Business Value of Information Sharing and the Role of Emerging Technologies

by

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Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things.

Sir Isaac Newton

To the one to whom I owe all.

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Abstract

Information Technology has brought significant benefits to organizations by allowing greater information sharing within and across firm boundaries leading to performance improvements. Emerging technologies such as Service Oriented Architecture (SOA) and Web2.0 have transformed the volume and process of information sharing. However, a comprehensive understanding of how information sharing beyond firm boundaries results in business value is still lacking. This dissertation explores the business value of information sharing beyond firm boundaries and the role of emerging technologies in driving the business value.

The dissertation consists of three related parts. The first part builds a taxonomy and research model of business value of information sharing beyond firm boundaries. This provides a broad framework for studying the phenomenon and identifies research gaps. Two empirical studies then follow to address two of these research gaps.

The first empirical study is a cross-sectional analysis that looks at information sharing with suppliers and the impact of SOA in moderating the impact of transparency and complexity of information sharing processes on supply chain efficiency as measured by inventory and accounts payable. Results show that SOA use mitigates the negative impact of complexity of information sharing process on supply chain performance. However, SOA use also reduces the positive impact of information sharing transparency.

The second empirical study is a longitudinal analysis that considers an Internet based peer to peer financial market and the decision making by market participants based on shared information. The results show that the group decision making has significant error compared to an efficient benchmark. The quality of decision making improves with time as a result of learning and with increase in information availability. The study shows that improvement in quality of decision making follows a punctuated equilibrium model.

This dissertation contributes to research by building an inter-disciplinary research model of business value of information sharing beyond firm boundaries and studying the impact of process characteristics, technology architecture and decision making processes on business value of information sharing. Dissertation results provide a framework for future research and for managers to design and manage information sharing beyond firm boundaries using emerging technologies.

CHAPTER – 1

Introduction

The role of Information Technology (IT) in how organizations operate, communicate and interact is rapidly changing. IT, from its humble beginnings as simple transaction processing machines, has grown to incorporate new roles such as: process enabler, innovation platform, collaboration mechanism and electronic marketplaces. We live in a networked world of ubiquitous connectivity, computing clouds and real time information sharing. Firms are spending billions of dollars to leverage the ever increasing capabilities and reach of IT to derive business value. However, as the nature and role of IT in organizations is changing, how IT drives business value is changing as well.

Historically, the emphasis in "Information Technology" has been on the "technology" part. Traditionally firms have looked at how the technology part of IT could lead to business value – faster hardware could bring down process execution times, smarter software could detect efficiency improvement opportunities, ubiquitous communication networks allowed flexible work arrangements and so on. The focus is now shifting to the other part of IT – information. Firms are dismantling information barriers within the firm, functional silos are being removed to enable complete

information visibility and new business models are emerging that take information sharing within and across firm boundaries to new levels. Success stories such as open source software, electronic markets and total supply chain visibility depend on using IT to share vast amounts of information with partners, suppliers, customers and even general public.

Research on business value of IT has traditionally focused on the technology element. Previous studies have looked at how IT leads to business value through adoption of specific systems, IT investments or efficient use of IT artifacts. However, how the other element of IT – information, leads to business value is less well studied. Even the sparse research interest on information sharing and its effect on business performance have mostly concentrated on information sharing within the firm. Information sharing beyond firm boundaries is increasing rapidly and is supported by emerging technologies such as Service Oriented Architecture (SOA) and Web 2.0. This dissertation explores the phenomenon of information sharing beyond firm boundaries with a focus on how it results in business value and how emerging technologies influence the business value of information sharing beyond firm boundaries.

The dissertation consists of three related studies that explore how information sharing beyond firm boundaries result in business value in the context of emerging technologies. The first study integrates relevant previous research to builds a taxonomy and a research framework to study business value of information sharing beyond firm boundaries. The research model is used to identify potential research gaps. Two of the research gaps are studied in the two empirical studies that follow. A brief overview of the three research studies that comprise the dissertation is provided next.

Study 1: Business Value of Information Sharing beyond Firm Boundaries: A Taxonomy and Research Model

Different aspects of business value of information sharing beyond firm boundaries have been studied independently in many different research streams such as operations management, management information systems and business strategy. This study integrates relevant previous research and insights from contemporary practice examples to build a taxonomy and overall research framework for studying business value of information sharing beyond firm boundaries.

The study identifies four components of how information sharing beyond firm boundaries leads to business value: information sharing context, information sharing process, information sharing environment and actions based on information shared. Important constructs and issues in each component are identified along with their potential impact on the business value of information sharing beyond firm boundaries. Individual components, constructs and potential relationships are integrated into a broad framework for studying the business value of information sharing beyond firm boundaries.

The studied identifies research gaps for future research to address. Specifically, two research questions are identified for further exploration through empirical studies that form the next two parts of the dissertation.

Study 2: Impact of SOA Use on Performance Outcomes of Information Sharing in Supply Chain

The second study in the dissertation focuses on the process of information sharing with suppliers and the use of service oriented architecture as the technology platform to enable the information sharing. This chapter integrates insights from extensive previous research in operations management literature regarding information sharing in supply chain, management information systems research regarding inter-organizational information systems and nascent research on integrative technology platforms like SOA to build a research model of interaction between "what" information is shared and "how" it is shared. The research model is tested using Seemingly Unrelated Regression (SURE) on a cross sectional dataset of large publicly listed US firms.

The results show that increasing the amount of information shared (transparency) has a positive impact on business value of information sharing. However, the study also finds that use of SOA in supply chain reduces the positive impact of transparency on business value. Further, results show that the complexity of information sharing process has negative impact on business value of information sharing and the use of SOA in supply chain is beneficial in mitigating the negative impact of complexity on business value. The study shows that elements of information sharing process (transparency, complexity) have a significant impact on business value of information sharing and the technology architecture used for implementing the process has a significant moderating impact on the relationship between information sharing process and business value of information sharing.

Study 3: Information Sharing and Decision Making in Peer to Peer Electronic Markets: Frictionless No More!

The third and the last of the research studies that form the dissertation focuses on decision making based on shared information in peer to peer electronic markets. Electronic markets are expected to have low transaction costs (friction) because of lower communication and coordination cost of market operations over the Internet. This study analyzes the quality of collective decision making by market participants as a source of friction in electronic markers.

Using longitudinal data from a peer to peer financial electronic market – Prosper.com, the research studies the quality of decision making by market participants over time. Using the anchor and adjustment theory of decision making with incomplete and uncertain information, the study develops a research model to study two mechanisms for improving quality of decision making – learning and information availability. The research model is tested using an ordinary least square (OLS) regression analysis of interest rates charged and a logistic regression analysis of loan failures in a 12 month observation period.

The study develops a measure of the quality of decision making by lenders in Prosper.com called "risk premium deviation". Risk premium deviation represents the absolute difference between actual additional interest rate charged for different risk factors and the risk neutral interest rate premiums that compensate for the increased risk of default resulting from the risk factors. Calculation of risk premium deviation at Prosper.com at different time periods show that a significant difference exists between the actual quality of decisions made and the best decision given the available information.

This error in group decision making represents a unique source of friction in electronic markets.

The study explores two mechanisms for improving the quality of decision making – learning and increased information availability. Using longitudinal data, the study builds examines the impact of learning over time and a sudden change in information availability. Results show that the evolution of the quality of decision making over time closely follows the punctuated equilibrium model. For a given information sharing regime, the quality of decision making improves with time and reaches an equilibrium level of quality. As the information sharing regime is changed via a sudden increase in information availability, the equilibrium is disturbed and another period of learning follows. The learning again reaches another equilibrium level. The results show that an increase in information availability results in a net improvement in the quality of decision making.

The three research chapters discussed above have significant implications for research on information sharing beyond firm boundaries and for practitioners involved in designing and managing such information sharing initiatives. The last chapter of the dissertation concludes the dissertation by summarizes the research and practice implications of the three research studies that comprise the dissertation.

CHAPTER - 2

Business Value of Information Sharing beyond Firm Boundaries: A Taxonomy and Research Model

2.1 Introduction

The old adage: "*Information is power!*" is representative of how information has traditionally been viewed: as closely guarded secrets, as assets that need to be protected and even as something to be hidden and disclosed only when mandated by regulatory requirements like financial disclosures. Giving voice to the dominant logic of the day, Richie Lowry remarked: "*secrecy maximizes the power potential of knowledge*". A popular example of this approach of closely guarding information within the firm is how Apple fosters a culture of secrecy. As the Wall Street Journal noted: "*Apple keeps customers, workers and business buyers in the dark, leading to frustration*" (Wingfield 2006). Starting from Apple's product development plans - even code names for future products, to the health status of CEO Steve Jobs, Apple has created such a culture of secrecy that the New York Times wrote that "… *to be blunt about it, ... Apple simply can't be trusted to tell [the] truth ...*" (Markoff 2005; Nocera 2008). Apple's products,

especially the software like the operating system for Macintosh, have been known to be closed systems that do not allow outside developers to create programs for the Apple platform. Similarly, Wal-Mart declines to share even aggregate consumer sales information with consumer information agencies and market research firms. Contracts signed by Wal-Mart suppliers forbids them to talk publicly about their relationship with Wal-Mart without permission (Fishman 2006). In case of Apple and Wal-Mart above, they indeed consider information to be power and do their best to keep all information contained within the firm boundaries.

On the other hand, numerous contrasting examples can be found of firms that are running more open and transparent businesses that share surprising amount of information with suppliers, partners, customers and even to general public. Peter Drucker identified information sharing as a key element of the "*new organization*" (Drucker 1988). Netflix shared 100 million movie ratings to anyone who wants to attempt building a recommendation system that can outperform the in-house system at Netflix (Hafner 2006). Google has shared the entire source code for Android, the operating system for mobile phones, as open source software that can be viewed, modified and further developed by any interested person (Claburn 2008). The business model of Prosper.com, a peer to peer financial market, depends upon sharing anonymized credit history details of potential borrowers and letting the distributed community of lenders make decisions regarding creditworthiness of the borrower (Hof 2006b; Kumar 2007a). Volkswagen is planning an all-glass assembly plant for its top-of-the-line model. The glass walls of the plant allow potential customers to see their car being built and provide literal transparency into the manufacturing process (Tapscott et al. 2003). Wal-Mart, contrary to

its popular image as a secretive organization, shares updated sales and inventory information with its supplier's systems so that they can make stocking decisions based in early sales data (Hammond 1993).

The examples above are a part of the growing trend towards firms sharing more information beyond firm boundaries to outside entities including suppliers, partners, customers and even general public. However, information sharing beyond firm boundaries is not without business objectives - it involves specific business benefits for the firm. Information shared by firms to an outside entity results into positive business value for the firm when the shared information is utilized by the entity to make decisions that positively influence the common operational elements between the firm and the entity. Increased information sharing beyond firm boundaries is enabled by recent advances in Information Technology (IT) that allow firms to share large volume of data with a large number of recipients at low cost. Technologies like Service Oriented Architecture (SOA) allow firms to seamlessly connect with corresponding systems on the suppliers or partners side and share information efficiently (Kumar et al. 2007b). Firms are also using recent development of interactive Web2.0 sites and social networking websites to share information with a large audience and encouraging the distributed audience to collaborate and make decisions that have positive business value for the firm.

Even though IT, especially emerging technologies like SOA and the Web2.0, is central in the growing trend of information sharing beyond firm boundaries and the resulting business value, there is little research that addresses technology's important role. Further, research on business value of information sharing beyond firm boundaries is dispersed across several different research streams such as Management Information

Systems (MIS), Operations Management, Knowledge Management, Business Strategy and Decision Sciences. It is important that the disparate research streams be integrated into a single vocabulary and a unified research model is generated that depicts the current level of understanding. This chapter addresses this need by building a taxonomy and an integrated research model of business value of information sharing beyond firm boundaries.

The rest of the chapter is organized as follows: the next section (Section 2.2) details the objective of building a taxonomy and the process used to generate the same in this study. Section 2.3 looks at different aspects of business value of information sharing across firm boundaries including practice examples and previous literature to develop an analysis framework. Section 2.4 through 2.7 discuss individual elements of the framework that are consolidated into an integrated research framework in section 2.8 that also identifies two research opportunities for empirical studies to follow. Section 2.9 concludes the chapter by identifying limitations of the study, future research and practice and research contributions of this study.

2.2 Taxonomy - Objective and Process

The word taxonomy is rooted in two Greek words: *taxis,* which means arrangement and *nomie*, which means method (TFD 2008). Thus, taxonomy essentially means the method of arranging a complex context under study. The concept of taxonomy in social sciences research is borrowed from the natural sciences, in particular biology, where taxonomy is a branch of biology that is concerned with classifying all species. Similarly, in this study, the objective of building taxonomy of business value of information sharing beyond firm

boundaries is to identify and classify relevant constructs that can impact business value of information sharing beyond firm boundaries so that we can develop a comprehensive research model to guide future research.

Previous research has used taxonomies for two main purposes: first to integrate large established research streams and identify common themes and research gaps and second to build a common understanding and vocabulary for an emerging research area. Research areas that have been studied in detail and depth for long often need a research effort to summarize the current understanding and reduce the expanded list of constructs and their relationships to their core elements. Such taxonomies have value as they identify the common themes through different views and allow a more coherent picture to emerge that provide a common understanding regarding essential constructs and their relationships with each other. For example – several taxonomies have looked to summarize the large research on Enterprise Resource Planning (ERP) systems including a taxonomy of players and activities across ERP life cycle (Somers et al. 2004), and a taxonomy of critical success factors (Al-Mashari et al. 2003). Miller et al. (1994) studied the established literature on manufacturing strategies and built a numerical taxonomy of manufacturing strategies using cluster analysis and identified three distinct clusters of manufacturing strategies.

Taxonomies have also been traditionally used in understanding and building the vocabulary for an emerging research area. As nascent research areas and the associated theories develop, taxonomies provide a formal description of constructs relevant to the emerging research area and the potential relationships between these constructs of interest. For example – as e-commerce was gaining popularity and new business models

for B2B e-commerce were being experimented with, Kaplan et al. (2000) provided a taxonomy of B2B business models. Such taxonomies provide a structure and common vocabulary for the growing discussion within the emerging research. Early taxonomies often become the reference work and lay the foundation for future research in the growing research areas e.g. (McGee et al. 1986).

Taxonomies are especially important for the information systems research as IS research has often been characterized as fragmented and theoretically scattered (Alavi et al. 1992; Orlikowski et al. 1991). After decades of research in core IS issues, the resulting large body of research is poorly integrated (Benbasat et al. 1999). As Larsen (2003) mentioned: "*for the field to move forward and have an impact on practitioners and other academic fields, the existing work must be examined and systematized*". This is especially true of research on information sharing as the large body of research is dispersed across different research streams.

This chapter uses a combination of the above two approaches to building taxonomy. We look at the established research area of information sharing and supply chain and use past literature to identify and formalizing the core constructs and relationships between them. We study the nascent research on information sharing beyond form boundaries in the context of emerging technologies like SOA and Web2.0 using contemporary practice examples and early research studies to formalize relevant constructs and relationships between the constructs and the business value. The integrated taxonomy is then used to discover potential opportunities for empirical research efforts that can then be further addressed by the chapters to follow in the dissertation.

2.3 Analysis Framework

Information sharing beyond firm boundaries encompasses very different objectives, processes, technologies and even regulatory requirements. We first extract the broad common themes to build an overall analysis framework that can guide the detailed work to follow later in this chapter. We begin by presenting the literature background for the study and introducing four contemporary examples of business value created by information sharing beyond firm boundaries.

2.3.1 Literature Background

Research on business value of information sharing beyond firm boundaries spans several research disciplines. For generating a taxonomy of constructs that are important in studying business value of information sharing, we surveyed the relevant literature in operations management, knowledge management, business strategy and information systems. The constructs identified through the survey were then aggregated into four different groups that represent four components of the business value of information sharing beyond firm boundaries. The four components are described below followed by a summary of the constructs identified and their literature sources.

Components of Information Sharing Beyond Firm Boundaries

The constructs identified through the literature review can be grouped into clusters of similar constructs. Each of these clusters can be considered a component of the overall process of business value of information sharing beyond firm boundaries. We have

grouped the constructs into the following four clusters: Origin, Process, Environment and Action. The four components are introduced below:

1. **Origin of Information Sharing**: The first component includes constructs that relate to the objective, enablers and constraints related to information sharing beyond firm boundaries at the firm sharing information. The three main elements of the origin component are the objective of information sharing, capabilities needed to effectively implement information sharing and the role of organizational culture in success of information sharing.
2. **Information Sharing Process**: The process of information sharing includes elements related to how information is shared. Important elements that are part of the process component are the degree of information sharing (transparency), the complexity of the information sharing process, richness of the information medium used for sharing information and the technology platform used to enable information sharing beyond firm boundaries.
3. **Information Sharing Environment**: Information sharing beyond firm boundaries is conducted within a regulatory and business environment that affects the resulting business value. Three main elements of the environment are regulatory concerns including privacy requirements, incentive alignment between information sharing firm and information recipients and the level of trust between the firm and information recipient. The environment component is crucial in determining the business value of information sharing as it affects the next component - actions taken based on the shared information.

4. **Action Based on Shared Information**: The firm shares information with the expectation that the recipient will use the information to take actions or make decisions that will result in business value for the firm. The quality of decision making by information recipient can have a significant impact on the resulting business value. Constructs that affect the quality of decision making include learning and information processing including information overload.

Literature sources for the constructs identified as part of the taxonomy are summarized in the table below (Table 1). The constructs are further discussed in detail later in the chapter.

Component	Construct	Literature Sources
Origin		
	Objective	Barrett et al. (1982): Managing boundary spanning processes; Malone (1987): Managing economic activity using markets; Bakos (1991b; 1998a): Electronic market based business models
	Capability	Barrett et al. (1982), Alavi et al. (2001): Technical capability – inter-organizational information systems, knowledge and content management systems; Widom (1995), Inmon (1996):Information capability - data warehouse and data mining
	Culture	Schein (1996), McDermott et al. (2001): Organizational culture as barrier to information sharing; Sunassee et al. (2002), Holsapple et al. (2000), Davenport et al. (1998): Overcoming

		cultural resistance to information sharing
Process		
	Transparency	Lee et al. (1997), Cachon et al. (2000), Lee et al. (2000b), Yu et al. (2001): Transparency in supply chain; Barua et al. (2004): Degree of information sharing in electronic integration with suppliers
	Complexity	Kim et al. (2006): Importance of complexity in information sharing process; Roberts et al. (2004), Bystrom et al. (1995), Plumlee (2003): Impact of complexity on performance
	Technology Platform	Barrett et al. (1982), Iacovou et al. (1995), Mukhopadhyay et al. (1995): Inter-organizational systems, EDI; Albrecht et al. (2005): Limitations of EDI; Murtaza et al. (2004), Lim et al. (2003): Service oriented architecture
	Media Richness	Mayer (2001), Card (1996), Pu et al. (2003): Advantages of visual interface; Moore (1989), Kozma (1991): Impact of interaction on learning and comprehension; Terdiman (2006), Wagner (2007): Visual interactive media like virtual worlds
Environment		
	Privacy Regulations	Milberg et al. (2000): Privacy regulations; Goodwin (1991; 1992), Phelps et al. (2000): Consumer concerns on privacy; (Hann et al. 2007): Overcoming privacy concerns
	Trust	Mayer et al. (1995), Schoorman et al. (2007):

		Integrative model of trust; Goffman (1971), Zucker (1986): Trust in economic transactions; Buskens et al. (2002): Improving the level of trust; Zaheer et al. (1998), Gefen et al. (2003), Ba (2002): Impact of trust on performance
	Incentive Alignment	Eisenhardt (Eisenhardt 1989): Principal agent conflict; Jensen et al. (Jensen et al. 1976), Holmstrom (Holmstrom 1982), Fama et al. (Fama et al. 1983): Efficient contracts for incentive alignment – outcome based and behavior based;
Action		
	Decision Making	Tversky et al. (1974), Einhorn et al. (1986): Decision making based on incomplete information – anchor and adjustment model; Resnick et al. (2000): Recommender systems to assist in decision making
	Learning	Tversky et al. (1974), Einhorn et al. (1986): Learning in anchor and adjustment model of decision making; Klayman et al. (1987): Drag effect in adjustment; Edmunds et al. (2000): Learning to process information
	Information Overload	Lewis (1996), Klapp (1986): Negative impact of information overload; Koniger et al. (1995): Information use limited by processing effort required; Edmunds et al. (2000): Mitigating information overload with learning.

Table 1: Theoretical Background for Research Framework

The four components and the constructs that comprise the components are shown in the figure below (Figure 1):

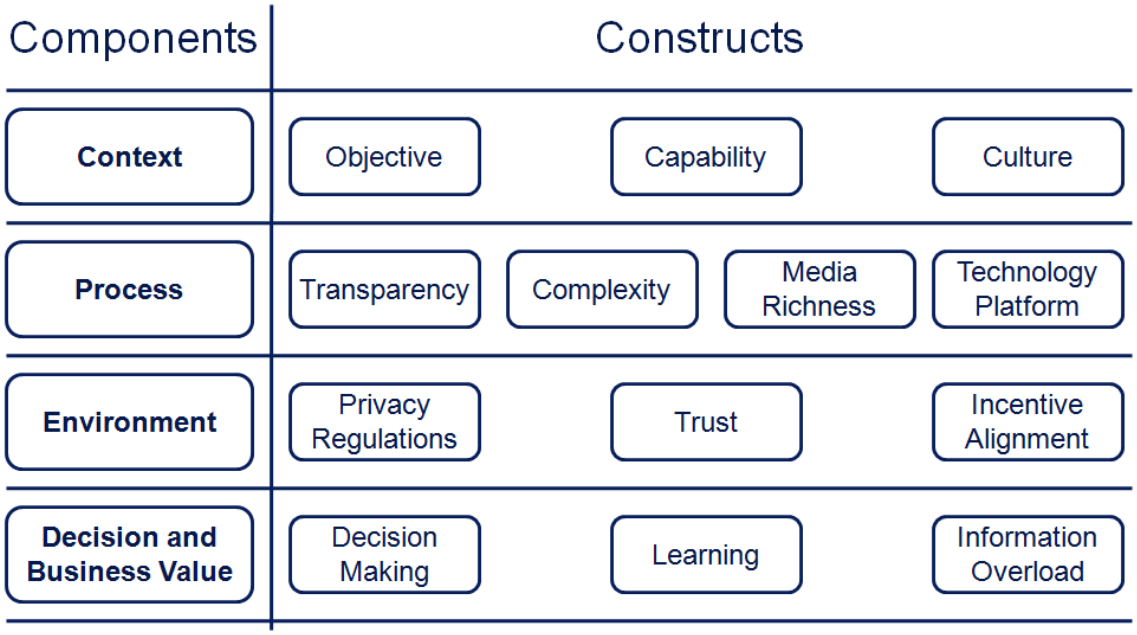

Figure 1: Research Framework – Components and Constructs

The next section discusses each of the constructs in detail including previous research and potential relationship between the construct and the business value of information sharing. The constructs are then illustrated using contemporary examples of Dell, eBay, Google and Prosper.com. The contemporary examples are introduced below.

2.3.2 Contemporary Examples

We consider four contemporary examples information sharing beyond firm boundaries: Dell, eBay, Google and Prosper.com.

