Organizational Information Markets: Conceptual Foundation and an Approach for Software Project Risk Management

Areej M. Yassin

University of South Florida

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Organizational Information Markets:
Conceptual Foundation and an Approach for Software Project Risk Management

By

Areej M. Yassin

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy
Department of Information Systems and Decision Sciences
College of Business
University of South Florida

Major Professor: Alan R. Hevner, Ph.D.
J. Ellis Blanton, Ph.D.
Terry L. Sincich, Ph.D.
Richard P. Will, Ph.D.

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Keywords: prediction markets, systems thinking, structuration theory, status reporting, project management, risk assessment, whistle-blowing, agency theory, design science

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Dedication

To Mom and Dad
Acknowledgments

First and foremost, I thank God for giving me the strength and courage to succeed and achieve my goals. I also thank my family for their love and support throughout my graduate studies and the writing of my dissertation.

I owe my gratitude to my dissertation committee, whom without their help, this dissertation would have not been possible. I am particularly grateful to my advisor Dr. Alan R. Hevner who through his respect instilled confidence in me, and by trusting me taught me to trust myself, and through his guidance, keen insight and encouraging remarks at the end of each stage in the process motivated me to go forward and to keep going. Dr. Hevner will always be a source of inspiration in my work and a role model to follow. It was an honor to have him as my mentor and dissertation chair.

I am very thankful to Dr. Blanton for his help with the data collection and for carefully reading and commenting on my surveys. His comments were very helpful in clarifying my ideas. I am also very thankful to Dr. Sincich, who kept me thinking two steps ahead, for long discussions that helped me sort out the details of my experiments. I am also very grateful to Dr. Will for giving me access to his classes which has been a tremendous help with my experiments and for his constant encouragement and support.

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Note to Reader

The original of this document contains color that is necessary for understanding the data. The original dissertation is on file with the University of South Florida library in Tampa, Florida.
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ABSTRACT

This dissertation employs both design science and behavioral science research paradigms to investigate an emerging form of technology-enabled human collective intelligence known as information markets. This work establishes a conceptual foundation for the study of organizational information markets and the design and use processes of information markets inside organizations.

This research conceptualizes markets from an information systems perspective and presents an information systems research framework for organizational information markets. This work develops a systems theory of information markets to facilitate investigation of the relationships and interactions between markets as systems and their context of use. It proposes a structuration model for design and use of IT artifacts in organizations and applies it to the study of information markets. A framework of market users is developed to guide market design to satisfy the different motivational and informational needs of market users. A design based solution is proposed to an important open question in the information markets literature; how to generate sufficient
uninformed trades. This research extends structuration theory by developing the structuration model of technology-induced organization development.

A well-designed information market can generate several benefits to organizations that contribute to their growth and development. Due to the importance of software in everyday life, and the high costs and percentages of failure in software projects, this dissertation proposes an information market solution to help organizations better manage the risks facing software projects. It also develops a theoretical framework for the determinants of software project risk assessment accuracy and evaluates the market’s efficacy in improving assessment accuracy via the use of controlled laboratory experiments.

The results of the experiments demonstrate the market’s efficacy in improving assessment accuracy by increasing the currency, accuracy and completeness of reported status information about project main objectives such as cost, schedule, performance and functionality. The results also demonstrate the market’s efficacy in increasing individual willingness to report negative status information by decreasing their perception of information asymmetry between them and management/clients, and by increasing their perception of both the anonymity of the reporting mechanism and their perceived self-interest in reporting negative status information.
Chapter One
Motivation and Dissertation Objectives

Motivation

“If foresight is not the whole of management at least it is an essential part of it"

(Henri Fayol, 1916)

Foresight is the oldest term used to describe an interdisciplinary field known today as Futurology; or the study of the future. H.G. Wells envisioned the establishment of this modern academic discipline as early as the 1930’s when he said in a BBC radio broadcast aired on November 19, 1932 “There is not a single Professor of Foresight in the world”. In the latter third of the 20th century, Futurology emerged as an academic discipline and Wells’ foresight was realized, perhaps sooner than he could have imagined. But who could have imagined, few decades ago, that the most respected futurists of the 21st century will not be professors, but rather markets?

_The Economist_ recently published a trends article titled “The future of futurology” describing prediction markets as “the most heeded futurists … where the informed guesswork of many is consolidated into hard probability” (The Economist 2007, p.1). The article cited several markets forecasts of political outcomes, such as those of NewsFutures, Inkling Markets, and InTrade. Other well known applications of prediction
markets, such as the Iowa Electronic Market, has proven to outperform polls and experts forecasts in predicting the outcomes of the presidential elections more than 75 percent of the time over the last ten years. In 2009, Hollywood Stock Exchange announced a 78.4% success rate in predicting the 81st Annual Academy Awards nominations, bringing its 11 years average to an impressive 82.1%.

