and/or timeliness – initially within a firm (payroll, time and attendance, labor reporting, inventory, etc…..) and then across firms - (order entry, accounts payable, purchasing, accounts receivable and so on….). Here in begins to emerge some competitive differentiators in the usage of I.T. - best in class practices would do these transactions very well, with a minimum amount of data entry, minimal or no rekeying, and integration between upstream and downstream activities needing the information. Last in class practices would involve frequent rekeying, poor integration between upstream and downstream users of the information, unreliable data transfer, and poor information content causing a great deal of human intervention to transact business. Clearly, these differences in usage need to be discerned to understand the impact of I.T. Understanding the usage of I.T. is critical to knowing how I.T. value is realized through its support, or failure to support the business processes.

2 Soh and Markus then explain that variance theories excel in explaining variances in magnitude of outcomes, when the outcome is certain; but where outcome is uncertain as in the results of an I.T. investment, process theories provide explanations even when causal elements are not sufficient to produce the outcome. In cases of outcome uncertainty, process theories have been shown to have distinct advantages over variance theories (Markus and Robey, 1988). They claim the appropriate theoretical approach is process theory for this research area. Citing Lucas, value is achieved through appropriate use of I.T. A necessary condition for I.T. value is a well designed I.T. - but that is not sufficient for an outcome. Variance theory assumes and requires necessary and sufficient causal conditions to produce outcomes. Process theory on the other hand is an appropriate formulation technique (Mohr, 1982). They go on to clarify this - “…Generally speaking, conditions that are only necessary but not sufficient do not make for very satisfying theories because they allow for the possibility of other, more powerful causal factors to
Soh and Markus’s process oriented model in figure 1 is shown below:

![Figure 1. How I.T. Creates Business Value: A Process Theory (Soh and Markus, 1995)](image)

One revealing aspect of the model is that I.T. investment alone does not lead to organizational performance – its use must be considered. This is to emphasize that economic studies, although valuable, provide inadequate explanations into how I.T. value is created. The middle process of connecting I.T. assets to I.T. impacts is not well understood – particularly in areas such as what constitutes 1.) appropriate use; 2.) how use differs depending on the types of I.T. investment; 3.) skill in using I.T. (Soh and Markus, 1995).

The process oriented approach of Mooney (1996) provides a richer explanation of the usage impacts on operational and management processes. As I.T. is diffused further and deeper into the organization, the value of I.T. in affecting these activities and processes increases. This coupled with transformations in the organization and process improvements supported by and caused by I.T., further enhance I.T.’s value impact. (Mooney, 1996)

Mooney adopts Davenport’s (1993) classification of processes into operational and management. Operational processes are “ those that embody the execution of tasks comprising the activities of an organization’s value chain… In effect, operational processes constitute ‘doing of business’. Management processes are those activities associated with the administration, allocation, and control of resources within organizations”.

Mooney’s process oriented model relating the I.T. impacts on these operational and management processes to organizational performance is shown in figure 2 below:

**Figure 2. A Process Oriented Model of Business Value (Mooney, Gurbaxani, Kraemer, 1996)**

The effects of I.T. impacts are recognized at these operational and management processes, not the organizational level. Attempting to measure I.T. impacts directly at the organization level bypasses these processes where I.T. value is created (Mooney, 1996).

I.T. can have three separate but complimentary effects on business processes. It is through these effects that I.T. creates value. Automational effects refer to the efficiency aspects of the role of I.T. substituting for labor. Informational effects emerge from I.T.’s abilities to collect, store, process and forward information. Transformational effects are value derived from I.T.’s enabling ability to facilitate process innovation and transformation (Mooney, 1996).