Dell: Sharing Information with Suppliers

Dell Inc. is one of the world's largest manufacturers of personal computers (PC). Dell pioneered the direct marketing approach coupled with a make-to-order and just-in-time manufacturing system. Dell manufactures PCs configured to customer specifications that are manufactured after customer places the order. Dell has a very lean supply chain with less than 72 hours of inventory across its entire operation (Breen 2007). To achieve this Dell has developed extensive capabilities to share information related to quality, relationship management, design, daily production requirements and inventory levels even on an hourly basis with some suppliers (Magretta 1998).

As a customer places an order on Dell's website or other sales channels, the detailed order information is shared with relevant suppliers with details such as expected delivery lead times, component type and delivery destination. Based on the stream of real time information coming from Dell, the supplier can make decisions on its production schedule and batch size to ensure that the delivery is made on schedule without the need for excessive safety stock. Dell benefits by sharing information with suppliers as the orders are fulfilled on schedule while maintaining a lean supply chain with relatively little inventory.

eBay: Sharing Information with Customers

eBay is the world's largest Internet auction website. Millions of buyers each day bid on items put for auction by sellers on eBay. As buyers and sellers conduct business anonymously, the prospect of a dishonest buyer or seller is always around the corner. A dishonest seller can list a particular quality of product for sale and deliver an inferior

quality. Such dishonest participants in the eBay marketplace need to be identified otherwise unsuspecting market participants can fall victim.

eBay shares transaction histories of all buyers and sellers with all market participants in the form of a reputation system to help market participants identify dishonest buyers or sellers (Resnick et al. 2000). Information such as number of transactions, positive or negative feedback, membership duration etc are shared. Based on this information, market participants can make a decision about the reliability of other sellers or buyers and make appropriate decisions regarding whether to participate in an auction. This provides incentive for buyers and sellers to behave responsibly so as to not accumulate a negative reputation and provides an environment of trust in eBay among market participants.

Google: Android - Open Source Mobile Device Platform

Google is the world's largest Internet search and advertising company. Android is a software platform and operating system for mobile devices, initially developed by Google and later released as an open source software that can be downloaded, viewed, modified and further developed by anyone (Claburn 2008). Google also provides a SDK (Software Development Kit) so that independent developers can easily develop applications that run on Android. Google even offered prizes totaling 10 million USD for the competition called Android Developer Challenge, for the most innovative application for Android (Krazit 2008).

In contrast to other operating systems like Microsoft Windows, where Windows source code is jealously guarded by Microsoft; Google has released more than 11 million

lines of code for Android to public under open source licenses. Google's manager of mobile platform groups elucidated Google's approach: "*We feel fairly strongly, and it's resonating loudly through the industry, that innovation is maximized when no one entity controls a platform*" (Shankland 2008). The response from developers has been strong – within one week of launch, the number of applications available for Android increased from 62 to 167 (Siegler 2008).

Prosper.com: Information Sharing in Electronic Markets

Prosper.com is a peer to peer financial electronic market that individual lenders and borrowers to interact and transact in an eBay like online auction environment (Hof 2006a). Borrowers list their loan requests and lenders bid small amounts at a desired interest rate against the listing. If there are enough bids then the loan is originated at the lowest market clearing interest rate.

Peer to peer electronic markets like Prosper.com leverage the "new" Internet or Web2.0, to allow individuals to collaborate and harnesses the collective intelligence and decision making power of large groups of individuals (Oreillynet.com 2007). Prosper.com's business model depends upon sharing anonymized credit history details of potential borrowers with hundreds of thousands of potential lenders and allowing the distributed community of lenders to make decisions regarding creditworthiness of the borrower and the interest rate to be charged (Hof 2006b; Kumar 2007a).

Information sharing between Prosper.com and the lender group is central to the operations of Prosper.com. Interest rate charged in Prosper.com is an aggregation of individual interest rate decisions made by lenders. However, unlike a traditional bank,

lenders do not have access to information such as detailed credit reports, market research, loyalty programs or previous purchase history. Instead lenders depend on Prosper.com to provide them with information relevant to decision making and base their decision on the information shared.

Prosper.com has achieved significant success. It has more than 180,000 registered users with more than $6 millions in new loans being originated every month (Prosper.com 2007b).

The next section leverages the contemporary examples introduced above along with previous research literature summarized in Table 1 to discuss the constructs that form the four components of business value of information sharing beyond firm boundaries and their potential impact on the business value.

2.4 Origin of Information Sharing

The starting point for analyzing the business value of information sharing beyond firm boundaries is the information sharing firm itself. The firm makes decisions and choices in starting the information sharing that have significant impact on the other components and constructs of the business value of information sharing framework. Previous literature suggests that there are three important elements of the origin component of information sharing: the objective of the firm in adopting information sharing with outside entities, the capabilities required and available within the firm to manage information sharing and the organizational culture that support or inhibit information sharing beyond firm boundaries. The three elements are discussed in detail next.

2.4.1 Objective of Information Sharing

Previous research and contemporary examples indicate that firms share information beyond firm boundaries for three main objectives – managing boundary spanning processes, shifting from hierarchy to market for coordinating economic activities and adoption of market oriented business models.

Managing Boundary Spanning Processes

In case of information sharing with suppliers and partners that share a common boundary spanning process with the firm, the main objective of information sharing is to improve the performance of the process. A common example of such information sharing is between a firm and its suppliers. Suppliers and the firm share a common process and are partners in executing the process. Any improvement in how the process is managed benefits both the supplier and the firm. However, the supplier needs timely information regarding production schedules, inventory levels, new product introductions and promotion plans to maintain reliable supplies while keeping costs low. Management of shared boundary spanning processes is the earliest and most popular form of information sharing beyond firm boundaries.

As management of boundary spanning processes involve information sharing between two firms, integrative technology platforms that link the IT systems of firms and conduct the information transfer are crucial for achieving the objective of information sharing. The driving reason behind the popularity of inter-organizational information systems, systems that span the boundaries of two or more organizations and share information between them, has been the potential to improve inter-organizational process

efficiencies (Barrett et al. 1982). Early inter-organizational information systems like EDI and integrative architectures like SOA have been used extensively to support information sharing between firms for managing shared processes.

Managing Economic Activity Using Markets

Advances in IT have allowed firms to move parts of their operations outside the firm boundary. As firms outsource activities to market mechanisms, they need to share information related to the outsourced task. With growing business process outsourcing (BPO), information sharing with outsourcing vendors is also growing.

The move from organizing economic activities within the hierarchy to a market mechanism can be studied using the Transaction Cost Economics (TCE) framework. On one extreme, a firm could have all the activities within its boundary and operate as a hierarchy. On the other extreme, a firm could outsource most of the activities, except the core activities, and operate as a market (Williamson 1975). The trade-off between hierarchy and market is influenced by the two main costs involved: production cost and coordination cost. While hierarchies suffer from higher production cost, they have lower coordination cost. On the other hand, markets have lower production cost but higher coordination cost (Malone 1987).

Coordination cost includes elements like gathering and processing information, negotiating contracts and also costs to protect against opportunistic behavior by market participants. In their seminal work, Malone et al. (1987) note that advances in IT are likely to significantly reduce the cost of gathering and processing information and the coordination cost resulting from asset specificity and complexity of product descriptions.

As lower coordination costs favor markets as the mechanism for coordinating economic activities, the increasing use of IT is expected to lead to a shift towards the use of electronic markets rather than hierarchies (EMH – Electronic Markets Hypothesis) (Glassberg et al. 2007).

Increasing popularity of the new generations of web technologies like Web2.0 and social networking allow firms to reach a large number of potential market participants without incurring significant coordination costs. This allows firms to share the necessary information for conducting an activity and effectively move it to market rather than keep it inside the hierarchy. For example - Google could continue to develop the Android software in-house but by offering it as open source, it effectively outsources the future development of the system to thousands of independent developers.

Market Oriented Business Models

The shift from hierarchies to market discussed above seeks to outsource non-critical activities while maintaining core tasks inside firm boundaries. Market oriented business models, on the other hand, are designed to have the market conduct the core activities. Such business models, by definition, involve continued interaction with the electronic market participants and sharing large amounts of information with the participants so that they can successfully take actions or make decisions that form the core activity of the business model. The firm enables the market to efficiently conduct these essential activities by sharing the information needed and providing the tools needed to conduct the tasks.

Prosper.com is an example of market oriented business model. Prosper.com shares credit history information with independent lenders and let them make the decision on risk premiums to be charged to borrowers. This is a core activity in the lending process and usually done in-house in large banks and lending firms. The business model is enabled by sharing of information (in this case anonymized credit information) beyond firm boundaries with market participants.

Electronic market, as an early definition notes, is an inter-organizational information system that allows participating buyers and sellers to exchange information about prices and product offerings (Bakos 1991b). Since then electronic markets have grown in complexity and versatility. Bakos (1998a) later updated his definition of electronic markets to electronic systems that facilitate the exchange of information, goods, services and payments. Successful operation of electronic markets requires the market to share information with market participants. Information shared include such diverse elements as market activity history for recommender systems (e.g. eBay) and proprietary and confidential information that market participants need for conducting transaction but do not have access to themselves (e.g. Prosper.com).

Electronic markets based business models often call for high levels of interactivity. Business to Consumer (B2C) electronic commerce business models, like that of Amazon.com and Netflix.com, depend on their consumers to provide valuable contextual information for their products like reviews, ratings, discussions, recommendations and lists. To facilitate generation of such contextual information, firms share information that would normally be considered confidential and proprietary in traditional offline business models. For example – Amazon shares all product feedbacks

with customers - including negative feedback, Yahoo Auto allows buyers to check car dealer's invoice price and Google publicly shares the main basis for its search algorithm – the page rank for all web pages. Thus, operating market based business models is another objective that is driving information sharing beyond firm boundaries.

2.4.2 Information Sharing Capability

The business objectives behind information sharing beyond firm boundaries can be realized only if the firm possesses the requisite capabilities for conducting the information sharing activity. There are two aspects of the required capability: technical capability and information capability.

Technical Capability

Technical capability required for information sharing beyond firm boundaries include the necessary IT infrastructure such as inter-organizational information systems to connect with IT systems of information recipients (Barrett et al. 1982), content management systems and knowledge management systems to manage the information available (Alavi et al. 2001), and network connectivity to distribute large volumes of information to the intended recipients. Required technical capability would also include maintaining security of inter-organizational information systems and governance mechanisms to comply with relevant regulations such as privacy laws.

Information Capability

Information capability refers to the organization's ability to collect, store and retrieve in time the appropriate information as needed for sharing. Information sharing initiatives cannot be successful if the firm does not have reliable access to the information to be shared.

However, a typical large organization goes through millions of individual events every day that generate information - a bar code read on the sales counter, an inventory check in the warehouse or even a click on the website or online advertising. All these events generate information, typically in a form of event logs that can quickly become too large to effectively store, manage and retrieve. Further, as information is stored in different databases - a sales database for all sale events, a human resource database for all check-in and check-out information for hourly sales counter clerks so on, it becomes very difficult to provide integrated access to these multiple, distributed and heterogeneous databases. Building information capability to successfully capture, store and share information in a context of such information overload requires a data warehouse.

In case of a data warehouse, information from each source or database that may be of interest is extracted in advance and stored in a centralized repository along with all other relevant information. Any query is then addressed directly to this repository without accessing the original data sources (Widom 1995). As the data warehouse stores not only integrated data from multiple sources but also summary data and metadata, it sets the stage for effective data mining (Inmon 1996).

The three objectives identified above present a case for information sharing and the capabilities discussed above discuss the required capabilities for sharing information.

However, information sharing cannot be successful if the organizational culture does not support it.

2.4.3 Organizational Culture

Organizational culture is formally defined as: "*A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems*" (Schein 1996). As the definition suggests, organizational culture is a learned group behavior that perpetuates itself and directs the group's approach towards not only managing internal issues but also adapting to external changes. Organizational culture is reflected in the overt visible aspects of the organization, like its mission and vision. However, culture exists on a covert level as well and is demonstrated by how people act, what they expect of each other and how they make sense and react to of each other's actions. Organizational culture is rooted in the organization's core values and assumptions that are often not articulated and even inconsistent with the articulated mission or values (McDermott et al. 2001).

Research on Knowledge Management has studied the role of culture on information sharing in great depth, although mostly in the context of information sharing within the firm. Their conclusions can be extrapolated to information sharing beyond firm boundaries as well. The fundamental conclusion regarding the role of culture in information sharing and knowledge management is, as McDermott et al. (2001) mention: "*... however strong your commitment and approach to knowledge management, your*

culture is stronger". In an organization with an information sharing culture, information sharing would be expected and considered the right thing, rather than something the organization is forced to do. On the other hand, in organizations where the culture is resistant to information sharing efforts, whether within and beyond firm boundaries, it would be difficult to successfully implement such an initiative.

Previous research provides some directions on how the cultural resistance can be overcome. In a study of overcoming cultural barriers to knowledge sharing, McDermott et al. (2001) suggest that it is important to make a visible connection between knowledge sharing and tangible business goals and objectives. It is important that information sharing strategy be aligned with the overall business strategy of the organization (Sunassee et al. 2002). Top management leadership and support has been shown to be instrumental in success of knowledge management initiatives and can be expected to be crucial for the success of information sharing initiatives as well (Holsapple et al. 2000; Liebowitz 1999). Further, the organization needs to provide the required technical and organizational infrastructure for a knowledge management or information sharing initiative to succeed (Davenport et al. 1998). The technical infrastructure may include software, hardware and networking while organizational infrastructure may include clear articulation of individual roles and responsibilities including well defined processes and measurement systems and an incentive structure that supports knowledge management or information sharing (Holsapple et al. 2000). Experimental research suggests that individual attitudes towards information sharing is influenced by organizational norms such as organizational ownership of information (Constant et al. 1994).

2.5 Information Sharing Process

The origins of information sharing discussed above leads to the next component - the actual process of sharing information with entities beyond firm boundaries. The information sharing process stage includes the nuts and bolts – what information is shared (transparency), processes used to share information (complexity), what form is information shared in (media richness) and the technology platforms used to support the process (technology platform).

2.5.1 Transparency

The decision of how much information to share is central to the information sharing process. Transparency of the information sharing process refers to the amount or the degree of information sharing. An information sharing process with high transparency may improve the decision making by information recipient but sharing too much information can also lead to lower performance through higher cost of information sharing and information overload.

Previous studies in operations management and MIS literature have provided support for the positive impact of higher degree of information sharing. Barua et al. (2004) showed that electronic integration and information sharing with suppliers leads to performance improvement. Lee et al. (1997) showed that when only order information is shared through the supply chain, it misguides upstream members in their inventory and production decisions resulting in lower supply chain performance (bull whip effect). They argue that information sharing of sell-through and inventory status data can help in mitigating the bull whip effect and improve supply chain performance. Previous research

on information sharing in supply chain (Cachon et al. 2000; Lee et al. 1997; Lee et al. 2000a) indicates that higher transparency provides more information to channel partners to make optimal decisions, avoid distortion of demand data through bull whip effect and lead to higher supply chain performance. In a comparison of limited information sharing with full information sharing policy, Cachon et al. (2000) found that full information sharing leads to an average reduction of 2.2% in supply chain cost. Lee et al. (2000b) argued that advances in IT has allowed supply chain partners to operate in tight coordination through increased information sharing leading to performance benefits. Similarly Yu et al. (2001) showed that increasing information sharing among members of a decentralized supply chain leads to Pareto improvements in the performance of the entire supply chain.

Overall, previous research supports the argument that higher transparency in the information sharing process results in performance improvement for the process.

2.5.2 Complexity

The process of information sharing can be implemented in many different ways – real time access, customized reports, structured reports etc. This represents the "how" part of information sharing process compared to the "what" part represented by information sharing transparency discussed above. The current research has focused more on "what" information to share and there is less emphasis on looking beyond just the degree of information sharing and consider the context as well, which has been identified as a research need (Kim et al. 2006).

The information sharing process can be structured with varying degree of customized reporting, real time access, data access frequency, access levels and software integration. Depending upon the configuration selected, the information sharing process can have high complexity making it difficult for information recipients to manage and effectively use the received information. Increased complexity increases the cognitive load on information recipients and reduces their ability to understand the information received and take timely action.

Previous research suggests that higher complexity of an information processing task negatively affects performance. Roberts et al. (2004) showed that complexity affected how users interacted in groups – communication, participation and group integration were found to be lower in more complex tasks. Complexity impacts the information seeking behavior of users as they are less likely to use the information (Bystrom et al. 1995). Complexity has been shown to impair assimilation of information and lead to larger errors in decision making (Plumlee 2003). Complexity of the information sharing process also results in delays in information sharing which can have a negative impact on performance. Bensoussan et al. (2005) show analytically that the total inventory-related cost decreases when the length of the information delay decreases.

Thus, complexity of the information sharing process is expected to have a negative impact on business value of information sharing as higher complexity has a negative impact on the performance of the information recipient.

2.5.3 Technology Platform

Information sharing beyond firm boundaries requires use of technology platforms that reaches both the information sharing firm as well the information recipient. When the information is being shared with public at large and the information is not sensitive, it can be shared over public network infrastructure like the Internet. However, when sharing information with suppliers or partners, the information need to be shared using inter-organizational information systems (IOS) that connect respective information systems of the firm and the information recipient and perform the information transfer.

Inter-Organizational Information Systems

The promise for information systems that cross organizational boundaries and deliver improved performance have existed for decades (Kaufman 1966). However, traditionally information systems have been limited to a single organization due to technical and organizational limitations. With time inter-organizational systems have become more popular and have received increased research interest as their potential to create and exploit inter-organizational efficiencies become clear (Bakos 1991a; Cash Jr et al. 1985).

In an early study, Barrett et al. (1982) defined Inter-organizational information systems as systems that involve resources shared between two or more organizations. One of the earliest forms of IOS is Electronic Data Interchange (EDI) (Iacovou et al. 1995). EDI was widely adopted for information sharing between partners, especially in a supply chain context (Mukhopadhyay et al. 1995). However, EDI is limited in the amount and nature of information that can be transferred through it. EDI is also considered expensive and inflexible (Albrecht et al. 2005). Recently, Service Oriented Architecture

(SOA) has emerged as a popular alternative for integrating information systems and share information between them.

Service Oriented Architecture

Considering the complexities of inter-organizational information systems integration, adoption of the appropriate technology platform and IOS is crucial for success of information sharing beyond firm boundaries. To enable information sharing across firm boundaries and different technology platforms, new technologies (e.g. web services) and architectures (e.g. SOA) have emerged that provide a platform for integration. These integrating technologies use services with standardized protocols and data formats for exchanging information.

The advantage of SOA lies in its ability to provide seamless integration across business units, customers and partners (Lim et al. 2003). By exposing the business services that are available in an organization to external customers, SOA offers a way to integrate data and processes across organizations. It also provides a way to combine the business services across partner organizations and offer a unified service to the end user application. Recent surveys have found evidence of SOA platforms being used widely and SOA deployment growing rapidly (Iyer et al. 2003). Many large corporations have had successful implementations of web services and SOA in their ecommerce channels and supply chain. Lim et al. (2003) provide examples of Motorola and General Motors. Several studies have concluded that adoption of SOA leads to performance benefits in supply chain (Chatterjee et al. 2002; Murtaza et al. 2004).

2.5.4 Media Richness: Interaction and Interface

Advances in IT have allowed information sharing to involve much more than just passive transfer of numerical data. Information can be shared not just as passive text but different rich media interfaces such as hypertext, images, videos and 3-D virtual worlds. Further, information transfer is not a one way and passive affair but may include a significant degree of interactivity as well. These new dimensions of interface and interaction have a significant impact on the effectiveness of information sharing and the resulting business value.

Interface

In today's world of graphical user interface (GUI) and the Internet as a multi-media platform, information shared is not just numerical and text information – it is also visual. Borrowers at Prosper.com can attach pictures of themselves, their children, their dog, home or anything else. Recent research suggests that lenders at Prosper.com consider both the objective numerical credit history and also the subjective visual information such as attached images while making decisions about borrower's credit risk (Kumar 2007b).

Recent advances in development of virtual worlds such as Second Life, World of Warcraft and The Sims Online promise to take visual information sharing to even greater levels. Popularity of Second Life, a virtual world created in 2003 by San Francisco based Linden Labs, has attracted many real world businesses to establish a virtual presence there (Terdiman 2006). Firms like Cisco are using Second Life for communications with business partners and customers despite information security concerns (Wagner 2007).

The highly visual nature of information sharing in virtual worlds is considered more effective. Irving Wladawsky-Berger, IBM's vice president of technical strategy and innovation, mentioned: "*... text-based interfaces, including browsers, [are] 'narrowband' into our brains, whereas visual interfaces are 'broadband' into our brains*" (Shankland 2006). Research on effectiveness of different media found that use of richer media leads to better understanding of the subject matter (Mayer 2001). "Reading" and "seeing" represent two different ways in which the human mind processes information – reading is a controlled processing activity while seeing is an automatic processing activity (Card 1996). As a result, information processing is more effective when textual and visual information is combined together (Pu et al. 2003). Richer media also allows for greater interaction and involvement that leads to improvement in learning (Lin 2002).

Interaction

The effect of interaction on learning and comprehension of information has been studied in depth in the online and distance education literature. In the context of distance learning, Moore (1989) identified three kinds of interaction: interaction with content, interaction with instructor and interaction with peers. Research studies have suggested that all three kinds of interaction are beneficial for learning and comprehension of received information (Kozma 1991).

Interaction allows the information recipient to explore the information and communicate with the information source or other information recipients (peers) that can help in improving learning and comprehension. Interaction with content can be implemented through richer interfaces described above that allow the information

recipient to explore or play with the content. Interaction with instructor or the information source can be operationalized by providing the information recipient the ability to ask questions and explore relevant details like past performance and historical information.

Peer interaction can be provided using tools such as discussion boards. Peer interaction can be helpful when information is shared with a large number of recipients. In such cases, peer interactions allows for individual contributions to be combined into broader group knowledge that positively affect the business value of information sharing. Examples of such peer interaction include collaborative filtering at Amazon.com and determination of a market clearing interest rate at Prosper.com (Pearlstine 2006).

2.6 Information Sharing Environment

The information sharing process makes the information available to the recipient. However, the effective use of that information to generate business value depends on several crucial environmental factors. These environmental factors affect whether the recipient will be able to take effective actions and make quality decisions based on the shared information. The environmental factors that significantly impact the business value of information sharing beyond firm boundaries are: trust in the information sharing regime, incentive alignment to facilitate favorable actions and decision making by the information recipient and finally the regulatory environment including privacy concerns regarding personal and financial information.

2.6.1 Trust in Information Sharing Environment

Trust has been studied by scholars from different disciplinary perspectives such as psychology, sociology and economics. The diversity of scholarship has naturally led to different conceptualization and operationalization of trust (Bhattacharya et al. 1998). While the personality psychologists have viewed trust as an individual characteristic (Rotter 1971; Rotter 1980), social psychologists have focused on contextual factors that enhance or impede the development and maintenance of trust (Lewicki et al. 1994). Economists, on the other hand, have explored how incentive structures affect uncertainty and thereby trust in transactions among strangers e.g. (Goffman 1971; Zucker 1986).

An integrative model of organizational trust is proposed by Mayer et al. (1995) (Mayer et al. 1995; Schoorman et al. 2007). The integrative model is an effort to combine the essential aspects of trust from different disciplines. In the integrative model, trust is defined as "*the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party*." (Mayer et al. 1995, page 712).

The integrative model emphasizes that trust is based on expectations. Expectation is the perceived likelihood of a trustee's actions and outcomes of the actions. It is adjusted based on the amount and type of information a trustor obtains about a trustee (Bhattacharya et al. 1998). Trustors who receive more frequent and more diverse information about trustees can better adjust their expectation about actions and outcomes than those who receive information sporadically or receive redundant information about trustees. Thus, communication of information affects an individual's trustfulness.

Communication of information also affects trust via its effect on trustor's assessment of characteristics of trustees. In the integrative model of trust, a trustee's characteristics such as ability, benevolence and integrity are recognized as critical antecedents of trust (Mayer et al. 1995, p722). Information from other trustors or third parties like independent certifiers can help an individual form or update his/her belief about characteristics of a trustee (Buskens et al. 2002; Mayer et al. 1995).

The level of trust between information sharing firm and the information recipient is likely to significantly impact the business value of information sharing. Previous research on inter-organizational trust show that trust affects costs, satisfaction and performance of inter-firm relationships (Zaheer et al. 1998). Trust has been shown to affect consumer behavior and satisfaction in online environments (Gefen et al. 2003) and electronic markets (Ba 2002). As information sharing beyond firm boundaries typically involve contexts like inter-firm relationships, online environments and electronic markets, level of trust is likely to significantly affect the performance and the business value of information sharing.

2.6.2 Incentive Alignment

Business value of information sharing beyond firm boundaries incorporates an agency relationship where one party, called the principal, delegates work to another party, the agent, who performs that work. The fundamental problem with the agency relationship is that the desires and goals of the principal and the agent may be in conflict (Eisenhardt 1989). As the business value of information sharing depends upon the actions and decisions made by the information recipient, any conflict between the objectives of the

information recipient and the firm sharing information is likely to have a negative impact on business value of information sharing.

Literature in agency theory have focused on efficient contracts as a mechanism for resolving goal conflicts in agency relationships (Jensen et al. 1976). Such contracts can be helpful in aligning the incentives for the principal (firm sharing information) and the agent (information recipient) in case of formally contracted contexts like a firm-supplier relationships. However, many context of information sharing beyond firm boundaries do not involve enforceable contracts e.g. open source development, peer to peer electronic markets like eBay and Prosper. In such cases, the agency problem can be resolved by adopting business models that are designed such that the agent's best interests are also contributive towards the principal's objectives.

Contracts

In formally contracted information sharing contexts like a firm-supplier relationship, explicit contracts can be used as governance mechanisms that align the incentives of the agent with the objectives of the principal. Agency theory literature shows that two kinds of contracts can be used for the purpose: outcome based contracts and behavior based contracts.

Outcome based contracts are designed to curb opportunistic behavior by linking the rewards for the agent with the outcome of agent's actions. The classic example of outcome based is that increasing the firm ownership of the managers decreases managerial opportunism (Jensen et al. 1976). Outcome based contracts are effective when outcomes can be easily measured and assigned to agent's actions. However, in case of

outcome uncertainty, when the outcome is also dependent on factors other than agent's actions, an outcome based contracts transfer additional risk on the agent, who are typically risk averse. A behavior based contract on the other hand focuses on the desired behavior by the agent and can be effectively used in situations with outcome uncertainty.

Behavior based contract are effective the principal has complete information about the agent's behavior. However, when complete information on agent's actions is not available, the behavior based contracts suffer from the problems of moral hazard and adverse selection as the principal cannot determine whether the agent has behaved in accordance with the contract. Moral hazard refers to the problem of inducing agents to supply proper amount of productive input or effort when their actions cannot be observed or contracted for directly (Holmstrom 1979). In situations involving teams, moral hazard can also lead to the problem of free-riding by team members when only the aggregate output can be monitored and not the individual effort (Holmstrom 1982). Adverse selection is concerned with misrepresentation of their skills and ability by the agents. It arises when the principal cannot completely verify the professed skills and ability at the time of hiring or when the agent is working (Eisenhardt 1989).

Problems with behavior based contracts result from information asymmetry: principal does not have complete information on the behavior of agents. The information asymmetry can be reduced by effective use of information systems like budgeting systems, reporting process, monitoring and supervision. Such investments reveal agent's behavior, reduce information asymmetry and approach the case with complete information where behavior based contracts are more effective.

Business Model

Many information sharing contexts do not involve an explicit contract between the information sharing firm and the information recipient. For example - open source development is driven by voluntary contributions from large number of independent developers who are not legally contracted to work on the project (Lakhani et al. 2003). In open source projects, if there are conflicts between developer's motivation and the project objectives, then the project cannot influence developer's behavior through outcome based or behavior based contracts.

Previous research suggests that open source software development does suffer from a conflict between developers' incentives and project objectives. One of the primary motivations for developers to contribute to open source projects is to showcase their talents and signal their skills and ability to potential employers (Hertel et al. 2003; Lerner et al. 2002). As a result, programming tasks that are essential but do not require high level of skills are not attractive for developers leading to open source software applications lacking in essential but low skill features like documentation and usability.

Another example of incentive misalignment can be found in the eBay recommender system. Even though eBay would like its users to provide honest feedback about eBay transactions, many users are wary of providing negative feedback for the fear of getting a negative feedback in retaliation. In this case the agent's objective of maximizing individual feedback score is not aligned with the principal's objective of having a true reflection of market participants' reliability in the recommender system scores.

The problem of incentive misalignment in non-contractual contexts can be managed by designing business models that encourage actions by information recipient that satisfy both the agent's and the principal's objectives. In such incentive aligned business models, incentives are aligned by design and it is not necessary to impose additional contracts to influence agent behavior.

Lending process at Prosper.com and movie recommendation system as Netflix are good examples of incentive aligned business models. Individual lenders in Prosper.com make decisions to maximize their own returns. However, high returns for individual lenders also mean that the market as a whole is more efficient in identifying credit risk and charging appropriate risk premium for it. Thus, individual agent incentives are in line with the principal's objective. Similarly, the Netflix movie rating system has incentives for users to provide their true ratings so that they can get recommendations for future rentals that are closer to their taste. True ratings from individual users also result in an aggregate feedback score which is an accurate reflection of the community's opinion, which is in line with the overall objective of the rating system.

2.6.3 Privacy Regulations

Information sharing beyond firm boundaries also means sharing information beyond the IT security arrangements of the firm. Especially when the shared information includes confidential and financially sensitive information, privacy regulations need to be followed (Milberg et al. 2000). Information privacy is important both from both a regulatory compliance point of view and also from a consumer psychology point of view.

Information privacy is defined as the individual's ability to control the collection and use of personal information (Stone et al. 1990). Research on consumer psychology suggests that individuals seek to maintain their privacy and avoid unwanted disclosure and intrusion (Goodwin 1991; Goodwin 1992). Research also suggests that individuals are much more sensitive about the use of medical, financial, and family information than they are about information such as brand usage (Phelps et al. 2000). Recently, serious concerns have been raised over the erosion of personal privacy as a result of advances in technology allowing firms to collect and analyze large amounts of consumer information (Whiting 2002)

Information sharing beyond the firm boundaries sometimes takes the form of public release of information over the Internet (e.g. Prosper.com). In such cases privacy concerns dictate that information shared should not be personally identifiable with regard to sensitive information like financial information, medical information or personal identifications like driver's license numbers or social security numbers. Privacy requirements are usually met by making the information being shared anonymous. However, anonymity of information available can negatively affect decision making by the information recipient. Anonymous information also commands less trust than personally identifiable information.

2.7 Action Based on Shared Information

The last component in the framework for business value of information sharing beyond firm boundaries is the actual actions and decision making by the information recipient based on the shared information and the resulting accrual of business value for the firm

sharing information. Decision making by information recipients is affected by the two other constructs that comprise the action component – learning and information overload.

2.7.1 Decision Making

Business value of information sharing depends on the quality of decision making by the information recipient. The purpose of information sharing with the recipient is that the recipient can use that information to take appropriate actions or make quality decisions. Examples of these decisions include previously discussed instances such as delivery schedules for a supplier, risk premiums for a borrower in Prosper.com and writing software for an open source development project like Google Android.

The error in decision making can results from two sources: first, the information available itself may be incomplete and uncertain and second, market participant may not be able to fully utilize the available information. Both sources of error in decision making have been well studied in previous research. The focus of the research has been to model the process through which managers convert available incomplete information into their decision.

The most popular model of decision making based on incomplete information, anchoring and adjustment model, was proposed by Tversky and Kahneman (Tversky et al. 1974). Anchoring and adjustment implies that managers start with an estimate of the unknown or uncertain information (anchor) and then adjust their estimate as more information becomes known or as they learn through repetitive decision making (adjustment) (Einhorn et al. 1986). The anchor and adjustment model has been shown to be a good approximation of the decision making process under uncertainty through many

experiments and field studies in many diverse fields (Jacowitz et al. 1995; Mussweiler et al. 2004).

Information sharing firm provide information recipients with tools that assist in making decisions. Such assistance includes a recommender system (Resnick et al. 2000), Integrated development environment (IDE) for contributing to open source projects and information regarding the performance of past decisions (Prosper.com).

Business value of information sharing results directly from decisions made by information recipients based on the information shared. For example – the goal of eBay sharing feedback ratings with buyers is to improve buyer satisfaction by safeguarding buyers against fraudulent sellers. However, the perceptual and more difficult measure of buyer satisfaction is a direct result of whether buyers make the right decision to not bid on listings by fraudulent sellers. Thus, the quality of decision making, an objective and more easily computable measure, can serve as a proxy for business value.

As discussed in previous components of information sharing beyond firm boundaries, quality of decision making by information recipient is influenced by several factors such as transparency, complexity and media richness. These factors are exogenous to the information recipient. In this section we look at factors that are directly associated with the information recipient and affect its decision making: learning and information overload.

2.7.2 Learning

Decision making by information recipients can be studied using the anchor and adjustment model of decision making under incomplete information proposed by Tversky

et al. (1974). Anchoring and adjustment implies that decision makers start with an estimate of the unknown or uncertain information (anchor) and then adjust their estimate as more information becomes known or as they learn through feedback or through repetitive decision making (adjustment) (Einhorn et al. 1986).

The anchoring and adjustment model suggests that as new information becomes available, the estimates are adjusted. The adjustment process can be considered equivalent to learning. For repetitive decision making tasks, information recipients can observe the outcome of their decisions and use past performance to adjust their decision criteria. This constitutes an important learning mechanism for improving the quality of decision making with time.

Previous research has indicated that the impact of the learning process is limited by the "drag effect" – the adjustments are typically insufficient and excessively influenced by the initial anchor (Klayman and Ha 1987). Thus, according to anchoring and adjustment heuristics, although new information will result in improvement in decision making, some residual inefficiency will continue.

The bounds of the learning based on anchor and adjustment process can be overcome through a disruption in information sharing regime. With significant change in the information sharing regime (e.g. a significant increase in information availability), the equilibrium achieved by adjustment of initial anchor through long term learning is disrupted. The information recipient forms a new anchor based on the changed information sharing regime and the learning process starts again as a result of adjustment to the new anchor. Thus, a significant increase in information availability can lead to

better decision making. However, increase in information availability can also lead to information overload, discussed in the next section.

2.7.3 Information Overload

"*The technological developments of the last 50 years have made more information more available to more people than at any other time in human history*" (Feather 1998)

We live in an information society and are bombarded with information continuously in our daily lives. At the same time information is seen as crucial to success for organizations and today's workers have to deal with an overwhelming amount of information from many sources as part of their job. In 1850, 4% of American workers handled information for a living, now most do, and information processing (as opposed to material goods) now accounts for more than half of the US gross national product (Shenk 1997). Success in modern organizations depends on the ability to take in, understand and work with vast amounts of new information. However, the need to comprehend and process more and more information is leading to people being overwhelmed by available information. Such information overload is shown to lead to stress, loss of job satisfaction and physical ill health (Lewis 1996). Large amount and high rate of information act like noise when they reach the overload situation represented by a rate too high for the receiver to process efficiently (Klapp 1986).

Information overload has a negative impact on business value of information sharing as it negatively affects the quality of decision making by the information recipients. The negative impact of information overload can be mitigated by sharing

information in structured form that requires less effort to process (Königer et al. 1995). Sharing information in visual form improved the comprehension as well and helps mitigate the negative impact of information overload (Card 1996). Negative impact of information overload can also be limited by improving the ability of individuals to process information through training and learning (Edmunds et al. 2000).

The constructs that comprise four components of the business value of information sharing beyond firm boundaries were discussed in sections above. Previous literature and contemporary examples were used to present the nature of the constructs and their potential relationship with the business value of information sharing. Identified potential relationships between constructs and the business value of information sharing are integrated in the next section to identify research gaps and develop two research models for further empirical investigation.

2.8 Developing Research Model

The four components of the framework for analyzing business value of information sharing beyond firm boundaries and the constructs within the components discussed above comprise the taxonomy of business value of information sharing beyond firm boundaries. The taxonomy provides a foundation for identifying potential empirical research opportunities that explore how different components and constructs impact business value of information sharing. For identifying research gaps and building research models for future empirical research, we consider the main focus of the dissertation – business value of information sharing, as the focus of the analysis or the dependent variable for future empirical studies.

2.8.1 Dependent Variable: Business Value of Information Sharing

As the focus of this dissertation is on the business value of information sharing beyond firm boundaries, the most important variable to study is the end result – business value. Accordingly, we consider the business value of information sharing to the firm sharing information as the core dependent variable for future empirical studies. Thus, the main focus of proposed empirical research opportunities to follow is to study the antecedents of business value – factors that drive business value and moderating factors that influence the relationship between other factors and the business value of information sharing. However, before business value can be used as a dependent variable, it needs to be measured. Business value of information sharing can take different forms depending on the objective of information sharing.

Traditional well researched contexts like supply chain have established operational and performance variables like inventory, lead times and fulfillment rate that can serve as proxy for business value of information sharing. There are no such established proxies that directly and accurately measure the impact of information sharing for novel contexts like electronic markets and sharing of information with customers. For such contexts, the business value of information sharing can be measured with a metric that represents the extent to which the objective of information sharing is being met.

The efficiency of the shared process (e.g. fulfillment rate in supply chain) is an appropriate measure of the business value of information sharing when the objective of information sharing is to improve shared process efficiency. Similarly, when information

sharing is directed towards enabling conduct of an economic activity through markets, then the efficiency of that activity conducted through markets can be considered a measure of business value of information sharing. For example – Netflix is sharing operational information with teams attempting to build a recommendation system for Netflix as part of a public competition. Performance of the new recommendation system that emerges out of this exercise would be an appropriate measure of the business value of information sharing by Netflix.

2.8.2 Antecedents of Business Value

All constructs identified in the taxonomy for business value of information sharing beyond firm boundaries are expected to have a significant role in determining the business value that results from information sharing. This section summarizes potential relationships between different constructs and business value of information sharing. Potential relationships are presented as a numbered list so that they can later be uniquely identified.

1. **Origins of Information Sharing**
    a. *Objective and Culture*: Objective of information sharing beyond firm boundaries need to be in alignment with the organizational culture for the information sharing initiative to succeed. Previous research on information sharing within the organization suggest that for any information sharing initiative to succeed, it need to adapt to the organizational culture (McDermott et al. 2001). A misalignment between objective of information sharing and the

organizational culture is likely to negatively affect resulting business value of information sharing.

Cultural barriers to successful information sharing can be reduced by demonstrating a strong connection between objective of information sharing and tangible business goals and objectives (McDermott et al. 2001) and overall business strategy of organization (Sunassee et al. 2002). Negative impact of cultural barriers on business value of information sharing can be further mitigated by top management leadership and support (Holsapple et al. 2000; Liebowitz 1999).

b. *Capability*: Technical capability and information capability have a significant impact on successful implementation of information sharing initiatives. Davenport et al. (1998) note that the organization needs to provide the required technical and organizational infrastructure for a knowledge management or information sharing initiative to succeed.

2. Information Sharing Process

a. *Transparency*: Transparency is expected to have a positive relationship with business value of information sharing. Previous research suggests that higher transparency provides more information for decision making and leads to performance improvements (Barua et al. 2004; Cachon et al. 2000).

b. *Complexity*: Complexity of the information sharing process is expected to have a negative impact on the business value of information sharing. Complexity affects information seeking behavior (Bystrom et al. 1995),

efficiency of decision making (Plumlee 2003) and results in delays in information processing that is expected to negatively impact business value of information sharing.

c. *Service Oriented Architecture*: SOA is expected to provide seamless integration across different systems and make it easier to share information. Hence, SOA can be expected to have a positive moderating role on the relationship between transparency and business value of information sharing.

SOA is expected to make IT systems more flexible and accommodative of change. SOA, by bringing flexibility to the IT architecture, is expected to help in managing complexity (Carter 2007). Thus, SOA is expected to mitigate the negative effects of complexity and have a moderating impact on the negative relationship between complexity and business value of information sharing.

d. *Media Richness*: Richer media interfaces have been shown to be more effective in enabling better understanding of the subject (Mayer 2001). Further, media allowing interaction with the content, peers or the information sharing source leads to better learning and comprehension of received information (Kozma 1991). Media richness in both their aspects – interface and interaction, are expected to lead to better decision making by information recipients as a result of better understanding and comprehension of the received information.

Internet provides the platform for media richness – both interface and interaction. Internet based information sharing can include rich media

interfaces like images and 3D simulations like Second Life. Interaction is also a natural part of Internet based information sharing through facilities like discussion boards and distributed decision making. Internet based information sharing that leverages the media richness allowed by the Internet is expected to have a positive impact on business value of information sharing.

3. Information Sharing Environment

a. *Trust*: In contexts where the information recipients needs to make decisions based on incomplete information and without formal incentive contracts, recipient's trust level significantly impacts the quality of decision making. High level of trust is expected to lead to better decision making. However, the level of trust itself depends on information sharing and communication (Bhattacharya et al. 1998). Trustors who receive more frequent and more diverse information about trustees can better adjust their expectation about actions and outcomes.

Trust can be further supported by specific measures such as third party certification. Information from other trustors or third parties can help an individual form or update his/her belief about characteristics of a trustee (Buskens et al. 2002; Mayer et al. 1995). Thus, such trust building measures are expected to have a positive impact on decision making using shared information.

b. *Incentive alignment*: A misalignment of the objective of information sharing and the incentives of information recipients is expected to negatively impact

the business value of information sharing as the decisions made by the information recipient would not be in line with the expectations of the information sharing firm. Incentive misalignment can be corrected by formal contractual relationships (e.g. a profit sharing arrangement with a business process outsourcing provider) or by devising specific business models that align information sharing objectives with incentives of information recipients. Such incentive alignment measures are expected to have a positive impact on business value of information sharing.

4. Decision Making and Business Value

a. *Learning and Disruption*: In repetitive decision making, decision heuristics get adjusted in time as decision makers get feedback and observe the performance of their decisions. This learning mechanism implies that the efficiency of decision making is expected to improve with time.

Decision making by information recipients can be future supported by providing additional information. However, the learning process can get disrupted if there is a substantial change in the information sharing regime as decision heuristics need to be adjusted. Such disruptions are likely to cause a short term decline in decision making efficiency. The impact of disruptions will be compensated in time through the learning effect as information recipients learn to make appropriate use of the additional information.

b. *Information Overload*: Large amount and high rate of information act like noise when they reach the overload situation represented by a rate too high for

the receiver to process efficiently (Klapp 1986). Information overload reduces the efficiency of decision making. However, negative impact of information overload can be mitigated by training, learning or using rich media that allows information recipients to process information better (Edmunds et al. 2000).

The potential relationships identified above as antecedents of business value of information sharing need to be validated using real data. Closely related relationships can be put together as part of theoretically motivated research models that can then be empirically tested. The next section builds two such research models.

2.8.3 Proposed Empirical Models

The potential relationships between independent constructs and the dependent variable of business value of information sharing identified above need to be structured as empirical models for being tested empirically. Structure of empirical models depend upon the research context, empirical analysis approach (cross-sectional, longitudinal or panel data analysis) and the applicable theoretical framework. This section identifies two such empirical models that integrate many of the relationships identified above into a testable empirical framework.

Information Sharing in Supply Chain

Supply chain is one of most popular contexts for information sharing beyond form boundaries. The long history of information sharing in supply chain provides a good

context for a cross-sectional study of how differences in information sharing process elements impact business value of information sharing in supply chain.

Business value of information sharing in supply chain can be measured by the performance of the supply chain. Level of inventory is a commonly used measure of supply chain performance (Cachon et al. 2000; Lee et al. 1997; Lee et al. 2000b).

Among the different constructs of information sharing process, only transparency, complexity and technology architecture are relevant in this cross sectional context as they are likely to demonstrate significant variation across different firms. As information sharing in supply chain is carried out through traditional inter-organizational information systems that share predominantly numerical information, media richness is not relevant in this context.

A cross-sectional empirical study of the impact of information sharing process elements on supply chain performance can effectively test the following relationships:

2-a: Positive impact of information sharing transparency on supply chain performance

2-b: Negative impact of information sharing complexity on supply chain performance

2-c: Moderating impact of technology architecture (SOA) use on the relationships between supply chain performance and transparency or complexity.

The empirical model is further developed and tested in the next chapter (chapter 3) of the dissertation.

Information Sharing in Peer to Peer Financial Market

Peer to peer financial markets present an excellent opportunity for longitudinal studies of decision making by information recipients. The peer to peer financial market being studied (Prosper.com) provides data on individual decisions made by market participants over time. This can be used to study decision making by information recipients and the mechanisms to improve the quality of decision making. Based on available data, two mechanisms can be explored: learning and increase in information availability.

As peer to peer financial markets use the Internet as the medium for information sharing, the impact of media richness – interface and interaction, on the business value of information sharing can also be studied. Thus, a study of decision making by market participants in peer to peer financial markets can help test the following potential relationships:

- 4-a: Positive impact of learning on quality of decision making; negative impact of disruption on business value of information sharing
- 4-b: Positive impact of additional information availability; negative impact of information overload on business value of information sharing
- 2-d: Positive impact of media richness on business value of information sharing

The empirical research model based in a peer to peer financial market context is further developed and tested in chapter 4 of the dissertation.

2.9 Conclusion

Recent advances in IT have led to a dramatic increase in information sharing both within and beyond firm boundaries. Although information sharing has attracted significant research interest, most of the focus has been on either information sharing within the firm or with traditional partners like suppliers (Susarla et al. 2004). As more firms share significant amount of information with partners, suppliers, customers and even with public, there is a research need to take a deeper look at business value of information sharing beyond firm boundaries.

Studying complex inter-disciplinary subjects like business value of information sharing beyond firm boundaries is difficult as it involves integrating insights from different research streams and theoretical backgrounds. Often the approaches taken by different research streams are in conflict with each other and use a parallel set of constructs, language and nomenclature. Thus, as a first step, it is important to building an overall research framework that integrates insights and constructs from different research streams and provides the foundation for future inter-disciplinary research. Such frameworks also provide the opportunity to study interactions between constructs belonging to different research streams. This study performs this essential step of integrating relevant previous research to build an inter-disciplinary taxonomy and research framework of business value of information sharing beyond firm boundaries.

Combining previous literature with insights from contemporary practice examples of information sharing beyond firm boundaries, we first developed a four component framework for studying business value of information sharing. Constructs that comprise each of the components were further detailed using past literature and their potential

impact on business value of information sharing identified. These constructs and their potential impact on business value of information sharing form the taxonomy that defines the research space and builds a common vocabulary.