The effects created through the impacts of I.T. are summarized in table 2 below:

<table>
<thead>
<tr>
<th>Business Processes</th>
<th>Automated</th>
<th>Informational</th>
<th>Transformational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Labor costs</td>
<td>Utilization</td>
<td>Product innovation</td>
</tr>
<tr>
<td></td>
<td>Reliability</td>
<td>Wastage</td>
<td>Cycle times</td>
</tr>
<tr>
<td></td>
<td>Inventory costs</td>
<td>Operational flexibility</td>
<td>Customer relationships</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>Quality</td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>Administrative costs</td>
<td>Effectiveness</td>
<td>Competitive flexibility</td>
</tr>
<tr>
<td></td>
<td>Control, reporting</td>
<td>Decision quality</td>
<td>Organizational form</td>
</tr>
<tr>
<td></td>
<td>Routinization</td>
<td>Resource usage</td>
<td>Creativity, empowerment</td>
</tr>
</tbody>
</table>


The framework identifies how I.T. creates value through these effects and offers an understanding of I.T. impact on business value. The approach moves away from firm level output measures (particularly financial measures) towards process oriented measures. Assessing specific I.T. effects and measuring those still needs further research (Mooney, 1996).
Explanatory Model of I.T. Value Creation

Building on these models by Soh and Markus, and Mooney, figure 3 below is an explanatory model of how I.T. creates value in a firm and across firms through its impacts in the supply chain.

The cycle begins with the strategic plan for both I.T. and the business. Management approval establishes authorization for I.T. investments. The I.T. investments become I.T. assets through a group of factors Weill (1992) collectively refers to as “conversion effectiveness”. I.T. value impacts are realized by appropriately using the I.T. assets in the organization’s supply chain. Through this usage, I.T. impacts effect the operational and management processes in the firm as well as non value added business activities. Barua (1995) found that I.T. impacts result from “first order effects” and those in turn lead to higher order benefits. First order effects are usage at or near the point where the technology is implemented which results in direct benefits such as productivity improvements, substitution or elimination of labor, and cost reductions as examples. The I.T. investment for an MRP system in a manufacturing firm is an example. Initial, first order benefits may include reductions in inventory and improvements in overall capacity utilization, which in turn yields a higher return on assets (second order effects) (Barua, 1995).

The model in figure 3 refers to I.T. potential value as I.T. enabled transformations of the business. This distinguishes the potential value these transformations may yield from the operational impacts realized through “appropriate usage”. The I.T. enabled business transformation will have some future I.T. value impact after the transformation is completed, implemented, and usage of the transformed process begins. At that point appropriate usage commences and automational / informational I.T. impacts in the newly transformed organization supply chain are realized.

In figure 3, alignment is a mechanism to close the loop on this I.T. value cycle. Tallon (1998) defines strategic alignment as the extent to which I.T. strategy supports and is supported by the business strategy. Alignment provides feedback for the continuing process to review the investment cycle, identify opportunities for greater I.T. value in the supply chain, or transform the business through the enabling capabilities of I.T. (Venkatraman 1994, Mooney, 1996). Management practices act as the alignment mechanisms that deal with translating strategic choices into administrative and operational practices (Henderson and Venkatraman, 1993).

The I.T. impacts may (or may not) influence organization performance. I.T. impact is only one of many factors influencing organization performance. These other factors include the competitive environment, organization environment, and management focus.

Observations and Conclusions

This paper began with an examination of Coase’s recognition that analysis of transaction costs within and across firms was a key element back in 1937. This remains the cornerstone of I.T. value creation and analysis in the supply chain. The model in figure 3 presents an explanatory model of how to create I.T. value for a firm using Porter’s value chain framework, with Evans and Wurster’s extension as the backdrop to focus on supply chain opportunities.

The formal public domain (Davis and Olson, 1985) of I.T. value has been given attention, but areas of I.T. value that have remained unaddressed are the domains of informal public, formal private, and informal private. These domains contain characteristics and dimensions of value – specifically to information gathering, decision making, and data analysis.

Second, more work needs to be done analyzing I.T. in terms of constituent components – specifically data and information content; the delivery system (technology itself); and application (process) function support. Analyzing I.T. as these components will yield greater understanding into how I.T. creates value. Most analysis appears to consider the application (process) interaction alone. This presumes that the data and information

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1 It is my opinion that most of the literature on I.T. value assumes I.T. consists exclusively of the formal public domain.
content is satisfied and that technology delivers the process. These assumptions ignore the value aspects of technology providing accessibility to data and information outside of a process. This has value implications in its support of decision support analysis, and information gathering. The study of usage type, and system domain will add dimensions to recognizing how I.T. usage creates value for a firm.

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