Using previous research and practice examples, this study identifies potential relationship between the constructs in the taxonomy and the dependent variable of business value of information sharing. The individual relationships are then structured into two empirical research models that form the next two chapters of the dissertation.

Managers responsible for designing or managing information sharing initiatives need to take into account factors belonging to different functional areas. In addition, interactions between factors belonging to different areas may also have significant impact on success of information sharing initiatives. The integrated framework developed in this chapter is beneficial to practitioners as well since it provides a consolidated view of different constructs from different research and practice domains that may influence the success of information sharing beyond firm boundaries. The framework further contributes to practice by identifying potential interactions between constructs that may influence business value of information sharing.

The next two chapters in the dissertation extend the framework developed in this chapter by empirically testing two research models identified in this chapter. The framework forms the base for other similar empirical studies to follow.

CHAPTER - 3

Impact of SOA Use on Performance Outcomes of Information Sharing in Supply Chain

3.1 Introduction

Advances in Information Technology (IT) have had a significant impact on how firms manage their supply chain. Companies have used IT to connect with their suppliers and share relevant information in a timely and efficient manner for improving supply chain performance. Companies like Wal-Mart and Dell have achieved impressive improvements in supply chain performance by tightly integrating their suppliers in an electronic network.

Greater information sharing with supply chain partners is a key driver of improvements in supply chain performance. Information sharing through the supply chain reduces uncertainty, enables the channel participants to match supply and demand closely and anticipate future changes in the market, leading to improved supply chain performance. For example: Wal-Mart shares information regarding retail sales of P&G's products at Wal-Mart stores in real time with P&G. This enables P&G to better manage

its production process and inventory levels in the supply chain. Dell Inc. has developed extensive capabilities to share information related to quality, relationship management, design, daily production requirements, and inventory levels even on an hourly basis with suppliers. This has enabled Dell to reduce cost and improve customer service (Magretta 1998).

Adoption of inter-organizational information systems like EDI, ERP and SCM have grown rapidly as firms realize the value of electronically integrating their supply chain and sharing information with channel partners. However, efforts to integrate supplier and improve information sharing in supply chain have not always been successful. Many companies have suffered setbacks in electronically integrating their suppliers. Prominent examples include Nike's inventory buildup in 2001, Hershey missing shipments during Halloween in 1999 and Toys-R-Us' failure to fulfill Christmas demand in 1999 (SupplyChainDigest 2006). Failure rate in supply chain management system implementations have been estimated to be as high as 70% with the complexity of processes and technology involved considered one of the main reasons for disappointing performance levels in electronic supply chains (Lewis 2007).

Information sharing in supply chain has been actively studied by both information systems as well as operations management researchers. Information systems researchers have focused on empirical studies of business value of inter-organizational systems such as EDI. In a study of EDI at Chrysler, total benefits of EDI per vehicle amounted to over $100 resulting in annual savings of $220 million for the company (Mukhopadhyay et al. 1995). In contrast, operations researchers have mainly focused on analytical studies of the impact of information sharing on parameters such as inventory and lead times. Using an

analytical model of two level supply chain, Lee et al. (2000a) showed that sharing of demand information leads to lower inventory and cost levels. Similarly, Cachon et al. (2000) found that by sharing order information in addition to inventory information led to an average reduction of 2.2% in supply chain cost.

While the impact of information sharing on supply chain performance has been well studied, the extant research has focused mainly on "what" information is shared and has not given due attention to "how" the information is shared. In particular, the characteristics of the information sharing process and the technology architecture used to enable the information sharing process have not been considered. In a recent paper, Kim et al. (2006) argue that in case of electronic information sharing, more is not always better and that the fit between contextual factors and electronic information sharing is needed to achieve improved channel performance. We extend their emphasis on the context for information sharing in this chapter and argue that for getting deeper insights into performance benefits of information sharing, we need to look at the process and technology level.

The current research is deficient in studies that integrate the impact of process characteristics and specific technology architecture use on the performance benefits of information sharing in supply chain. This study fills the research gap by empirically analyzing the impact of information sharing on supply chain performance while explicitly considering the impact of characteristics of the information sharing process as well as the technology architecture used to enable the process. We look at the impact of information sharing process complexity on supply chain performance and analyze whether the new

generation of integrative IT architecture, Service Oriented Architecture (SOA) can help manage the complexity and hence improve supply chain performance.

This study considers the emerging and increasingly popular technology architecture for inter-organizational information systems – Service Oriented Architecture as a solution to manage complexity. SOA is a technology architecture where the basic element of design, development and use of software solutions are services (Papazoglou et al. 2003). Services are self- describing components, which can be recognized by client applications through look up from a registry (such as UDDI: Universal Description, Discovery and Integration). Applications communicate with each other in such architectures through services. The client application and the service provider communicate via standard protocols (e.g. SOAP, HTTP) and exchange information using standard data formats like XML.

There has been a rapid growth in adoption of SOA by firms. According to a recent survey by IDC (Dubie 2006), the worldwide spending on SOA is likely to reach about $9 billion by 2009. Another survey by Aberdeen group (Aberdeen 2006) indicates that 45% of companies surveyed have projects underway involving SOA in their supply chain and another 17% plan to start such projects in the next 12 months.

Amid this rapid growth in SOA deployment, IT managers are faced with concerns about net business value of their SOA investments. CIO.com (2006) reported that managers perceive the difficulty in demonstrating net business value of SOA as one of the main problems with SOA use. While IT managers have to make a decision on SOA adoption to facilitate migration to new technology platforms and to enable efficient information exchange in their supply chain, they have little information available about

organizational impact of SOA use, especially about impact of SOA use on the supply chain performance. In this study, we provide empirical evidence of the impact of SOA use on supply chain performance.

Although previous IS research has focused on strategic benefits of technology adoption (Sambamurthy et al. 2003), in particular from adoption of web technologies (Chatterjee et al. 2002) and electronic supply chains (Malhotra et al. 2005; Subramani 2004), to our knowledge there has been no broad cross-sectional empirical study of supply chain performance impact of use of new web technologies or architectural paradigms. Previous research on business value of SOA have mainly focused on anecdotal or case study based evidence (Lim et al. 2003) rather than empirical studies. We bridge this research gap in this study by analyzing the impact of SOA use on performance of supply chains. This is one of the first broad empirical studies to provide evidence of business value of SOA use and to explore the mechanisms of supply chain performance improvement associated with SOA use.

This chapter brings together two research streams focusing on information sharing in supply chain – operations management and information systems. We combine the operational issue of how the degree and the process of information sharing can affect supply chain performance with the information systems issue of how SOA adoption can mitigate process complexity and lead to tangible business value in supply chains.

This study contributes to both research and practice. On the research side, it contributes to the literature on business value of IT by providing broad empirical evidence of business value of SOA adoption and its interaction with process characteristics. The study contributes to the operations management literature by

providing empirical support to previous theoretical research (Lee et al. 2000a; Yu et al. 2001) that suggests that information sharing in supply chain leads to performance improvements. Further, it extends that research by showing that apart from the degree of information sharing, the characteristics of the process of information sharing also affects performance. The study also contributes by combining operations and information systems research streams in a broad empirical study while keeping the focus on details at process and technology level.

On the practice side, this study provides IT managers with an assessment of the impact of information sharing and SOA adoption on supply chain performance. The results show how the process characteristics and technology choice interact to result in performance improvement in supply chain. This would help managers orchestrate better information sharing processes and make informed decisions about SOA adoption for their supply chain context.

The rest of the chapter is organized as follows. The next section provides a summary of previous work on information sharing in supply chain and service oriented architecture to develop the hypotheses. Section 3 formulates the research model used and details the data and methodology used to test the hypotheses. Results and their analysis are presented in Section 4 followed by a discussion of the results, limitations of the study and conclusions in Section 5.

3.2 Theory, Hypotheses and Research Design

We are focusing on the business value of SOA adoption and its interaction with process characteristics in the context of the supply chain relationship between firms and their

suppliers. Supplier relations have been an important destination for IT investments (e.g. EDI and SCM systems). Widespread adoption of SOA systems for connecting with suppliers provides an ideal setting to study performance impact of SOA adoption.

Based on prior supply chain literature as well as potential benefits of SOA adoption, we frame the impact of SOA adoption on supply chain performance in terms of two characteristics of the information sharing process between the firm and its suppliers: transparency and complexity. Transparency of information sharing relationship refers to "what" information is shared including production information, customer information, financial information and marketing and promotion information. Complexity of information sharing relationship measures "how" information is shared: using custom reports, providing real time access, using ad-hoc reporting or allowing scheduled access.

In this study we first look at how the characteristics of the information sharing process, transparency and complexity, impact the performance of the supply chain and then we focus on how use of SOA in supply chain moderates the impact of supply chain process characteristics on supply chain performance.

3.2.1 Information Sharing and Supply Chain Performance

Information sharing in supply chain has been studied in depth in both the information systems and the operations management literature. In the information systems literature, Clemons et al. (1992) concluded that information transfer using IT has the unique capability of simultaneously trimming down a firm's cost of decision making and operation, and the transaction cost of its channel partners. There have been several studies on use of EDI. E.g. Mukhopadhyay et al. (1995) studied the use of EDI systems

and concluded that the systems provided significant business value. In a recent study of Internet enabled business value, Barua et al. (2004) showed that electronic integration and information sharing with suppliers leads to performance improvement.

On the operations management side, in their seminal work on information distortion in supply chain, also known as the bull whip effect, Lee et al. (1997) showed that when only order information is shared through the supply chain, it misguides upstream members in their inventory and production decisions resulting in lower supply chain performance. They argue that information sharing of sell-through and inventory status data can help in mitigating the bull whip effect and improve supply chain performance. Using an analytical model of two level supply chain, Lee et al. (2000a) showed that sharing of demand information leads to lower inventory and cost. Yu et al. (2001) showed that increasing information sharing among members of a decentralized supply chain leads to Pareto improvements in the performance of the entire supply chain. Lee et al. (2000b) argued that advances in IT has allowed supply chain partners to operate in tight coordination through information sharing. They describe five types of information sharing: inventory, sales, demand forecast, order status and production schedule.

Overall, both information systems and operations management literature indicate that larger degree of information sharing results in improvements in supply chain performance. We define the level of information sharing in supply chain as "information sharing transparency". Information sharing transparency is a measure of how much information is being shared in the supply chain. For example: a supply chain that shares demand, inventory and production data has higher information sharing transparency than

a supply chain that only shares demand and inventory data. As per previous research higher transparency will provide more information to channel partners to make optimal decisions, avoid distortion of demand data through bull whip effect and lead to higher supply chain performance (Cachon et al. 2000; Lee et al. 1997; Lee et al. 2000a). Hence, we posit our first hypothesis:

Hypothesis 1: *Higher transparency of the information sharing process is associated with higher supply chain performance*

While transparency describes what information is being shared, the information can be delivered in a variety of ways. Advances in information technology have allowed firms to structure information sharing process with varying degree of customized reporting, real time access, data access frequency, access levels and software integration. However, these customization dimensions increase the complexity of the information sharing process.

To study the impact of complexity of information sharing process on supply chain performance, we follow the previous literature on task complexity and its performance impact. March et al. (1967) described complex tasks are characterized by uncertain alternatives or consequences of action. Complex tasks are characterized by the existence of a number of subtasks, which may or may not be easily factored into nearly independent parts. Bystrom and Jarvelin (1995) divide task complexity into different categories based on the pre-determinability of the task. The pre-determinability of the task includes the pre-determinability of the information requirements, process and

outcome. If the task is more structured then the elements of the task are known in advance and it becomes less complex. Similarly, previous knowledge about the task and information requirements for the task makes the task less complex.

Complexity of the information sharing process in supply chain is likely to have a negative effect on the supply chain performance. The increase in complexity makes it difficult for the information recipient to make timely and efficient decisions based on the received information as managers need to manage additional cognitive load to manage the additional task complexity. Task complexity has been shown to affect information seeking behavior of users (Bystrom et al. 1995). Complexity has been shown to impair assimilation of information and lead to larger errors in decision making (Plumlee 2003). Roberts et al. (2004) showed that complexity affected how users interacted in groups – communication, participation and group integration were found to be lower in more complex tasks. Complexity of the information sharing process can also result in delays in information sharing which can have a negative impact on performance. Bensoussan et al. (2005) showed analytically that the total inventory-related cost decreases when the length of the information delay decreases.

The complexity of the information sharing process is expected to have a negative impact on supply chain performance as higher complexity will place incremental burden on managers to get and understand the information shared. Complexity of the information sharing process may also delay access to the information by channel partners; thereby affecting the performance of the supply chain. Hence, we present our second hypothesis:

Hypothesis 2: *Higher complexity of the information sharing process is associated with lower supply chain performance*

The above two hypotheses consider two dimensions of the information sharing process that provide a more holistic assessment of information sharing in supply chains than simply the amount of information that is shared. However, the information sharing process is enabled using technology architectures that may affect the impact of process characteristics on supply chain performance. We now consider the performance impact of using service oriented architecture to enable the information sharing process.

3.2.2 Service Oriented Architecture

The many vendors and wide variety of specialized software systems like ERP, SCM, CRM and EDI have made integration of these software costly and difficult. To enable information sharing across systems, a new breed of enterprise and web technologies (i.e. web services) and architectures (i.e SOA) have emerged that provide a platform for integration. These integrating technologies employ standardized protocols and data formats for exchanging information across enterprise applications.

Recent surveys have found evidence of SOA platforms being used widely and SOA deployment growing rapidly (Iyer et al. 2003). The real advantage of SOA lies in its ability to provide seamless integration across business units, customers and partners (Lim et al. 2003). By exposing the business services that are available in an organization to external customers, SOA offers a way to integrate data and processes across the

organization. It also provides a way to combine the business services across partner organizations and offer a unified service to the end user application.

There is a small but growing body of literature that studies the performance impact of the new technology paradigm including SOA or web services. Sambamurthy et al. (2003) provide a theoretical model for analyzing the role of information technology in business strategy and how new technologies are leading to strategic flexibility in firms. They encourage further inquiry into how firms achieve agility and what technologies lead to flexible business processes and business models. Their research provides a theoretical foundation but lacks empirical support that will enlighten managerial decisions regarding investments in these new technologies including web services and SOA. Chatterjee et al (2002) suggest that organizational assimilation of web technologies leads to very useful business process benefits and study the role of top management sponsorship, investment rationale and extent of coordination on such an assimilation of web technologies. Previous research has provided anecdotal and case-study based evidence of the positive impact of SOA adoption on organizational performance. Lim et al (2003) provide examples of benefits of SOA adoption in companies like Motorola and General Motors. However, there is a need of empirical studies that studies the adoption of integrative web technologies and architecture like SOA and their impact on organizational performance.

Impact of SOA Use on Supply Chain Performance

Adoption of SOA in the supply chain impacts the performance of the supply chain in two ways. First, SOA is an integrative architecture that has the ability to bring together disparate systems, technologies and data formats. Hence, SOA makes information

sharing across silos easier. Thus, while information sharing with suppliers can be expected to be beneficial on its own (Hypothesis 1), use of SOA in the information sharing process would further enhance the benefit by making communication and information sharing easier because of SOA's inherent standards based interoperability. Hence, a firm with SOA would be in a better position to efficiently share information with its suppliers. We therefore expect that SOA will have a positive interaction effect on the benefit of information sharing transparency. We posit the following interaction effect hypothesis:

Hypothesis 3: *SOA adoption by firms increases the impact of information sharing process transparency on supply chain performance.*

The second impact of SOA on supply chain is to increase flexibility. SOA is expected to make IT systems more flexible where changes can be accommodated easily (Gartner 2005). In a CIO/Computerworld survey, 77% of the respondents believed that SOA adoption will bring greater business flexibility (Koch 2006). As complexity of business processes and IT systems has emerged as one of the major concerns especially as companies grow with mergers and acquisitions and need to merge different IT systems together; SOA, by bring flexibility to the IT architecture, is expected to help companies in managing the complexity (Carter 2007). Chung et al. (2005) analyzed the relationship between IT infrastructure flexibility, mass customization and business performance. They found that an infrastructure with increased flexibility leads to increased business

performance. The flexible infrastructure is also more hospitable in supporting mass customization, which leads to higher customer satisfaction (Chung et al. 2005).

In the context of information sharing in supply chain, we previously argued that the complexity of the information sharing process will have a negative impact on supply chain performance. Use of SOA in supply chain will lead to more flexibility and will be helpful to firms and suppliers manage the complexity of the information sharing process. Therefore, we expect that SOA use will help mitigate the negative performance impact of information sharing complexity on supply chain performance (interaction with Hypothesis 2). We can formalize the argument as follows:

Hypothesis 4: *SOA adoption by firms reduces the impact of information sharing process complexity on supply chain performance.*

The four hypotheses above capture the process and technology level relationships between information sharing and supply chain performance. The hypotheses are summarized below in a research design that can be empirically tested.

3.2.3 Research Design

Integrating the four hypotheses described above into a combined research model, we can conceptualize hypotheses 1 and 2 as the direct effects and hypotheses 3 and 4 as interaction effects. We are controlling for factors that have been shown to affect the business value of IT systems in general and supply chain performance in particular. In accordance with previous literature, we are controlling for firm size (Dewan et al. 1998),

industry affiliation (Stiroh 2002) and the use of SCM systems (Subramani 2004). When using accounts payable as the supply chain performance measure (discussed in the next section), we also use accounts receivables as the control for financial processes in the firm. The research design is shown in Figure 2 below.

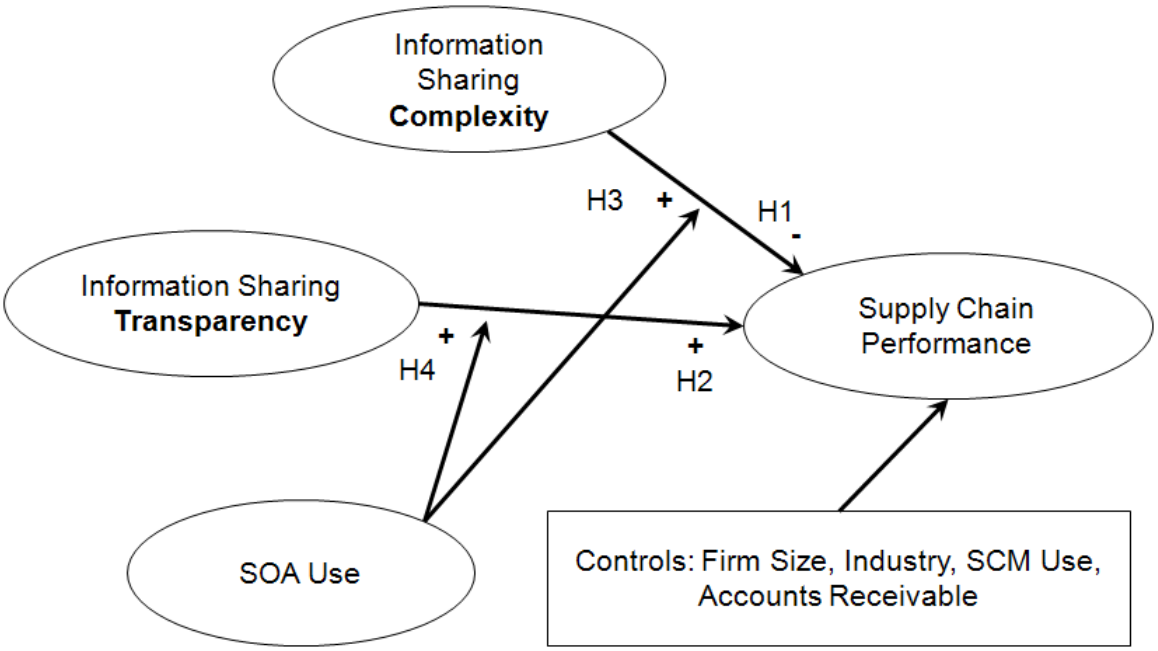

Figure 2: Research Model

Testing the research model requires data for a sample of firms on characteristics of the information sharing process, SOA use, supply chain performance and firm level controls. The research model can then be tested using multivariate regression analysis.

3.3 Data and Methodology

Data for this study has been collected from two sources. Data regarding SOA adoption and the information sharing process was collected through an annual survey of top IT

managers of large publicly traded US based firms. We obtained the data from InformationWeek, a leading and widely circulated publication for the IT industry. The data was part of the annual InformationWeek500 ranking of the IT industry for year 2003. A practitioner oriented analysis of the data was published in InformationWeek (InformationWeek 2003). InformationWeek is considered a reliable source of IT industry related data and many academic studies have been conducted based in data provided by InformationWeek (Bharadwaj et al. 1999; Mithas et al. 2005).

The InformationWeek data was supplemented with supply chain performance, firm size and industry control data collected from Compustat. Compustat is an information service provided by Standard and Poor that includes a database of financial, statistical and market information for publicly listed companies. The combined dataset consists of 305 companies. This is an adequate sample size and is comparable with previous broad empirical studies on business value of IT (Dewan et al. 1998).

The two data sources are used to build empirical measures for the constructs used in the research model (Figure 2).

3.3.1 Construct Operationalization

The variables from the two data sources used in the empirical model are described below. Measures for constructs with multiple measures are mentioned in the Table 2 that follows the construct measurement details below.

Variables from InformationWeek Survey:

- **Information Sharing Transparency**: This is a 11-item summative index that represents a count of different information elements that are shared between the firm and its suppliers. The information elements include inventory information, demand information, marketing and promotion information and financial information and includes the five types of information sharing in supply chain described by Lee et al. (2000b) – inventory, sales, demand forecasting, order status and production schedule. The items included in the index are explained in Table 2 below.

- **Information Sharing Complexity**: This is a 2-item summative index that measures the complexity of information sharing process. The items that form the index include whether custom reports are provided to suppliers and whether the supplier is provided structured reports or allowed access to ad-hoc reports (Table 2).

- **SOA Use**: This is a 2-item summative index measuring the level of SOA and web technologies adoption in the focal firm. The items that form the index include use of web services and XML in the organization and broad implementation of service oriented architecture (Table 2).

- **SCM Use**: Binary variable indicating whether the firm uses supply chain management (SCM) systems to connect and interact with its suppliers.

Variables from Compustat:

- **Supply Chain Performance**: We use two measures of supply chain performance that complement each other – the operational measure of inventory and the financial measure of accounts payable. Level of inventory in supply chain is the traditional measure of supply chain performance in the operations management literature (Cachon et al. 2000; Moinzadeh 2002). We complement the primary measure of inventory with the level of accounts payable as an additional measure of supply chain performance. Inventory and accounts payable both are inverse measures of supply chain performance, i.e. lower inventory and accounts payable indicates better performance.

  Accounts payable is an unconventional measure of supply chain performance compared to more traditional measures like inventory and lead times. We have refrained from using inventory as the only dependent variable as our sample consists of different industries that have very different inventory profile. Service industries are the largest part of US economy and we want the scope of the study to include both manufacturing as well as services supplier. Accounts payable is a more inclusive measure that is relevant for both manufacturing and services industries.

  Accounts payable and inventory combine to measure benefit of supply chain performance to both sides of the supply chain relationship. A reduction in inventory benefits the firm while a reduction in accounts payable benefits the suppliers.

For checking the robustness of accounts payable as a measure of supply chain performance, we calculated the correlation between accounts payable and inventory levels and found the correlation to be very high (73%), indicating that accounts payable (like inventory) is a good measure of supply chain performance.

A potential problem with accounts payable as a measure of supply chain performance is that firms may consider higher accounts payable desirable since delaying payments to suppliers is similar to an inexpensive and flexible source of financing for the firm. However, previous research has shown that low levels of accounts payable is associated with better firm performance. Deloof (2003) analyzed data from more than 1,000 large Belgian firms to show that firms that take longer to pay their suppliers (indicating high accounts payable) are in fact likely to be less profitable. Mukhopadhyay et al. (2003) showed that electronic integration in supply chain leads to reduction in delays in payments to suppliers.

Late payment of invoices can be very costly if the firm is offered a discount for early payment. Deloof (2003) reports that in a survey, 75% of firms offered a discount for payment within 10 days with average discount of 3%. Even though the average contractual credit period was 41 days, the average actual payment period was 61 days with 49% of all trade credit paid late with adverse performance implications.

Even though an increase in accounts payable may lead to higher profitability in the short run – a sustained high level of accounts payable indicates clogged processes and inefficient information sharing. High level of accounts payable adds delay to completion of transaction and increases the potential for

errors and late error detection leading to higher costs of fixing the errors (similar to inventory). Hence, we conclude that accounts payable is a good inverse measure of supply chain performance.

If a firm's financial processes are oriented towards maximizing working capital then the firm is likely to keep accounts payable higher and accounts receivables lower. To control for firm's financial processes, we are using levels of accounts receivable as a control in the research model for the cases when accounts payable is the dependent variable.

- **Firm Size**: Annual revenue in million USDs.
- **Industry**: Based on the first digit of the North American Industry Classification System (NAICS) code for each firm, we have divided firms into five sectors and included a binary (dummy) variable to take into account sector wise differences in performance. The five sectors are: NAICS 1 (agriculture and related industries), NAICS 2 (mining, utilities and construction), NAICS 3 (manufacturing), NAICS 4 (retail and transportation) and NAICS 5 (information technology and financial services). NAICS 1 and firms falling in the other category have been taken as the base industry sector and hence has no dummy assigned to it.
- **Accounts Receivables**: Level of accounts receivable in million USDs.

The Table 2 below details the survey questions used for constructs with multiple measures:

Construct	Measures	Scale
Information Sharing Transparency	Which applications or data types does your company give electronic access to the [suppliers]	
	Customer demographics	Binary
	Sales forecasts	Binary
	Marketing Plans	Binary
	Sales or campaign results	Binary
	Production schedules	Binary
	Accounts payable	Binary
	Customer loyalty or satisfaction metric	Binary
	Cost structure data	Binary
	Order management	Binary
	Product development specifications	Binary
	Inventory levels	Binary
Information Sharing Complexity	Please indicate how frequently is the following business practices conducted: Customized information sharing with suppliers	Scale of 1 to 4
	Do members of your electronic supply chain query your systems directly for pertinent information on an ad-hoc basis or do they obtain structured reports?	Scale of 1 to 4
SOA Adoption	Has your IT department developed and deployed a companywide services based IT architecture?	Scale of 1 to 4
	Are the following products or technologies widely deployed in your organization – Web services (applications using SOAP, UDDI, XML)?	Scale of 1 to 4

Table 2: Constructs with Multiple Measures

Dataset Validity and Descriptive Statistics

As several variables were collected from one InformationWeek survey, we assessed the potential concern of common method bias using Harman's one factor test (Podsakoff et al. 2003). Results of this test suggest that common method bias is unlikely to be a serious problem in the data. The routine tests for reliability of survey measures are not applicable because we use formative (i.e., summative) scales for our constructs. We assessed the accuracy and validity of survey responses by correlating revenue figures provided by survey respondents with the revenue figures obtained from Compustat. The correlation was found to be very high indicating that the survey responses were accurate and reliable.

Descriptive statistics of variables used in the empirical model are provided in Table 3. Table 4 presents the correlation matrix for the variables. Supply chain performance measures – inventory and accounts payable, firm size and accounts receivable control are used in the log form to account for their large variance and the resulting potential heteroskedasticity in regression results.

Variable	Mean	Std. Dev.	Min	Max
Inventory (log)	7.2081	1.5030	4.20	12.83
AP (log)	7.5263	1.6866	5.11	13.08
AR (log)	7.9273	1.8186	3.21	13.72
Firm Size (log)	9.5958	0.7979	8.52	12.46
Ind_NAICS2	0.1122	0.3165	0	1
Ind_NAICS3	0.3571	0.4804	0	1
Ind_NAICS4	0.1990	0.4003	0	1
Ind_NAICS5	0.2857	0.4529	0	1
IT Intensity	3.6433	3.4239	0	30
SCM Use	0.5738	0.4953	0	1
Transparency	3.2068	2.8202	0	11
Complexity	1.8926	0.9580	1	4
SOA Use	3.0458	0.9592	1	4

Table 3: Descriptive statistics for variables used

		1	2	3	4	5	6	7	8	9	10	11	12
1	Inventory (log)	1.00											
2	AP (log)	0.67	1.00										
3	AR (log)	0.57	0.84	1.00									
4	Firm Size (log)	0.59	0.57	0.69	1.00								
5	Ind_NAICS2	(0.19)	(0.16)	(0.03)	0.03	1.00							
6	Ind_NAICS3	0.04	(0.22)	(0.09)	(0.03)	(0.24)	1.00						
7	Ind_NAICS4	0.03	(0.09)	(0.27)	0.00	(0.15)	(0.38)	1.00					
8	Ind_NAICS5	0.16	0.47	0.40	0.02	(0.19)	(0.50)	(0.30)	1.00				
9	IT Intensity	0.19	0.11	0.13	(0.05)	(0.08)	(0.14)	(0.10)	0.32	1.00			
10	SCM Use	0.13	0.20	0.15	0.10	0.01	(0.05)	(0.07)	0.08	0.07	1.00		
11	Transparency	0.02	(0.14)	(0.06)	0.19	(0.07)	0.16	0.21	(0.33)	(0.06)	0.11	1.00	
12	Complexity	0.16	0.13	0.04	0.12	(0.13)	0.01	0.09	(0.03)	0.08	0.14	0.35	1.00
13	SOA Use	(0.09)	(0.05)	0.03	0.04	(0.02)	(0.02)	(0.04)	0.08	0.08	0.22	0.16	0.15

Table 4: Correlation coefficients for variables used

Regression Methodology

The functional form of the two regression equations is shown below in Figure 3. The empirical model contains two regression equations corresponding to two supply chain performance measures – inventory and accounts payable. The accounts receivable control is used only for estimating the regression equation with accounts payable as the dependent variable.

Primary Model:

$$\text{Ln(Inventory)} = \beta_0 + \beta_1 \text{ Transparency} + \beta_2 \text{ Complexity} + \beta_3 \text{ (Transparency * SOA Use)} + \beta_4 \text{ (Complexity * SOA Use)} + \beta_5 \text{ Ln(Firm Size)} + \beta_6 \text{ SCM Use} + \beta_{7\text{-}10} \text{ Industry Dummies} + \varepsilon$$

Secondary Model:

$$\text{Ln(Accounts Payable)} = \beta_0 + \beta_1 \text{ Transparency} + \beta_2 \text{ Complexity} + \beta_3 \text{ (Transparency * SOA Use)} + \beta_4 \text{ (Complexity * SOA Use)} + \beta_5 \text{ Ln(Firm Size)} + \beta_6 \text{ SCM Use} + \beta_{7\text{-}10} \text{ Industry Dummies} + \beta_6 \text{ Ln(Accounts Receivable)} + \varepsilon$$

Figure 3: Empirical Models

There are two regression equations corresponding to two supply chain performance measures. As both equations are to be estimated using the same data sample, the error terms of the two models are likely to be correlated. This implies that we cannot estimate the two models separately using two different OLS regression models since unbiased OLS estimation requires the error terms to be uncorrelated with each other (Greene 2003). Seemingly Unrelated Regression Estimation (SURE) technique allows for potential correlations between different simultaneously estimated models to obtain consistent and efficient estimates (Srivastava et al. 1987). The Breusch-Pagan test for independence of error terms across equations was rejected providing support for the appropriateness of SURE technique (Greene 2003).

3.4 Results and Analysis

We tested the research model using our final dataset of 120 large US companies. The two regression equations contained in the research model were tested simultaneously using SURE. Results of the SURE regression analysis are presented below in Table 5. The first part of the figure labeled "primary model" presents the results for inventory as the supply chain performance measure. The second part, labeled "secondary model", presents the results for accounts payable as the supply chain performance measure and accounts receivable as the additional control.

Variable	Primary Model (Inventory)			Hypotheses	Secondary Model (Accounts Payable)			Hypotheses
	Coeff.	p-value	Sig.		Coeff.	p-value	Sig.	
Intercept	-3.1071	0.082	*		0.0907	0.934		
Information Transparency	-0.7420	0.000	***	H1: Supported	-0.5078	0.000	***	H1: Supported
Information Complexity	0.8297	0.043	**	H2: Supported	0.1308	0.593		H2: Not Sig.
SOA Adoption	-0.2627	0.383			-0.3049	0.088	*	
Transparency * SOA Adoption	0.1895	0.001	***	H3: Not Supp'td	0.1359	0.000	****	H3: Not Supp'td
Complexity * SOA Adoption	-0.2467	0.055	*	H4: Supported	-0.0351	0.647		H4: Not Sig.
Firm Size	0.9568	0.000	****		0.2798	0.008	***	
Industry: NAICS 2	1.4800	0.038	**		0.2996	0.482		
Industry: NAICS 3	2.1570	0.002	***		0.0964	0.817		
Industry: NAICS 4	2.2882	0.003	***		1.0779	0.016	**	
Industry: NAICS 5	1.5184	0.034	**		0.5949	0.185		
SCM Use	0.1267	0.556			0.1522	0.241		
IT Intensity	0.0961	0.051	*		0.0647	0.032	**	
Accounts Receivable					0.6558	0.000	****	
Chi-Square	117.48	0.000	****		6.7700	0.000	****	
R-Square	0.5032	N = 116			0.4529	N = 116		

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Note: Supply chain performance is measured in an inverse scale. Negative coefficients mean better

Table 5: SURE Results

The results of the primary model with inventory as the supply chain performance measure support the main effects hypotheses (H1 and H2) that information sharing transparency improves supply chain performance while information sharing complexity reduces supply chain performance. This adds an important dimension to the research on information sharing in supply chain. We find that although higher degree of information sharing (information sharing transparency) does lead to higher levels of supply chain performance; it is not the only mechanism by which the information sharing process affects performance. We find that the complexity of the information sharing process is important as well in determining supply chain performance. Thus, we show that managers and researchers need to consider not only "what" information is shared in the supply chain but also "how".

Further, we find significant support for the hypothesis (Hypothesis 4) that SOA use mitigates the negative impact of information sharing complexity. This provides support for the practice assertion that SOA adds flexibility to IT system and helps combat complexity. However, the impact of SOA use on the relationship between information sharing transparency and supply chain performance (Hypothesis 3) was found to be negative and significant. This means that, in contrast to the posited effect direction in Hypothesis 3, SOA use reduces the positive impact of information sharing transparency on supply chain performance. Although this does not support our hypotheses, this is in agreement with concerns raised in practice media about governance issue associated with SOA (Coticchia 2006).

Results for the secondary model with accounts payable as the supply chain performance measure are similar to the primary model for hypotheses 1 and 3. The

relationships considered in hypotheses 3 and 4 were not statistically significant in the secondary model. Thus, we find additional support for the positive relationship between information sharing transparency and supply chain performance (H1). We also find additional support for the negative interaction effect between SOA use and the relationship between information sharing transparency and supply chain performance (H2). While we did not find statistically significant support for hypotheses 2 and 4 in the secondary model, the coefficient values are in the hypothesized direction. None of the statistically significant results in the secondary model are inconsistent with the corresponding results in the primary model.

The

Table 6 below summarizes the results of the two regression models. The relationships that are supported by both the models are labeled as strong support while the relationships that are supported by the primary model with statistically insignificant results in the secondary model are labeled as having moderate support.

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No	Relationship	Support
1	Information sharing transparency improves supply chain performance	Strong
2	Information sharing complexity reduces supply chain performance	Moderate
3	SOA use reduces the positive impact of information sharing transparency on supply chain performance	Strong
4	SOA use mitigates the negative impact of information sharing complexity on supply chain performance	Moderate

Table 6: Summary of Regression Results

The results show that overall, SOA adoption leads to performance improvements. This represents the first broad empirical evidence of business value of SOA adoption using objective performance measures. Previous studies on business value of SOA had either used a case study approach (Lim et al. 2003) or used perceptual measures with potential for common method bias (Kumar et al. 2007a). As the coefficient of SOA Adoption in the model with interactions is not significant, we can conclude that the entire impact of SOA adoption in supply chain performance is mediated through the two interaction effects.

Our results show that while SOA adoption does lead to tangible business value in general, its specific impact depends on the characteristics of the processes on which SOA

is implemented. While we find that SOA is successful in mitigating the negative impact of process complexity. However, we also find that SOA reduces the benefits attached to a more transparent information sharing regime. This can be due to problems in governing SOA systems when a large number of information elements are being managed.

3.5 Discussion and Conclusion

Our goal in this chapter was to study the impact of characteristics of information sharing process and SOA adoption on supply chain performance. We developed our theoretical model by integrating operations and information systems research streams. We used secondary data about characteristics of information sharing process and SOA adoption levels from InformationWeek and supply chain performance and other financial information from Compustat to build a dataset of 305 large publicly traded US companies. We used this dataset to test our research model using OLS.

We find that information sharing transparency is positively associated with supply chain performance while information sharing complexity is negatively associated with supply chain performance. Both these results support our main effects hypotheses. Our results emphasize that researchers need to study the information sharing in supply chain in the context of the process used for information sharing. While this does not invalidate conclusions from previous analytical research (Cachon et al. 2000; Lee et al. 2000a) that show positive performance benefits arising from information sharing in supply chain, it shows that actual benefits gained in practice may be lower and may depend upon the design of process and technology architectures used for information sharing.

In the case of interaction effects with SOA adoption, we find that as expected, SOA adoption reduces the negative impact of information sharing complexity. This confirms the flexibility benefit of SOA which helps in managing the complexity of the information sharing process. The interaction of SOA adoption with information sharing transparency is however negative and it reduces the performance benefits associated with information sharing transparency. The negative effect can be seen with practitioner concerns about SOA governance (Kobielus 2006). The Agile Journal, a practitioner publication, reports that "*SOA's loosely-coupled nature ... greatly increases the number of moving parts that must be managed and governed... Organizations that don't apply governance processes ... run the risk of ending up with a collection of point-to-point services that simply add another layer of technology spaghetti"* (Coticchia 2006). With high levels of information sharing transparency, SOA governance becomes even more difficult and that in turn may affect performance negatively. Previous studies have also shown that too much information can distract managers from more relevant data and reduce performance (Steckel et al. 2004).

Kim et al. (2006) note that prior research in information systems has taken the use of EDI as a surrogate measure for electronic information transfer. Venkatraman et al. (1989) argue that there is a mistaken tendency to equate electronic integration with EDI in existing electronic integration research. In this study we have avoided the problem by directly measuring elements of information sharing and not relying on surrogate measures of electronic integration.

As Subramani (2004) mentions, research in supply chain has tended to focus more on the focal firm and less on the suppliers to the focal firm. Our dependent variable,

although measures a part of the operations of the focal firm, is also beneficial to the suppliers and hence is in line with the integrative supply chain research advocated by Subramani (2004).

3.5.1 Post-Hoc Analysis

To counter the argument that our results may be due to short term changes in our dependent variables, especially accounts payable, we repeated the analysis with one year lagged dependent variable (inventory and accounts payable for one year after the survey). In the modified regression model, we use the one year lagged values of dependent variables (inventory and accounts payable) and financial variables while keeping the hypothesized variables at the previous level. This regression, hence, shows the effect of SOA use and information sharing level in year 2002 on the supply chain performance of year 2003. Using lagged variables is an accepted practice in business value of IT literature to account for the fact that IT systems implementation precedes the benefits accruing from it by a significant time.

The lagged model is estimated using SURE, similar to the original model estimation. The results of the lagged model are provided in Table 7 below.

Variable	Lagged Primary Model (Inventory)			Hypotheses	Lagged Secondary Model (AP)			Hypotheses
	Coeff.	p-value	Sig.		Coeff.	p-value	Sig.	
Intercept	-3.8403	0.062	*		0.4482	0.686		
Information Transparency	-0.5295	0.018	**	H1: Supported	-0.5096	0.000	****	H1: Supported
Information Complexity	0.7663	0.110		H2: Not Sig.	0.2990	0.233		H2: Not Sig.
SOA Use	-0.2057	0.564			-0.2188	0.242		
Transparency * SOA Use	0.1316	0.043	**	H3: Not Supp'td	0.1364	0.000	****	H3: Not Supp'td
Complexity * SOA Use	-0.1754	0.247		H4: Not Sig	-0.0742	0.350		H4: Not Sig.
Firm Size	1.0286	0.000	****		0.1862	0.093	*	
Industry: NAICS 2	1.4296	0.081	*		0.3422	0.430		
Industry: NAICS 3	2.0824	0.009	**		0.0009	0.998		
Industry: NAICS 4	2.0445	0.019	**		0.9175	0.044	**	
Industry: NAICS 5	1.6639	0.043	**		0.4725	0.300		
SCM Use	0.0589	0.812			0.1637	0.212		
IT Intensity	-0.0602	0.284			0.0577	0.057	*	
Accounts Receivable					0.6894	0.000	****	
Chi-Square	80.08	0.000	****		660.89	0.000	****	
R-Square	0.4084	N = 116			0.8518	N = 116		

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Note: Supply chain performance is measured in an inverse scale. Negative coefficients mean better

Table 7: SURE Results for Lagged Models

Results of the lagged model are broadly similar to the main results presented in Table 5. The direction and significance of results remain consistent with the main results for the impact of information sharing transparency on supply chain performance and the negative interaction between SOA use and the relationship between information sharing transparency and supply chain performance. Thus, the two strongly supported relationships from the main analysis are also supported in the lagged variable analysis.

Two relationships that were moderately supported by the main regression results are found to be not statistically significant in the lagged model even though their coefficients are in the hypothesized direction. However, this is not inconsistent with the

main results as some loss of power is expected with the lagged variable analysis. As no statistically significant relationship in the lagged variable regression is inconsistent with a corresponding relationship in the main regression analysis, we can consider the lagged results to be in alignment with the main results.

3.5.2 Research Implications

This research adds to the business value of IT literature by empirically demonstrating business value of specific technology architecture in a specific process context. The literature on business value of IT has progressed from overall studies of productivity with several mixed results (Brynjolfsson 1993; Brynjolfsson et al. 1998) to more process oriented studies that capture the business value of IT at the process stage (Mukhopadhyay et al. 1997). In addition, overall firm level measures of business value of IT tends to under-measure the benefit as productivity benefits are competed away in the form of consumer surplus (Hitt et al. 1996). We continue the movement towards process level studies by basing this research in a specific process context and measuring business value using objective process level measures. We also show how SOA interacts with process characteristics which can provide a base for future studies that integrate process and technology elements in a unified model.

Operations management researchers have studied the impact of information sharing on supply chain performance mainly through analytical models and have not considered technology issues. We extend this research by bringing an empirical dimension and integrating with information systems research. This is in line with recent trends in operations research. As Pannirselvam et al. (1999) noted in their survey of

operations management research: "*OM research shows a trend toward more integrative research ... with other business disciplines ... this kind of integrative research may require us to me more innovative in the future in our selection of methodologies used.*" This study further adds to research by studying the interaction between technology adoption and process characteristics.

3.5.3 Managerial Implications

There has been a din of vendor supported publicity about SOA. Firms like IBM and Oracle are supporting SOA and have produced several reports or white papers suggesting significant benefits of SOA adoption. It is difficult for managers of user firms to get unbiased opinions about potential benefits and pitfalls of SOA. In this chapter we present an academic investigation of SOA adoption and uncover both positive and negative impact of SOA adoption on supply chain performance. We believe that our results will help managers in getting a holistic picture of SOA and its performance impact.

There has been a rich theoretical literature about information sharing in supply chains. However, the managerial utility of the theoretical works have been questioned. As Li et al. (2006b) mentioned: "*while information sharing is important, the significance of its impact on the performance of a supply chain depends on what information is shared, when and how it is shared, and with whom.*" This study analyzed the how part of information sharing and provides managers with more tangible directions to implement information sharing and SOA adoption in supply chains for improving supply chain performance. This study shows that managers need to strike a balance between sharing information in the supply chain and controlling the complexity of the information sharing

process. Our results also show that managers can control the negative impact of process complexity by adopting SOA for managing their processes. However, this approach is only likely to be productive if the level of transparency in information sharing process is controlled as well.

Our study has important implications for SOA vendors like IBM, Sun and Oracle. Our results emphasize that even though there are substantial flexibility benefits to SOA, which helps counter complexity, the governance issues related to efficient management of an SOA environment when information sharing transparency is high deserves their attention. Otherwise governance problems could have an adverse impact on the scale of SOA adoption and companies that have high levels of process transparency but low process complexity would not be able to derive significant benefits from SOA adoption.

3.5.4 Limitations and Future Research

Empirical studies are naturally constrained by the availability and granularity of data. Although we have tried to go into process and technology level details in this research, our measure of SOA adoption is still coarse and does not take into account individual SOA standard elements being adopted by firms. Further, the data for the study was collected in 2003 and it can be argued that much development has taken place in SOA design, development and adoption since then. However, the basic nature and fundamental principles behind SOA remain the same and hence we believe that the results are still valid and relevant for current practice.

In this study, information sharing transparency only considers the amount (how many information elements – inventory, demand, promotion etc.) of information sharing.

We do not consider different types of information to have different main effect on supply chain performance and different interaction effects with SOA adoption. Previous research has classified information sharing in supply chain in three categories: transactional, operational and strategic (Li et al. 2006a). Our research can be extended to study whether different categories of information sharing have different impact on supply chain performance.

Our selection of accounts payable as a dependent variable can be considered a limitation as accounts payable is not a traditional measure of supply chain performance. However, as we have conducted several robustness checks including running the model with inventory data as well, we are confident of our selection of accounts payable as a measure of supply chain performance. Our research can be extended by using other process level indicators of supply chain performance as well.

3.5.5 Conclusions

In spite of the billions of dollars being invested by firms every year in developing and deploying SOA, there has been no broad based empirical investigation of the performance impact of SOA adoption. This study contributes to a better understanding of the impact of SOA adoption through an empirical study of SOA adoption and information sharing in supply chain for a cross section of large US firms. We found that adoption of SOA leads to better performance. While SOA adoption helps to mitigate the negative effects of the complexity of the information sharing process, it also reduces the positive impact of information sharing transparency. Our findings extend the business value of IT as well as operations management research into supply chain and SOA. The

results also provide insights for IT managers to make informed decisions about SOA adoption and information sharing process design. Although this study has certain limitations, we believe it provides a strong base for future research to further explore the information sharing process in supply chain and organizational impact of SOA adoption.

CHAPTER – 4

Information Sharing and Decision Making in Peer to Peer Electronic Markets: Frictionless No More!

4.1 Introduction

Markets bring buyers and sellers together and facilitate the exchange of information, goods, services and payments. Electronic markets leverages Information Technology (IT) to perform the functions of the traditional markets with increased effectiveness and lower transaction cost (Bakos 1998b). Examples of such electronic markets include business to business procurement markets like ChemConnect, reverse auction markets like Priceline and online auction markets like eBay. With increasing reach and popularity of the Internet, electronic markets have enjoyed significant growth in past years (Bacheldor 2000). Electronic markets first started in the business to business setting (e.g. ChemConnect) and have now expanded into the business to consumer (Priceline) and consumer to consumer or peer to peer (eBay) space as well. The "new" Internet, Web2.0, now allows individuals to collaborate and harnesses the collective intelligence and decision making power of large groups of individuals (Oreillynet.com 2007). This

reduces the search cost associated with finding other members of peer to peer electronic markets and makes these markets more viable.

Peer to peer electronic markets are part of the broader movement towards business models that emphasize sharing information beyond firm boundaries. These new business models are what Peter Drucker called the "new organization" that have information sharing as a key element of operation (Drucker 1988). For example - Netflix has openly shared 100 million movie ratings with hundred of independent teams that are attempting to build a recommendation system that can outperform the in-house system at Netflix (Hafner 2006). Open source ventures like Firefox by Mozilla, Android by Google and Eclipse by IBM have shared their entire source code as open source software that can be viewed, modified and further developed by any interested person (Claburn 2008). Prosper.com's business model depends upon sharing anonymized credit history details of potential borrowers with hundreds of thousands of potential lenders and allowing the distributed community of lenders to make decisions regarding creditworthiness of the borrower and the interest rate to be charged (Hof 2006b; Kumar 2007a).

Research on electronic markets can be traced back 20 years to the seminal paper by Malone et. al. that proposed the Electronic Markets Hypothesis (EMH) (1987). EMH argued that reduction in coordination cost resulting from increasing use of IT will lead to a shift towards the use of electronic markets rather than hierarchies to control economic activities. Early research on electronic markets focused on the low transaction cost of electronic markets and characterized them as "frictionless" (Bakos 1998b). Brynjolfsson et al. (2000) make a note of this view: "*the characteristics of the Internet will lead to a market where retailer location is irrelevant, consumers are fully informed of prices and*

product offerings, and all retailers make zero economic profits." However, further research has discovered sources of "frictions" unique to electronic markets. For example: the anonymous and impersonal nature of the electronic markets lead to a lack of trust between market participants (Resnick et al. 2000). Electronic markets have developed mechanisms like reputation systems to build trust between market participants and thus manage this new friction (Ba et al. 2002). As electronic markets evolve and incorporate new industries, audiences and business models, it is important that we discover other sources of friction that may affect the effectiveness of the market and also identify potential approaches to mitigate their negative effects.

Decision making by large number of market participants in peer to peer electronic markets represent another source of friction. The fundamental function of an electronic market is price discovery through matching of buyers and sellers. In peer to peer markets, large numbers of market participants pool their pricing decisions for an equilibrium market price to emerge. Decision making by market participants depends on the information available to them. In contrast to a firm that may have access to detailed data through credit reports, market research, loyalty programs, previous purchase history etc, electronic market participants depend on the market to provide them with information relevant to decision making. On the other hand, information sharing by the market with market participants is limited by constraints such as privacy concerns and participant anonymity. Further, markets participants in peer to peer electronic markets are often inexperienced and untrained individuals who are expected to assimilate large amounts of information and make a decision about price of complex goods of services. If market participants are not being able to adequately make use of the available information and

make inefficient decisions, then the participants are likely to suffer lower satisfaction and in the long run reduce their participation in the market. For example – if buyers cannot correctly identify fraudulent sellers on eBay then buyers will suffer a loss and will be less likely to use eBay in future. EBay's long term success depends on providing sufficient feedback information to buyers so that they can make good decisions and correctly identify fraudulent sellers. Thus, quality of decision making by market participants is important for long term success of electronic markets and inefficient decision making by market participants represent a new source of friction in peer to peer electronic markets.

In this chapter we empirically study the new and unique source of friction for peer to peer electronic markets – quality of decision making by market participants. We used Prosper.com, a peer to peer financial market, as the context for this research. We analyze decision making by lenders in Prosper.com and compare observed decision making with an efficient benchmark for the information sharing regime adopted by the market. We then look at potential mechanisms to manage the new source of friction by analyzing how the quality of decision making changes through self learning and as a result of increase in information available.

The rest of the chapter is organized as follows: next section provides details of the context for the research – Prosper.com, a peer to peer financial market. Section 3 discusses relevant previous literature and develops the hypotheses and research model. Data and methodology used for analyzing the quality of decision making by market participant and hypotheses testing are detailed in section 4. Results of empirical models and their analysis are presented in section 5, followed by a discussion of the results, limitations of the study and future research directions in section 6.

4.2 Peer to Peer Financial Market

In traditional business model of a bank, the bank acts as the aggregator and manager of deposits and loans. Banks take deposits from individuals at a lower interest rate and lend the money to others at a higher interest rate. The difference between the two interest rates, called the spread, is the main source of a bank's income. For example – a recent sample of prevailing interest rates indicate that while prime lending rate for banks is 8.25% (Bankrate.com 2007b), the deposit rate for a 1 year deposit is only 4.8% (Bankrate.com 2007a), giving the bank a spread of 3.25% even for the prime borrowers.

Peer to peer financial marketplaces allow lenders (individuals who deposit) and borrowers to interact, transact and take a share of the spread between borrowing and lending interest rates. Recent loans to quality borrowers at a peer to peer financial marketplace carried an average interest rate of only 7.79% (Prosper.com 2007a), which is lower than the prime lending rate for banks, indicating that the marketplaces are allowing the borrowers and lenders to get a share of the spread which would otherwise have gone to the bank.

Peer to peer financial marketplaces have alternately been called "the eBay for loans" (Hof 2006a; Pearlstine 2006). Borrowers list their requirements and the maximum interest rate they would be willing to pay and lenders then bid on the loan listings. If there is sufficient interest in the listing then the loan interest rate is bided down and the loan is finalized at the market clearing interest rate. The marketplace works as the platform provider and takes a commission from the borrowers and the lenders. The essential concept of peer to peer financial marketplaces has also been extended towards charitable

lending or “social lending”. For example: Kiva.org provides a platform for individuals to lend interest free to entrepreneurs in developing countries (Kiva.com 2007). Although profit oriented marketplaces like Prosper.com, where lender’s have an opportunity to get attractive returns, have also been sometimes clubbed together with marketplaces solely devoted to social lending (Vanderkam 2006), in this research we have assumed that lenders work for a profit motive and try to maximize their returns for the given risk profile of their investment. Informal discussions with lenders at Prosper.com support the assumption.

4.2.1 Operational Details: Prosper.com

Prosper.com is the largest peer to peer financial marketplace in the world. The service is essentially positioned as an eBay style loan marketplace. Prosper.com matches people who need small loans, but can't get them from traditional banks (or get them from traditional banks at higher interest rates than those available at the marketplace), with willing lenders. Prosper.com, established on Feb 13, 2006, is the first peer to peer financial marketplace in US; although Zopa.com provides a similar service in Britain. Prosper.com has witnessed rapid growth and now has more than 8000 loans with total loan origination of over $41 million. Prosper.com boasts of more than 180,000 registered users and currently clocks more than $6 millions in new loans every month (Prosper.com 2007b).

BusinessWeek (Hof 2006a) explains Prosper.com’s working as follows: People who want a loan of up to $25,000, put it up for bid at a maximum interest rate they're willing to pay. Although they can remain anonymous to everyone but Prosper.com and

regulatory authorities, they must submit to having their credit record checked and their credit grades displayed on their listing. They also must provide details of their annual income for calculating their debt to income ratio. Lenders bid in increments starting at $50, usually just for a portion of the loan. Prosper.com provides borrowers and lenders information on standard interest rates and default rates associated with the various credit rating levels, so they can make judgments about reasonable payments and risk levels. When the listing ends, the bids with the lowest rates are combined to produce a single loan that's repaid over three years. Prosper.com draws payments from the borrower's bank account and sends them monthly to the various lenders' accounts. Prosper.com charges borrowers a fee equal to 1% of the funded loans, as well as a 0.5% annual loan-servicing fee to lenders.

If a borrower fails to pay, Prosper.com refers the loan to collection agencies chosen by lenders. Prosper.com has also implemented a group membership system that attempts to introduce collective reputation for borrowers. People can form groups of borrowers whose collective repayment record is made public. It is expected that people will be less likely to default if they know that their delinquency will hurt a group of people they know, and that the group leaders will be inclined to make sure members don't miss payments. Group leaders get incentives when a loan is repaid in time. Group leaders can choose to keep or share rewards with the borrowers.

4.3 Theory and Hypotheses

Electronic market participants make decisions based on the information shared with them by the market. In a peer to peer auction context like Prosper.com, decision making by

market participants consists of estimating the value of the product (in this case a loan) being auctioned based on information about the product provided by the market. The error in decision making can results from two sources: first, the information available itself may be incomplete and uncertain and second, market participant may not be able to fully utilize the available information. Both sources of error in decision making have been well studied in previous research in the context of decision making by managers based on incomplete information. In this section we review relevant previous literature to develop our hypotheses regarding decision making by market participants in peer to peer electronic markets.

Business managers regularly make decisions based on incomplete or uncertain information. Accordingly, decision making by managers has been a rich area of research. The focus of the research has been to model the process through which managers convert available incomplete information into their estimation of the final decision. The most popular model of decision making based on incomplete information, anchoring and adjustment model, was proposed by Tversky and Kahneman (Tversky et al. 1974). Anchoring and adjustment implies that managers start with an estimate of the unknown or uncertain information (anchor) and then adjust their estimate as more information becomes known or as they learn through repetitive decision making (adjustment). The anchor and adjustment model has been shown to be a good approximation of the decision making process under uncertainty through many experiments and field studies (Jacowitz et al. 1995; Mussweiler et al. 2004). Anchoring and adjustment model has been shown to be applicable in such diverse fields as brand preferences, social choice, and hindsight

bias. We are using anchoring and adjustment as the theoretical lens to look at decision making in electronic markets by market participants.

4.3.1 Anchoring and Adjustment Model

Anchoring and adjustment model of decision making based on incomplete information has two components: an initial anchor and an adjustment to the anchor. The anchor is the starting point of the decision making process and represents the initial estimation of the final decision based on initially available information. The initial anchor can come from a variety of sources like the salient value in memory, views of the experts or experience with previous similar situations (Einhorn et al. 1986). The adjustment to the anchor represents the change in the current anchor based on incorporating new information in the decision making process. For repetitive decision making contexts, the new information also includes the observed net result of previous decisions made.

Learning

Electronic market participants observe the outcome of their decisions and can use past performance to guide adjustments to their decision anchors. In the case of peer to peer financial markets, lenders decide on the risk premium for risk factors and observe the performance of the loan. As loan default data becomes available with time, it provides feedback that can be used to adjust the initial choice of risk premium anchor. Thus, we expect that the quality of decision making by market participants will improve with time. The improvement with time is a result of learning by market participants. However, learning is based on continuance of the existing information sharing regime. A significant

change in information availability may make past experiences inapplicable. Thus, the learning effect can be summarized by the following hypothesis:

Hypothesis 1: Quality of decision making in electronic markets improves with time for a given information sharing regime.

Limitations to Learning

The improvement in decision making may be non-uniform and non-monotonic as the quality of decision making is a result of dynamic interaction between strategies adopted by different groups of participants. In peer to peer electronic markets, while lenders adjust their decision making heuristics by observing the performance of previous loans, potential borrowers also try to take advantage of any error in lender decision making. Further, as new lenders enter the market they start at the beginning of learning curve and although they are likely to learn faster by observing the behavior of other lenders and interacting with other more experienced lenders, it is likely that introduction of large number of new lenders will negatively affect the overall quality of decision making by lenders. Thus, although we expect that decision making will improve with time, the improvement in efficiency of decision making by participants can be non-uniform and non-monotonic.

We can expect that the fastest learning, represented by the largest improvement in the quality of decision making, will happen early in the learning phase when there is the largest gap between the existing decision making and the potential best decision making. As the gap shrinks as a result of learning and improvement in the quality of decision

making, the incremental improvement in quality of decision making with time will also become smaller. Thus, we expect that although the quality of decision making will improve with time, the amount of improvement itself will become smaller with time. Mathematically, we can say that the first derivative of the quality of decision making with respect to time is negative, while the second derivative is positive. After sufficient time, the quality of decision making will become asymptotic to an equilibrium value.

The essential premise of anchoring and adjustment heuristic is that as new information becomes available, the estimates are adjusted. However, previous research has indicated that the anchor has a drag effect – the adjustments tend to be excessively influenced by the initial anchor. The drag effect, reflected in the insufficient adjustment of anchor, has been shown to be a result of enhanced accessibility of anchor consistent information since people evaluate hypotheses by trying to confirm them (Klayman et al. 1987). Thus, according to anchoring and adjustment heuristics, although new information will result in improvement in decision making, some residual inefficiency will continue to exist. We can summarize the arguments above as the following hypothesis:

Hypothesis 2: After significant time for learning in a given information sharing regime, the quality of decision making in electronic markets will asymptotically reach an equilibrium value that is lower than the best quality of decision making possible.

Information Availability

The two hypotheses above focus on the context when the information availability is same for a long time. A stable information sharing regime allows for learning to accumulate

across time. Now we consider the impact of a significant increase in information availability on the quality of decision making. A change in information sharing regime can disturb the ongoing learning but can also provide additional information for improvement in decision making. However, too much information can also lead to information overload that can negatively affect the quality of decision making.

A significant change in information sharing regime disrupts the equilibrium achieved by adjustment of the initial anchor through long term learning. This provides the market participants an opportunity to form a new anchor based on the new information sharing regime. As the new anchor is based on more information, it is likely to result in better decision making than the initial anchor. However, since previous accumulated learning may not be applicable in the new environment, the net result of the disruption of equilibrium on the quality of decision making may be negative. The new anchor will then be adjusted in time through learning and eventually a new equilibrium will be achieved. We can expect that the new equilibrium, based on more information than before, will result in higher quality of decision making.

Increase in information availability increases the risk of information overload. Information overload results when people are inundated with more information than they can handle. Information overload is shown to lead to stress, loss of job satisfaction and physical ill health (Lewis 1996). When information reaches a receiver at a rate too high for the receiver to process efficiently, the information is treated as noise (Klapp 1986). Information is only valuable to the extent that it can be processed and overload can occur if information is received in a form that requires significant effort to process (Königer et al. 1995). Thus, increase in information availability can lead to information overload and

a corresponding negative impact of the quality of decision making. However, the negative effects are not permanent. As individuals work with the information, they identify patterns in the information and learn to manage all the information (Edmunds et al. 2000). Individual's ability to process a given amount of information improved with time, reducing the negative impact of initial information overload.

Integrating the arguments above, we see that a significant increase in information availability is expected to have a negative effect on quality of decision making through disruption of learning equilibrium and potential initial information overload. However, the negative impact is reduced with time as a new learning equilibrium forms and the information receiver's ability to process additional information improves. We formalize the argument as the following hypothesis:

Hypothesis 3: Increase in information availability may negatively affect quality of decision making in the short run but it will have a positive effect on the quality of decision making in electronic markets in the long run.

The three hypotheses presented above can be graphically represented as shown in Figure 4 below: In the beginning (Point A), an initial anchor is formed for decision making based on available information. With time, the anchor is adjusted and the performance improves. However, the incremental improvement slows with time and the performance reaches an equilibrium which still contains significant error (Point B). A disruption in the form of a significant increase in information availability results in initial deterioration of

performance (Point C). However, as the new anchor reaches a learning equilibrium (Point D), it is likely to result in better performance than the previous equilibrium (Point B).

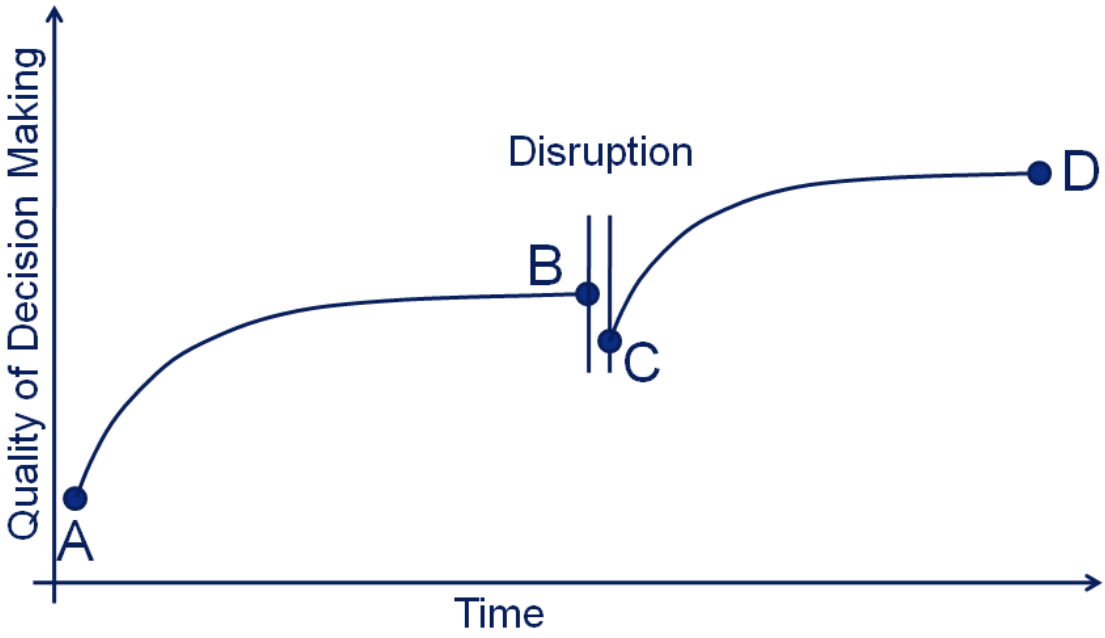

Figure 4: Graphical Representation of Hypotheses

We now focus on testing the hypotheses presented above. The next section provides details of the data and methodology used for evaluating the hypotheses.

4.4 Data and Methodology

Data for this study was collected from Prosper.com using a combination of spider scripts and proprietary data shared by Propser.com with its lenders. The dataset was then analyzed using OLS regression of actual interest rates charged for loans and a Logit regression of defaults of those loans over a 12 month observation period.

4.4.1 Data Collection

First stage of data collection was done using automated spider programs. These spider programs systematically access individual web pages, download the HTML code of the pages and then process the HTML code to extract relevant information into a local database. Previous research has pointed out several pitfalls, such as inconsistent data and missing data, of using spiders for extracting information (Crowston et al. 2004). We employed safeguards in the spider code to maintain data integrity including checks for IP blocking, server unavailability, unavailable internet connection and partial downloading of the web pages. We also manually verified a sample of the spider output to make sure that the output was correctly parsed.

Data collected using Spiders was then combined with proprietary data released by Prosper.com about loan performance. Loan performance data contains financially sensitive information and is not available through public web-pages. Prosper.com shares data in XML format files. We imported the XML files into an MS-Access database and wrote custom queries to extract the data needed for analysis.

We have collected listing, funding and loan repayment data for Prosper.com from its beginning in Feb 2006 until the end of data collection effort in July 2008. Following are the data items that are used in this research:

- **Amount Requested**: Amount of loan requested by the borrower. If the loan is funded then this becomes the principal amount for the loan.
- **Borrower's Credit Grade**: Prosper.com uses a letter grade credit rating system which has the following grades from higher to lower credit: AA, A, B, C, D, E, HR and NC. HR refers to "High Risk" and NC refers to "No Credit Information

Available". HR and NC credit grades were excluded from the analysis because of data reliability problems.

- **Borrower's Debt to Income Ratio**: Ratio of borrower's total debt (including the proposed Prosper.com debt) and total income from all sources.
- **Description Length**: Borrower's can include a title and a description in their loan listings to better convey the merits of their listing to the lenders. The description field is used to create a "Description Length" variable to indicate the amount of information contained in the description field.
- **Credit Length**: Total length of credit history in thousands of days. This is calculated as the difference between the loan listing date and the first recorded credit date.
- **Current Delinquencies**: Number of credit accounts that are in delinquent status at the time of loan listing.
- **Inquiries in 6 Months**: Number of credit enquiries made by the borrower in 6 months before the loan listing date.
- **Total Credit Lines:** Total number of credit accounts in the borrower's credit file. This includes revolving accounts, mortgages, installment accounts and other credit accounts.
- **Loan Interest Rate**: Final interest rate applicable for the loan. This is the minimum interest rate at which the loan is fully funded. This rate will be lower if lender interest is high and larger number of bids are received for the listing
- **Loan Status**: Current status of loan repayment. This can be current or in various stages of late payment/default. Loan status is coded as a binary variable where 1

means that the loan has defaulted or otherwise gone bad (status other than current) and 0 means that the loan is being repaid in time and is in good standing (status current).

The dataset is analyzed in groups of four week durations to make sure that any single analysis is not confounded by longitudinal factors. We then study the longitudinal factors by looking at the difference in results of our analysis between time separated models. The first step in the analysis is to develop a metric to measure the quality of decision making by market participants in electronic markets.

4.4.2 Measuring Quality of Decision Making

Quality of decision making in electronic markets is a core construct in this research. However, no widely accepted metrics exist for measuring quality of decision making in peer to peer electronic markets. For our research context of the peer to peer financial market, Prosper.com, we have developed a measure of the quality of decision making, called risk premium deviation, by comparing the actual interest rates charged with the risk neutral interest rate for the a loan listing.

Risk Premium Deviation

In peer to peer financial markets, lenders have a single decision to make – the level of interest rate to be charged for the loan. The interest rate should compensate the lenders for the risk of the loan default associated with a loan listing. A listing with higher risk of

default should be charged a higher interest rate. The difference in the interest rate because of the presence of a risk factor represents the risk premium for that risk factor.

A correct risk premium will *just* compensate for the expected value of principal loss resulting from higher probability of loan default. We call this value the risk neutral rate. A risk premium higher or lower than the risk neutral rate represents an error in decision making by lenders. The aggregate of absolute difference between the actual risk premium charged and the corresponding risk neutral rate for all the risk factors considered by the lender represents the overall error in decision making by lenders. We use this metric, called the risk premium deviation, as measure of the quality of decision making by lenders in peer to peer financial markets.

Calculation of risk premium deviation involves three steps. First the actual risk premiums charged is estimated for a group of loan listings. Then, for the same loans, the risk neutral rate is estimated using loan default data for the observation period. Finally, the actual risk premiums and the risk neutral rates are compared and the difference between them aggregated to arrive at the value of risk premium deviation.

The steps in calculation of risk premium deviation are illustrated below using real data from Prosper.com. We consider all the loans made during the month of August 2006 that belonged to credit categories other than HR (High Risk) and NC (No Credit). We do not consider HR and NC loans as many of the HR and NC loans had data problems. A total of 399 loans of credit grades other than HR and NC were funded during Aug 2006 that form our sample for calculating risk premium deviation.

Step 1: Estimating Actual Risk Premiums

The first step is to calculate the actual risk premiums charged for different risk factors that may influence the probability of loan default. Actual risk premiums charged for different factors can be estimated by a regression analysis with interest rates charged as the dependent variables and the risk factors that may influence the probability of loan default as explanatory variables.

Since we are only interested in factors that have a statistically significant impact on interest rates, we only consider explanatory variables that have a significance level above 0.9 (p-value below 0.1). This allows us to eliminate non-significant factors for analysis and discover the risk factors that have a significant impact on the interest rate charged for the loan. All the results that follow in this chapter show only the variables meeting the significance criteria.

As the dependent variable, interest rate, is continuous and well behaved, OLS regression can be used to estimate the impact of risk factors on interest rate. The results of the OLS regression are shown below in Table 8:

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Variable	Interest Rate		
	Coeff.	p-value	Sig.
Amount Requested	1.6968	0.000	****
Credit Grade AA	-1.4587	0.087	*
Credit Grade B	2.9475	0.000	****
Credit Grade C	4.5633	0.000	****
Credit Grade D	9.6967	0.000	****
Credit Grade E	12.2866	0.000	****
Debt to Income Ratio	6.8435	0.000	****
Current Delinquencies	0.1503	0.003	***
Credit Length	0.1685	0.028	**
Inquiries in 6 Months	0.1202	0.020	**
Constant	7.6912	0.000	****
F-Stat	82.7400	0.000	****
R-Square	0.6830	N = 395	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 8: OLS Regression Results for Interest Rate in Aug 2006

The coefficient for a risk factor in the regression result indicates the risk premium charged for a unit change in that risk factor. Taking examples from the table above, a coefficient of 1.6968 for the variable Amount Requested (measured in units of $10,000) indicates that lenders are charging an additional interest of 1.6968% for every $10,000 increase in the amount requested. Similarly, the coefficient value of -1.4587 for the binary variable Credit Grade AA indicates that lenders charged the borrowers with the credit grade AA on an average 1.4587% *less* in interest rate compared to borrowers with the base credit grade of A, other things being equal.

Step 2: Estimating Risk Neutral Rate

The *correct* level of risk premiums that lenders *should have* charged to neutralize the additional risk is comparatively difficult to estimate. Such estimation can only be done by observing how loans perform over the duration of the loans. Actual levels of defaults (or the absence of it) in loans associated with a risk factor can tell us the required level of risk premium to fully offset the impact of that risk factor.

We follow the performance of the 399 loans in our sample for 12 months. At the end of the observation period, loan performance was coded as a binary variables called Loan Default. A loan default value of 1 indicates that the loan has defaulted within the observation period while a value of 0 indicates that the loan is currently being repaid in time as of the end of the observation period.

We can estimate the relative contribution of different risk factors on the actual occurrence of loan default using a regression analysis with loan default binary variable as the dependent variable and the risk factors as the explanatory variables. As the dependent variable is discrete, OLS regression cannot be used since OLS requires the dependent variable to be continuous and normally distributed. Instead, we have used the Logistic Regression (Logit) approach that is more suitable for analyzing a binary dependent variable (Long 1997).

Logistic regression considers the log-odds of the probability of failure (also called the Logit function), which is a continuous variable ranging from ∞ to $-\infty$, as the dependent variable. Using that notation that for a loan i, p_i is the probability of loan failure, $x_{1,i}$ through $x_{k,i}$ represent k risk factors and β_0 through β_k represent regression

coefficients that show the impact of risk factors on the log-odd of the probability of default of loan *i*; the estimation equation for the logistic regression can be written as:

$$\boldsymbol{Logit(p_i) = ln\left(\frac{p_i}{1 - p_i}\right) = \beta_0 + \beta_1 x_{1,i} + \ \ldots \ + \beta_k x_{k,i}}$$

The coefficients (βs) can be estimated using maximum likelihood estimation. Table 9 below shows the results of the logistic regression analysis for all the loans funded during Aug 2006. We again consider only the variables with significance level higher than 0.9 to focus on explanatory variables that have a statistically significant impact on loan failure rates.

Variable	Loan Failure		
	Coeff.	p-value	Sig.
Amount Requested	0.7552	0.029	**
Credit Grade C	1.1844	0.010	***
Credit Grade D	1.3585	0.003	***
Credit Grade E	2.6115	0.000	****
Current Delinquencies	0.1206	0.002	***
Total Credit Lines	-0.0280	0.011	**
Constant	-2.5230	0.000	****
Chi-Square	76.8600	0.000	****
Pseudo R-Square	0.1756	N = 383	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 9: Logistic Regression Results for Loan Failures in Aug 2006

The coefficients in logistic regression represent the change in log-odds of loan default because of a unit change in the explanatory variable. The coefficients can be used to calculate the estimated probability of default for given values of explanatory variables. The following equation, derived from the logistic regression equation discussed before, gives the estimated probability of loan default:

$$\boldsymbol{p_i = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_{1,i} + \ldots + \beta_k x_{k,i})}}}$$

Using the equation above, we can calculate the incremental change on the probability of loan default because of a unit change in a risk factor while keeping other risk factors same at their mean values. As we have calculated the loan failure variable over an observation period of one year, the incremental change in probability of default can be compensated for by a similar increase in annual interest rate. Hence, the incremental change in probability of default because of a unit change in a risk factor can be considered the risk neutral rate for that factor. Table 10 shows the calculated values of risk neutral rates for loans in Aug 2006 based on the results shown in Table 9.

Variable	Optimum Risk Premium
Amount Requested	15.0577
Credit Grade C	25.3988
Credit Grade D	29.7453
Credit Grade E	57.3518
Current Delinquencies	2.0581
Total Credit Lines	-0.4580

Table 10: Risk Neutral Rates in Aug 2006

Step 3: Calculating Risk Premium Deviation

We now have both the risk neutral rates that should have been charged by lenders and the actual risk premiums that were charged. The absolute difference between the two represents the error in decision making – the risk premium deviation. However, the two rates have been calculated for a unit change in risk factors. Calculating risk premium deviation based on unit change in risk factors would not be appropriate since some risk factors show significantly more variation than others. For example – while debt to income ratio has a minimum value of 0 and maximum of 1.75 in the sample, total credit lines has the range of 2 to 83. Considering a unit change in the two variables will provide more weight to debt to income ratio, while the impact of total credit lines will be underemphasized. To correct this problem, we look at a normalized variation of one standard deviation change in the risk factors and the corresponding change in actual and optimum risk premiums.

Risk premium deviations of individual risk factors, corresponding to one standard deviation change in the respective risk factor, are added to arrive at the final aggregate

risk premium deviation figure. We do not use the average of individual risk premiums because the effect of risk premium deviation is cumulative in nature and every new deviation increases the total deviation rather than only affecting the average impact.

Table 11 below shows the calculation of risk premium deviation for loans funded in Aug 2006 based on their performance in the twelve month period starting from the loan start. A figure of 0 for a variable in actual or optimum risk premium column indicates that the variable does not have a statistically significant impact and hence is considered to have a marginal impact of zero. Figures in parentheses represent negative values.

Variable	Standard Deviation	Optimum Risk Premium	Actual Risk Premium	Risk Premium Deviation
Amount Requested	0.4354	5.9353	0.7387	5.1967
Credit Grade AA	0.2832	-	(0.4132)	0.4132
Credit Grade B	0.3228	-	0.9514	0.9514
Credit Grade C	0.4064	9.0281	1.8545	7.1736
Credit Grade D	0.4249	11.0741	4.1201	6.9540
Credit Grade E	0.4354	24.2222	5.3490	18.8732
Debt to Income Ratio	0.1507	-	1.0316	1.0316
Current Delinquencies	3.9018	8.8047	0.5865	8.2182
Credit Length	2.4564	-	0.4138	0.4138
Inquiries in 6 Months	3.6943	-	0.4442	0.4442
Total Credit Lines	14.0964	(5.7696)	-	5.7696
Total				**55.4394**

Table 11: Risk Premium Deviation for Loans in Aug 2006

Thus we arrive at the final risk premium deviation figure for loans funded in Aug 2006: **55.4394**. This represents the level of error in decision making by lenders – a higher

number represents higher level of error and hence lower quality of decision making by lenders in the peer to peer financial market.

4.5 Results and Analysis

We now follow the methodology detailed above for calculating the quality of decision making by lenders in different time periods to test our hypotheses. We first look at the change in quality of decision making over time to test hypotheses 1 and 2. Then we study the change in quality of decision making before and after a significant increase in information availability to test hypotheses 3.

4.5.1 Effect of Learning

According to the anchor and adjustment model, we expect that lenders adjust their decision making heuristics as they get feedback on their decisions in the form of the actual performance of loans. Accordingly, we hypothesized that the quality of decision making would improve with time (hypothesis 1). In other words, we expect the risk premium deviation to go down with time. However, the learning accumulates only when the information available for decision making continues to be stable. A significant change in information availability would lead to formation of new anchors rather than an adjustment of existing anchor.

To test the learning effect, we use the methodology detailed above to measure the risk premium deviation at three month intervals. Even though Prosper.com started operations in Feb 2006, initial months of operations included many changes to the interface, listing rules and information available to lenders. Accordingly, we have started

risk premium deviation measurement after a six month period of stabilization. The first measurement is done for loans funded in Aug 2006 followed by Nov 2006 and Feb 2007. We cannot continue the learning evaluation beyond loans funded in Feb 2007 as there is a significant change in the amount and nature of information sharing by the market in Feb 2007.

Risk Premium Deviation in Nov 2006

There were 439 loans in our sample during Nov 2006. We observe the performance of these loans for 12 months. We first estimate the actual risk premiums for these loans using an OLS regression with interest rate charged as the dependent variable. Results of the OLS regression are shown in Table 12. We then estimate the risk neutral rates using a logistic regression with loan failure as the binary dependent variable. Results of the logistic regression are shown in Table 13.

Variable	Interest Rate		
	Coeff.	p-value	Sig.
Amount Requested	3.6871	0.000	****
Description Length	-0.0910	0.001	****
Credit Grade B	4.0242	0.000	****
Credit Grade C	7.1380	0.000	****
Credit Grade D	10.6516	0.000	****
Credit Grade E	14.8453	0.000	****
Total Credit Lines	0.0227	0.066	*
Current Delinquencies	0.2496	0.000	***
Constant	7.1520	0.000	****
F-Stat	167.7800	0.000	****
R-Square	0.6923	N = 439	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 12: OLS Regression Results for Interest Rate in Nov 2006

Variable	Loan Failure		
	Coeff.	p-value	Sig.
Credit Grade E	0.5947	0.022	**
Inquiries in 6 Months	0.0963	0.000	****
Current Delinquencies	0.1486	0.001	****
Endorsements	-0.8671	0.007	***
Current Delinquencies	0.1367	0.000	****
Public Records 10 Years	0.2519	0.043	**
Constant	-0.6465	0.101	
Chi-Square	66.6800	0.000	****
Pseudo R-Square	0.1197	N = 439	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 13: Logistic Regression Results for Loan Failures in Nov 2006

We now calculate the actual risk premium and risk neutral rates for one standard deviation change in risk factors that were statistically significant in the OLS and logistic regression models. The absolute difference between the two gives us the risk premium deviation for each risk factor. The sum of individual risk premium deviations gives us the total risk premium deviation as shown below in Table 14.

Variable	Standard Deviation	Optimum Risk Premium	Actual Risk Premium	Risk Premium Deviation
Amount Requested	0.5099	-	1.8802	1.8802
Description Length	6.4068	-	(0.5829)	0.5829
Credit Grade B	0.3346	-	1.3464	1.3464
Credit Grade C	0.3844	-	2.7441	2.7441
Credit Grade D	0.4237	-	4.5127	4.5127
Credit Grade E	0.4477	5.9970	6.6466	0.6495
Total Credit Lines	14.2707	-	0.3241	0.3241
Current Delinquencies	3.0286	10.3885	0.7558	9.6327
Endoresements	0.3767	(6.5785)	-	6.5785
Public Records 10 Years	0.8676	4.8875	-	4.8875
Inquiries in 6 Months	4.4281	9.8120	-	9.8120
Total				**42.9505**

Table 14: Risk Premium Deviation for Loans in Nov 2006

The risk premium deviation for loans made during Nov 2006 was 42.9505. This is significantly lower than the previous measurement of risk premium deviation: 55.4394 for loans made during Aug 2006. Thus, we see that the quality of decision making by lenders improved significantly between Aug 2006 and Nov 2006. The improvement in quality of decision making is in line with the expectations of hypotheses 1.

Risk Premium Deviation in Feb 2007

There was a significant change in the amount and nature of information sharing during Feb 2007. Since we are looking for evidence of learning within a stable information sharing environment, we restrict our analysis to a time period ending a week before the scheduled change in information sharing. The one week gap between the end of the

analysis period and the start of the new information sharing regime ensures that the analysis is not biased by borrowers and lenders anticipating the change and altering their behavior.

Following the methodology developed for calculating risk premium deviation, we first estimate the actual risk premium using an OLS regression analysis with interest rate charged as the dependent variable. Then, we estimate the risk neutral rate required for compensating for default risks using a logistic regression with the loan failure during a 12 month observation period as the dependent variable. The Table 15 and Table 16 provide the results of the OLS regression and the logistic regression.

Variable	Interest Rate		
	Coeff.	p-value	Sig.
Amount Requested	2.9959	0.000	****
Credit Length	0.1226	0.042	**
Credit Grade B	2.9045	0.000	****
Credit Grade C	6.0931	0.000	****
Credit Grade D	10.2326	0.000	****
Credit Grade E	14.4766	0.000	****
Debt to Income Ratio	0.4296	0.000	****
Current Delinquencies	0.2656	0.000	***
Description Length	-0.0277	0.006	***
Constant	6.7729	0.000	****
F-Stat	167.7800	0.000	****
R-Square	0.7750	N = 498	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 15: OLS Regression Results for Interest Rate in Feb 2007

Variable	Loan Failure		
	Coeff.	p-value	Sig.
Amount Requested	0.6110	0.001	****
Credit Grade C	0.5956	0.096	*
Credit Grade D	1.3325	0.000	****
Credit Grade E	1.3706	0.000	****
Current Delinquencies	0.1367	0.000	****
Debt to Income Ratio	0.1459	0.069	*
Inquiries in 6 Months	0.0975	0.000	****
Constant	-2.9957	0.000	****
Chi-Square	85.7200	0.000	****
Pseudo R-Square	0.1468	N = 498	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 16: Logistic Regression Results for Loan Failures in Feb 2007

Table 17 below uses the OLS and logistic regression results shown above to the difference between actual risk premiums and the risk neutral rate for one standard deviation change in risk factors. All the individual values are aggregated to arrive at the risk premium deviation figure for loans made in Feb 2007 before the change in information availability (pre-event).

Variable	Standard Deviation	Optimum Risk Premium	Actual Risk Premium	Risk Premium Deviation
Amount Requested	0.6847	8.3454	2.0511	6.2943
Credit Length	3.1801	-	0.3898	0.3898
Credit Grade B	0.3377	-	0.9808	0.9808
Credit Grade C	0.3766	4.2807	2.2944	1.9863
Credit Grade D	0.4093	11.1714	4.1887	6.9828
Credit Grade E	0.4334	12.2821	6.2748	6.0073
Debt to Income Ratio	1.2325	3.3948	0.5295	2.8653
Description Length	14.5919	-	(0.4040)	0.4040
Current Delinquencies	3.3616	9.2514	0.8929	8.3585
Group Membership	0.4932	-	(0.6334)	0.6334
Inquiries in 6 Months	3.9141	7.5500	-	7.5500
Total				**42.4525**

Table 17: Feb 2007 Pre-Event Loans – Risk Premium Deviation

Evidence of the Learning Effect

The learning effect implies that the quality of decision making by lenders should improve with time as lenders observe the performance of their decisions and adjust their decision making models. We find that the quality of decision making, as measured by the risk premium deviation, indeed improved with time for the three measurements described above. The risk premium deviation in Aug 2006 was calculated to be 55.4394 as shown in Figure 5. The risk premium deviation improved with time and fell to 42.9505 in Nov 2006 (Table 14) and then to 42.4525 in Feb 2007 before the change in information sharing regime as shown in Table 17 above. As risk premium is an inverse measure of performance, we can see that the efficiency of decision making by lenders improved

substantially between Aug 2006 and Feb 2007. The chart below shows the change in risk premium deviation from Aug 2006 to Feb 2007:

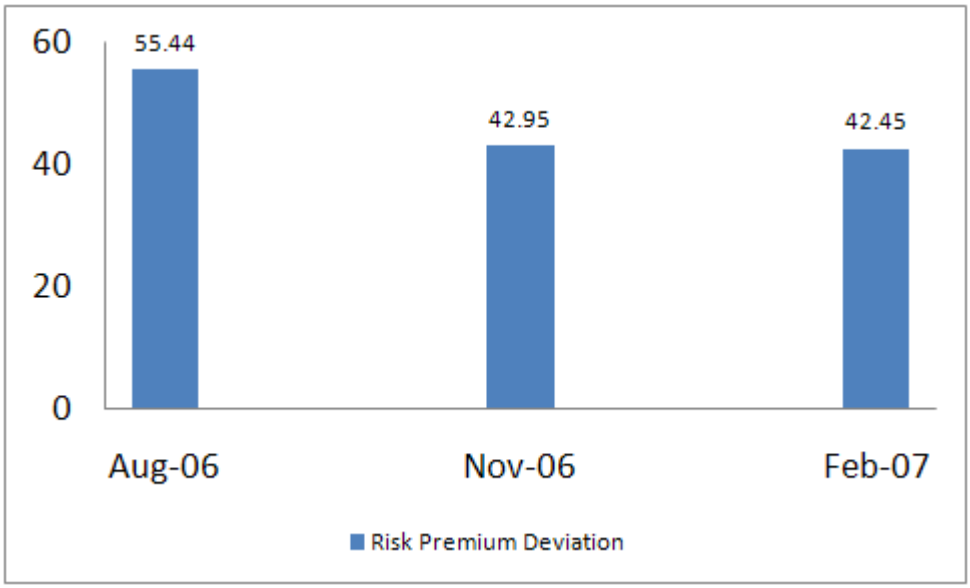

Figure 5: Change in Risk Premium Deviation from Aug 2006 to Feb 2007

While learning is expected to improve quality of decision making with time, the rate of improvement is expected to be faster initially when a significant gap exists between the current quality of decision making and the potential best quality of decision making. Early in the learning phase decision makers can identify and take care of low hanging fruits – obvious and glaring errors in decision making that can be adjusted quickly for immediate improvement in quality of decision making. We find that our results support the argument as the largest improvement in quality of decision making is observed between the first two measurement points. As Figure 5 shows, the quality of decision making improved substantially in the beginning (Aug to Nov 2006) and then improved only marginally for some time (Nov 2006 to Feb 2007).

Evidence of Limitations to Learning

We observe that the quality of decision making by lenders shows a significant early improvement. However, the quality of decision making shows only marginal improvement after that (between Nov 2006 and Feb 2007). The quality of decision making, after initial significant improvement, settles into an equilibrium state. Thus we find support for hypotheses 2 that argued that after significant time for learning in a given information sharing regime, the quality of decision making become asymptotic to an equilibrium value.

Hypothesis 2 also argues that the equilibrium state reached after learning is biased because of the choice of initial anchor. A residual inefficiency continues to persist as the "drag effect" of the original anchor choice. Further, two other factors reduce the equilibrium quality of decision making achieved by learning - the dynamic interaction between lenders and borrowers and the influx of new lenders. We observe that the risk premium deviation value for Feb 2007, after significant time for learning, is still 42.45, indicating significant inefficiency in decision making compared to the best risk premium deviation value of zero. Thus, we find support for hypotheses 2.

In summary, looking at changes in risk premium deviation values from Aug 2006 to Feb 2007, we find support for hypotheses 1 and 2. We find evidence of learning by lenders as reflected in the improvement in the quality of decision making by lenders over time. Further, we find that the improvement is not uniform – the initial quick learning leads to marginal learning later as the quality of decision making becomes steady, although still incorporating significant inefficiency.

4.5.2 Disruption in Information Sharing Regime

A disruption in the information sharing regime leads to the formation of new decision models by the lenders. In this study we consider the case when the amount of information shared by the market with lenders increases significantly. Lenders who have learned from long periods of feedback received from loan performance and have accordingly adjusted their anchors to improve their quality of decision making find themselves challenged to include the new information available in their decision models.

The expected impact of increase in information availability on performance was presented as hypothesis 3 before. Hypothesis 3 argues that a significant increase in information availability disrupts the learning equilibrium as new decision models are formed and previous learning may not be applicable in the new environment. Increase in information availability also increases the risk of information overload. The negative effects on performance reduce with time as new learning equilibrium forms and the ability to process additional information improves with time. To test the hypothesized impact of increase in information availability on quality of decision making, we need to measure quality of decision making before and after a significant increase in information availability.

Increase in Information Availability

The information sharing regime at propser.com was updated on Feb 12, 2007. New information elements including income levels, bankcard utilization, total revolving balance and public records in last 12 months were added to the loan listing information shared by Prosper.com with lenders. These new information elements constituted a

substantial increase in the amount of information available to the lenders for making decisions on the interest rate to be charged on potential loans. This change in information sharing regime provides an ideal context to study changes in quality of decision making by lenders as a result of a significant increase in information available to make the decision.

We test the hypothesized change in quality of decision making by lenders because of an increase in information availability by calculating the risk premium deviation immediately before and after the increase. We provide for a one week buffer period on either side of the date of change to make sure that the results are not confounded by transition factors such as anticipation of increase in information availability and old standing orders based on previous level of information available. Thus, we first consider a before change four week time period of Jan 5, 2007 to Feb 9, 2007. We have already analyzed the loans funded during this time period as Feb 2007 pre-event period as shown in Table 15 through Table 17. As shown in Table 17, the measure of efficiency of decision making by lenders, risk premium deviation, stood at 42.45 for the four week pre-event period.

Risk Premium Deviation in Feb 2007 (Post-Event)

We consider an after change four week time period of Feb 19, 2007 to Mar 18, 2007 for comparing quality of decision making by lenders before and after the change in information sharing regime. This post-event time period yielded 803 loans in the sample. We followed the established methodology for calculating the risk premium deviation: first estimate the actual risk premium using OLS regression with interest rate as the

dependent variable (Table 18); then estimate the risk neutral rate using logistic regression with loan failure as the binary dependent variable (Table 19); and finally calculate the risk premium deviation by calculating the difference between actual risk premium and risk neutral rate for one standard deviation change in all statistically significant risk factors and aggregating all the individual risk premium deviations to arrive at the total risk premium deviation (Table 20).

Variable	Interest Rate		
	Coeff.	p-value	Sig.
Amount Requested	3.1768	0.000	****
Credit Grade AA	-1.4712	0.000	****
Credit Grade B	1.9090	0.000	****
Credit Grade C	5.3369	0.000	****
Credit Grade D	8.2626	0.000	****
Credit Grade E	11.2756	0.000	****
Debt to Income Ratio	0.2068	0.001	***
Description Length	-0.0502	0.000	****
Current Delinquencies	0.2647	0.000	****
Public Records 10 Years	0.3390	0.026	**
Bank Card Utilization	0.6284	0.032	**
Delinquencies 7 Years	0.0255	0.021	**
Income Group	-0.3183	0.000	****
Group Membership	-1.2062	0.000	****
Constant	10.3846	0.000	****
F-Stat	144.9000	0.000	****
R-Square	0.7202	N = 803	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 18: OLS Regression Results for Interest Rate in Feb 2007 (Post-Event)

Variable	Loan Failure		
	Coeff.	p-value	Sig.
Amount Requested	0.8392	0.000	****
Credit Grade AA	-1.2121	0.031	**
Credit Grade C	1.1717	0.000	****
Credit Grade D	0.8566	0.004	***
Credit Grade E	1.5153	0.000	****
Current Delinquencies	0.1149	0.003	***
Inquiries in 6 Months	0.1298	0.000	****
Constant	-3.2371	0.000	****
Chi-Square	145.3000	0.000	****
Pseudo R-Square	0.1705	N = 803	

Signif. codes: 0.1: *, 0.05: **, 0.01: ***, 0.001: ****

Table 19: Logistic Regression Results for Loan Failures in Feb 2007 (Post-Event)

Variable	Standard Deviation	Optimum Risk Premium	Actual Risk Premium	Risk Premium Deviation
Amount Requested	0.6266	8.6142	1.9906	6.6237
Credit Grade AA	0.3569	(5.1796)	(0.5250)	4.6545
Credit Grade B	0.3469	-	0.6622	0.6622
Credit Grade C	0.4186	7.9531	2.2342	5.7189
Credit Grade D	0.4272	5.7160	3.5300	2.1860
Credit Grade E	0.3376	8.3469	3.8071	4.5399
Debt to Income Ratio	14.0076	-	2.8961	2.8961
Description Length	14.0076	-	(0.7030)	0.7030
Current Delinquencies	2.1961	3.8030	0.5813	3.2216
Public Records 10 Years	0.7247	-	0.2457	0.2457
Bank Card Utilization	0.3982	-	0.2502	0.2502
Delinquencies 7 Years	11.2082	-	0.2860	0.2860
Income Group	1.4653	-	(0.4664)	0.4664
Group Membership	0.4525	-	(0.5459)	0.5459
Inquiries in 6 Months	4.0365	8.5784	-	8.5784
Total				**41.5785**

Table 20: Feb 2007 Post-Event Loans – Risk Premium Deviation

As shown in Table 20 above, the quality of decision making by lenders, as measured by the risk premium deviation, for the four week period after the increase in information available, stands at 41.58. In comparison, the risk premium deviation for the four week period before the change in information sharing regime was 42.45. Thus, we see that the disruption in information sharing regime has led to a small improvement in the quality of decision making as shown by the reduction in risk premium deviation.

We hypothesized that a significant increase in information availability will result in an initial worsening of the quality of decision making. However, we observe that a small increase occurred in the quality of decision making. Availability of new information allows lenders to make better decisions based on the additional information available. In our context we find that the negative impact of disruption in learning and potential for information overload were more than compensated by the positive impact of additional information.

Long Term Impact of Increase in Information Availability

For assessing the long term impact of increase in information availability on the quality of decision making by lenders, we measure the risk premium deviation for two four week periods during May 2007 and July 2007. July 2007 is the last month for which data is available to measure risk premium deviation using a 12 month observation period.

We followed the methodology established for previous calculations of risk premium deviation for calculating the same for loans made in May and July 2007. The table below shows the calculation of risk premium deviation for loans made in May 2007 followed by the calculation of risk premium deviation for loans made in July 2007.

Variable	Standard Deviation	Optimum Risk Premium	Actual Risk Premium	Risk Premium Deviation
Amount Requested	0.6244	8.1082	1.7912	6.3170
Credit Grade AA	0.3301	-	(0.9012)	0.9012
Credit Grade B	0.3770	5.7122	0.8790	4.8332
Credit Grade C	0.4289	5.1818	2.4216	2.7602
Credit Grade D	0.4174	8.5588	4.0848	4.4740
Credit Grade E	0.1061	2.6174	1.2547	1.3628
Debt to Income Ratio	1.8318	3.9260	0.6861	3.2399
Description Length	12.2422	-	(0.5051)	0.5051
Current Delinquencies	2.4196	4.1245	0.5583	3.5662
Income	1.3630	-	(0.3888)	0.3888
Total Credit Lines	14.5744	-	0.3284	0.3284
Inquiries in 6 Months	3.6158	7.9789	0.2690	7.7099
Total				**36.3868**

Table 21: June 2007 Loans – Risk Premium Deviation

The analysis of loans made in May 2007 show that risk premium deviation, after three months from the increase in information availability in Feb 2007, is significantly lower at 36.39 compared to a value of 41.58 in Feb 2007 just after the increase in information availability. The result shows that in the three month period from the increase in information availability, the quality of decision making by lenders improves significantly. Thus, we find support for the argument made in hypothesis 3 that the long term effect of increase in information availability on the quality of decision making would be positive.

The analysis of loans made in July 2007 shows that the risk premium decision improves marginally from the May 2007 levels to 35.87. The pattern of significant improvement immediately after the change in information availability followed by

smaller marginal improvement mirrors the pattern observed before as shown in Figure 5 above.

The trend in the quality of decision making with time is shown below in Figure 6. The quality of decision making shows rapid improvement initially with learning. The rate of change slows down with time and after a period of time, the change is marginal. The quality of decision making reaches an equilibrium state. However, when the equilibrium is disturbed via an outside shock – in our case a significant increase in information availability; the learning process starts again. A short period of rapid improvement settles into marginal improvement and an equilibrium state of the quality of decision making with time.

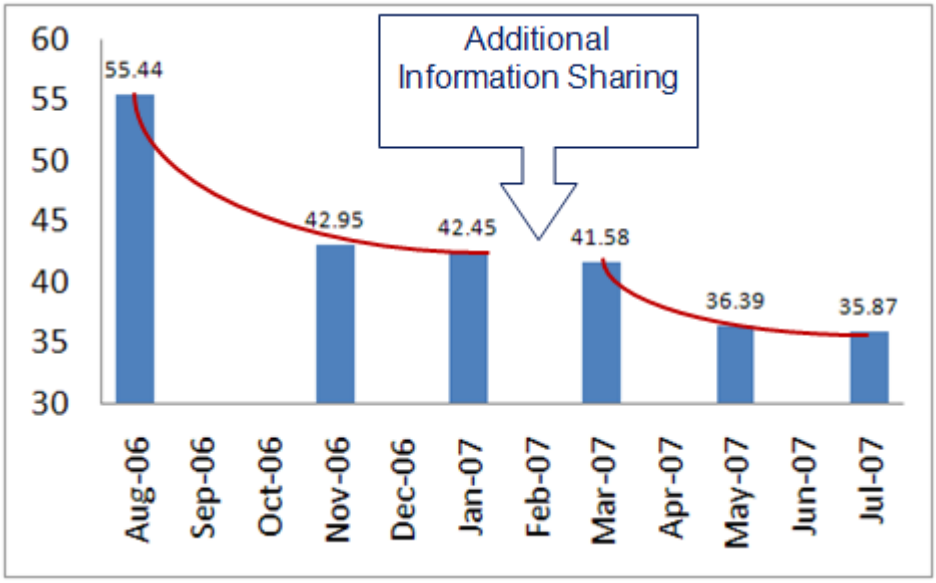

Figure 6: Change in Quality of Decision Making with Time

The pattern of change exhibited by the quality of decision making is similar to the popular theory of punctuated equilibrium. The theory of punctuated equilibrium was first

proposed by Eldredge et al. (1972) as a theory of biological evolution. The theory stated that evolution comprises of long periods of equilibrium with short bursts of significant change. The theory of punctuated equilibrium has since been adopted into social sciences and used to explain the evolution of constructs ranging from public policy (Givel 2006) to technology adoption (Hurberman et al. 1998).

4.6 Discussion and Conclusion

The business value of information sharing beyond firm boundaries depends upon the quality of decision making by the information recipients. In this chapter, we considered a peer to peer financial market to study the quality of decision making by lenders in the market. The market shares information regarding loan listings with lenders and lenders decide on the interest rate to be charged for the loan based on the information shared by the market.

We consider the decision making process of lenders as a dynamic learning process and use the anchor and adjustment model of decision making with incomplete information as the theoretical basis for the study. Based on the anchor and adjustment model of decision making, we propose two mechanisms that can result in improvement in the quality of decision making – learning and increase in information availability. The expected impact of learning and increase in information availability on the quality of decision making were formalized in three hypotheses.

For testing the hypotheses, we first developed a measure of the quality of decision making by lenders – risk premium deviation. Risk premium deviation represents the difference between the actual risk premium charged for risk factors and the risk neutral

rate that would fully compensate for the additional risk for a one standard deviation change in the risk factor. We detailed the steps needed to calculate risk premium deviation using an example of loans funded during Aug 2006. We then calculated the risk premium deviation for Nov 2006 and Feb 2007 before the change in information sharing regime to test the hypotheses related to learning (hypotheses 1 and 2). For testing hypothesis 3, we calculated the risk premium deviation for Feb 2007 (after the change in information sharing regime), May 2007 and July 2007.

Our results provide evidence for learning in decision making by lenders. We hypothesized that the quality of decision making will improve with time as lenders observe the performance of their decisions and adjust their decision models. Our results show that the quality of decision making by lenders did improve with time both before and after the change in information sharing regime. In both cases the improvement was rapid at the start and then settled into a more incremental improvement later on, becoming asymptotic to an equilibrium value. The equilibrium value, the result of long periods of learning, still contained a significant amount of error compared to the best quality of decision making possible with the available information.

Our results regarding the effect of a disruption in the information sharing regime in the form of a substantial increase in information availability, on the quality of decision making by lenders provides interesting results. The disruption in our case is the addition of several new information elements in the information sharing regime. This change is likely to have two contrasting effects. First, the change would lead to lenders making decision based on new information without the benefit of prior learning and experience which can result in lower quality of decision making. Second, the change would provide

many new information elements that can be used by lenders to make better decisions than those possible with the previous low levels of information transparency. Our results show that the positive effects of new information outweigh the negative effects of disruption in information sharing regime and results in a net improvement in the quality of decision making by lenders.

Changes in the quality of decision making closely resemble the popular punctuated equilibrium theory of organizational change. In accordance with the theory, an initial period of rapid learning is followed by a steady state. For the organization to enter the next phase of learning, an external shock is needed to disrupt the steady state. After the disruption, the learning process starts again with an initial period of rapid improvement followed by a near equilibrium of marginal improvement in the quality of decision making.

4.6.1 Research and Practice Contributions

This study contributes to both research and practice by developing a metric for measuring the performance of peer to peer electronic market participants. Previous research on electronic markets has focused more on the performance of individual participants rather than a participant group as a whole. In this study we extend previous research on electronic markets by focusing on the performance of the lenders as a function of the information sharing regime. We show that the performance of lenders improves as market participants learn to better use the information shared with them. We show that an increase in information availability improves the quality of decision making. Further, we

provide evidence that the evolution of lender performance in response to learning and external shocks resembles the punctuated equilibrium theory of organizational change.

Electronic markets hypotheses argues that increasing use of IT reduces coordination costs relative to production costs leading to a shift from hierarchies towards markets as the coordination mechanism for economic activities. Growing popularity of peer to peer technologies like Skype and Web 2.0 applications like Second Life herald the future potential of peer to peer markets like eBay and Prosper. As more and more business is conducted through markets, especially peer to peer markets, we would need a better understanding of factors that affect market participant behavior, decision making by market participants and the overall efficiency of the market for designing competitive and efficient market mechanisms. This study helps improve our understanding.

This research study extends the substantial literature on managerial decision making in a new context – peer to peer electronic markets. We show that the essential foundations of the anchor and adjust theory of managerial decision making are relevant in this novel context as well. We show that the change in group performance in electronic markets follows the pattern characteristic of a punctuated equilibrium model of organizational change.

4.6.2 Limitations and Future Research

The most significant limitation of the study results from a lack of sufficient empirical data. Even though we use rigorous OLS and logistic regression analysis to estimate the risk premium deviation, our main arguments regarding learning effect and disruption effect on the efficiency of decision making by lenders are tested using graphical and

visual evidence. We have only six data points, three before the disruption and three after the disruption, to test the learning effect. We have only one disruption event to analyze the impact of the disruption on the quality of decision making. However, as this is the first effort to develop a measure of the quality of decision making by lenders and use that measure to explore learning effects and disruption effects in peer to peer electronic markets, this research study makes a substantial contribution even without rigorous statistical testing of the two effects. We expect that future research, benefitting from a larger dataset, will extend our methodology to include time series analysis for statistical testing of learning effect and disruption effect.

Prosper.com presents an attractive context for studying business value of information sharing in a peer to peer electronic market context. However, as most of the loans at Prosper.com are yet to reach their scheduled 36 month maturity, we had to restrict our period of observation for loan performance to 12 months from the loan start date. We expect the underlying trends and relationships discovered through a 12 month observation period to hold for the full life of the loan. Future research, conducted after a significant number of loans at Prosper.com or other platform have reached maturity, can confirm this assumption.

4.6.3 Conclusion

Business value of information sharing beyond firm boundaries depends significantly on the quality of decisions made by information recipients. In case of electronic markets, errors in decision making by market participants, representing a low quality of decision making (high values of the risk premium deviation), present a unique source of friction or

transaction cost in an otherwise significantly frictionless environment. In this chapter, we have studied the decision making by lenders in a peer to peer electronic market to develop a better understanding of this very important process.

We have developed a rigorous measure of the quality of decision making by lenders. We have used the measure to study the impact of learning and the disruption in information sharing regime on the quality of decision making. We show that the quality of decision making by lenders does improve with time. We argue that this is a result of lenders learning and adjusting their decision models based on observed performance of previous decisions. We further show that for a specific disruption of information sharing regime that involved increasing the amount of information shared, the immediate negative impact the disruption on the quality of decision making is more than compensated by the positive impact of additional information availability for making better decisions.

The current study suffers from limitations resulting mainly from lack of sufficient data. In spite of empirical limitations, this chapter makes a significant contribution to our understanding on decision making in peer to peer electronic markets. As one of the first empirical studies to study the quality of decision making in electronic markets, this chapter develops a methodology and framework that can be used by future research to mitigate the limitation of this study. Future research, making use of larger dataset that will allow for time series analysis, will be able to further extend our understanding of decision making by market participants in peer to peer electronic markets and its impact on business value of information sharing beyond firm boundaries.

CHAPTER - 5

Conclusion

Business value of information sharing beyond firm boundaries encompasses different research disciplines like operations management, information systems, knowledge management and business strategy. Although individual research disciplines have been successful in expanding our understanding of business value of information sharing, it is important that insights from different disciplines are integrated to develop an overall research framework so that interactions and dependencies between constructs can be studied. The first research study (Chapter – 2) of this dissertation attempts to fill the research need by developing an overall research framework that integrates insights from different research streams as well as contemporary practice examples.

The rapid rise in information sharing beyond firm boundaries is fueled by advances in information systems. Emerging technology architecture like Service Oriented Architecture (SOA) has allowed firms to connect their information systems with those of their partners and suppliers easily and at low cost. Internet based electronic markets have facilitated business models that depend on sharing information with a large group of participants that support the functioning of the market by taking actions or making

decisions. Despite the importance of emerging technologies in facilitating and influencing business value of information sharing beyond firm boundaries, extant research is lacking in broad empirical studies of the impact of emerging technologies on business value of information sharing. The two empirical studies (Chapter 3 and 4) in this dissertation attempt to fill the research need by studying business value of information sharing in the context of emerging technologies: SOA and peer to peer electronic markets respectively.

The two empirical studies focus on the business value of information sharing as the dependent construct and explore how the business value is influenced by cross sectional factors (e.g. information sharing process characteristics like transparency and complexity; use of integrative technologies like SOA) and longitudinal factors (e.g. learning, information availability and disruption in information sharing regime) respectively. To conclude the dissertation, this chapter summarizes the salient findings of the dissertation and their implications for research and practice. Each of the research studies are discussed individually followed by an integrated conclusion and future research section.

Study 1: Business Value of Information Sharing beyond Firm Boundaries: A Taxonomy and Research Model

One of the difficulties in studying complex inter-disciplinary subjects like business value of information sharing beyond firm boundaries involves integrating insights from different research streams to generate a unified vocabulary and a common understanding. Building an overall research framework that integrates insights from different research

streams provides the foundation for future research to study interactions between constructs belonging to disparate research streams. This study performs this essential step of integrating relevant previous research to build an inter-disciplinary taxonomy and research framework of business value of information sharing beyond firm boundaries.

The research framework focuses on business value of information sharing as the dependent variable and identifies potential impact of other relevant constructs on the dependent variable. Many of these potential relationships have been studied empirically in previous research. However, the framework identifies research questions that need to be addressed by future empirical research. Two of these research questions are addressed in the two empirical studies that follow in this dissertation.

Managers responsible for designing or managing information sharing initiatives need to take into account factors belonging to different functional areas. In addition, interactions between factors belonging to different areas may also have significant impact on success of information sharing initiatives. The integrated framework developed in Chapter 2 is beneficial to practitioners as well since it provides a consolidated view of different constructs from different research and practice domains that may influence the success of information sharing beyond firm boundaries. The framework further contributes to practice by identifying potential interactions between constructs that may influence business value of information sharing.

The next two chapters in the dissertation extend the practice implications of the overall framework by empirically testing two sets of potential relationships between different constructs and the dependent construct of business value of information sharing. The empirical results provide specific insights about designing and managing information

sharing initiatives. The framework forms the base for other similar empirical studies to follow.

Study 2: Impact of SOA Use on Performance Outcomes of Information Sharing in Supply Chain

This study integrates insights from extensive previous research in operations management literature regarding information sharing in supply chain, management information systems research regarding inter-organizational information systems and nascent research on integrative technology platforms like SOA to build a model of interaction between "what" information is shared and "how" it is shared. Results show that elements of information sharing process (transparency, complexity) have a significant impact on business value of information sharing and the technology architecture used for implementing the process has a significant moderating impact on the relationship between information sharing process and business value of information sharing.

The literature on business value of IT has progressed from overall studies of productivity (Brynjolfsson 1993; Brynjolfsson et al. 1998) to more process oriented studies that capture the business value of IT at the process stage (Mukhopadhyay et al. 1997). Measurement of business value of IT is also moving away from firm level financial measures that tend to get competed away in the form of consumer surplus (Hitt et al. 1996) to process level operational measures. This study follows the movement towards process level studies by basing this research in a specific process context and measuring business value using objective process level measures.

Operations management researchers have studied the impact of information sharing on supply chain performance mainly through analytical models. This study extends this research by bringing an empirical dimension and explicitly considering use of a specific technology platform. This study further adds to research by studying the interaction between technology architecture use and process characteristics. The approach can be extended in future research that integrates process and technology elements in a unified research model.

Results of this study have important implications for SOA vendors like IBM, Sun and Oracle. Results emphasize that even though there are substantial flexibility benefits to SOA, which helps counter complexity; the governance issues related to efficient management of an SOA environment when information sharing transparency is high can be detrimental to performance. Current discourse on SOA is mostly centered on vendor supported studies and white papers suggesting significant benefits of SOA adoption shown through anecdotal reports and individual case studies. This study presents a broad generalizable empirical investigation of the impact of SOA on performance and uncovers both positive and negative impact of SOA use on supply chain performance.

Rich theoretical literature about information sharing in supply chain has provided important insights but lacks clear directions for managers about how to implement the insights. This study analyzes the "how" part of information sharing and provides managers with more tangible directions to implement information sharing and SOA adoption in supply chains for improving supply chain performance. Results shows that managers need to strike a balance between the degree of information sharing in the supply chain and controlling the complexity of the information sharing process.

Managers can control the negative impact of process complexity by adopting SOA for managing their processes. However, this approach is only likely to be productive if the level of transparency in information sharing process is controlled as well since use of SOA also reduces the positive impact of information sharing transparency on supply chain performance.

Study 3: Information Sharing and Decision Making in Peer to Peer Electronic Markets: Frictionless No More!

The main focus of the dissertation – business value of information sharing beyond firm boundaries, is a difficult construct to measure, especially in novel contexts like electronic markets. This study contributes to both research and practice by developing a metric to measure the quality of decision making by market participants in peer to peer financial electronic markets – risk premium deviation. Previous research on electronic markets has focused more on the performance of individual participants working independently. Risk premium deviation measures the quality of decisions taken by a group of participants together by aggregating the individual decisions.

The metric (risk premium deviation) can be used by future research to study the performance of electronic financial market participants and the impact of different independent construct on their performance. On the practice side, managers can use the performance measure to better manage electronic markets and evaluate the returns to initiatives such as additional information sharing, training and interface improvements, aimed at improving quality of decision making by market participants.

The results of the study provide evidence of learning in decision making by market participants in electronic markets. As market participants observe the decisions made by other participants and performance of their own past decisions, they are likely to adjust their decision model and hence improve the quality of their decision making. The results show that the quality of decision making by market participants as measured by the risk premium deviation improved with time. The improvement was observed to be faster at the start of the learning process compared to a more incremental improvement later on. After some time the learning process plateaus into equilibrium level of error in the quality of decision making.

Results of the study show that disturbing the learning equilibrium with an exogenous shock allows the learning process to reset at a new level of equilibrium quality of decision making. In the study, a significant and sudden increase in information availability led to an improvement in the quality of decision making. The evolution of the quality of decision making closely resembles the popular punctuated equilibrium model of organizational change.

This study contributes to research by extending the substantial previous literature on managerial decision making into a new context – peer to peer electronic markets. The study finds support for the popular anchor and adjustment theory of managerial decision making with incomplete and uncertain information in this novel context. The study also extends the punctuated equilibrium model of organizational change into the group decision making process in peer to peer electronic markets.

On the practice side, the study contributes by providing empirical evidence for the effectiveness of two potential mechanisms for improving the quality of decision making

by electronic market participants. The study shows that learning over time and an increase in information available for decision making both lead to improvement in quality of decision making. The resulting punctuated equilibrium model of evolution of the quality of decision making by market participants can be used by managers designing and operating electronic markets to formulate initiatives aimed at improving the quality of decision making by the market participants.

The study contributes to the growing research on electronic markets by exploring a source of friction unique to electronic markets – error in decision making by market participants and developing a metric to measure the extent of this friction. Electronic Markets Hypotheses (EMH) argues that increasing use of IT is reducing coordination costs relative to production costs leading to a shift from hierarchies towards markets as the coordination mechanism for economic activities (Malone et al. 1987). As more business is conducted through markets, especially peer to peer markets, there is a need for a better understanding of factors that affect market participant behavior, decision making by market participants and the overall efficiency of the market for designing competitive and efficient market mechanisms. This study contributes towards such an understanding.

Conclusion

The business environment in the twenty first century is characterized by heightened competition, increased turbulence and a significant transformation in firm's relationship with partners, suppliers and the market. Continued improvement in IT capabilities is seen as a significant force reshaping competition (McFarlan 1984). Emerging technology solutions like SOA, Web2.0 and inter-organizational systems are enabling higher

electronic integration and information sharing between firms and partners, suppliers and the market (Cash et al. 1985). This phenomenon of information sharing beyond firm boundaries is the main focus of this dissertation.

Information sharing beyond firm boundaries and the resulting electronic integration is influencing the firm's organization of work, changing firm's relationships with other firms and markets and even reshaping firm boundaries (Clemons et al. 1990; Malone et al. 1987). Although there is significant practice interest in leveraging information sharing beyond firm boundaries to improve performance, implement novel business models or outsource business processes; there has been little empirical research on business value of information sharing beyond firm boundaries. This dissertation attempts to fill the research gap by first building an integrated research framework and taxonomy of business value of information sharing and then empirically testing two research models – one with cross sectional data and the other using a longitudinal dataset.

Results of the empirical studies in the dissertation (chapter 3 and 4) make important contribution to research and practice as discussed in this chapter. However, the dissertation addresses only a small portion of the overall research framework developed in chapter 2. Future research may include the research questions identified in the research framework including the impact of independent constructs like media richness (interaction and interface), trust in information sharing relationships and the impact of organizational culture on success of information sharing initiatives. The research framework and the empirical studies in this dissertation provide a foundation for such future empirical research on business value of information sharing beyond firm boundaries.

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