The MIT center for collective intelligence calls for creating new forms of collective intelligence that take advantage of the opportunities created by the Internet and other new communication technologies, where human and machines can collectively act more intelligently than any individual, group, or collection of computers have ever done before. The center advocates prediction markets as a perspective on collective intelligence in its own right.

Undoubtedly prediction markets are at the frontier of predictive futures and collective intelligence research. Their impressive performance holds great potentials for the business world in areas such as forecasting, decision making, and, importantly, risk management. The value of risk management, in any project, can be assessed based on three measures: the importance of the project itself or its outcomes, the likelihood of occurrence of the risks facing the project, and their expected impacts on the project objectives. Software development projects score very high on all of the scales.

In the current era of ubiquitous computing, software is becoming an indispensable part of our daily lives, an absolute necessity for organizations to survive fierce competition with rivals, and even a matter of national security for governments.
Organizations and governments spend billions of dollars each year in new software initiatives and projects, and yet, by rough estimate, only about 35% succeed (Rubinstein, 2007). Software failure can lead to tragic societal and economic consequences that go well beyond inconvenience. But the biggest tragedy of all, according to risk management expert Robert N. Charette, is that software failure is predictable and for the most part avoidable (Charette, 2005).

The software development domain is in desperate need of better risk management tools and practices. Markets may prove to be invaluable in minimizing software projects’ chances of failure. By aggregating status information from all levels of the organization and providing early warning signals about risks, markets can assume the difficult task of “blowing the whistle” on challenged projects. However, for markets to become mainstream risk management tools that inform strategic decisions, policy making and help in long term planning, organizations must first buy into them, understand how they work, know how to use them, and value the information they provide to inform their decisions.

Research on prediction markets used inside organizations is still in its infancy. Little is known about the impact of organizational environments on market design, incentive structures, and types of questions asked in the market, or more simply put, what works and what does not. Little is also known about the impact of the market on work processes, corporate culture, and formal and informal reporting mechanisms in the organization.
Markets are, in essence, IT artifacts. To make the best out of this innovative technology, we must first theorize about it, and about the reciprocal relationship between it and its environment. We must understand how markets impact organizations, how the business setting impacts market design, and how design impacts use and, consequently, the market objectives. Also, studies are needed that empirically test the usefulness of prediction markets in managing risks facing organizations in general and software projects in particular. This dissertation is the first step in a long term research effort to accomplish these goals.

**Problem Statement**

A list of failed software projects states the problem loud and clear (Table 1). Software projects have a long history of failure that keeps repeating itself. Twenty years ago, the odds of a large software project finishing on time were close to zero (McConnell, 1996). Today the odds are not much better, but at least we know they cannot get much worse. In 2006, 19 percent of initiated software projects in the US were outright failures; canceled before completion or not deployed. 46 percent of projects failed to meet user requirements, had cost overruns, or were not delivered according to schedule (Rubinstein, 2007). In 2007, Dynamic Markets Limited surveyed 800 IT managers across eight countries. The results showed that failure rates are universal: 62 percent of IT projects failed to meet their schedules, 49 percent exceeded their budget, and 41 percent failed to deliver the expected business value and ROI.
Identifying the risks facing software projects and reasons behind their failures has occupied project managers, software industry consultants and academics for a long time. The most cited reasons are also universal. The literature is full of case studies, postmortem analyses, lessons learned, and recommended practices to improve the processes and outcomes of software projects. However, management is still unable to effectively manage the risks involved in these projects.

Although current risk management approaches can be useful in identifying and prioritizing risks, as well as in suggesting mitigation strategies, none of them addresses the fundamental problem behind software project failure; communication. Many large scale software disasters have been attributed to communication problems and inaccurate status reporting, such as the case of the CONFIRM project (Oz, 1994). Reluctance to transmit bad news (Kiel, Smith, Pawlowski and Jin, 2004), and both status misperception, and deliberate misrepresentation by software developers and project managers (Snow and Keil, 2002) are some of the reasons that lead to inaccurate assessments of risks and, eventually, project failure.

Existing risk management tools and initial risk assessments are ineffective in reducing a software project’s chances of failure unless there are methods that continuously provide complete, current, and accurate information about the status of project objectives as events unfold. Otherwise managers are left with unrealistic, dated assessments of project risks, and as a result fail to take appropriate actions to mitigate them.
Table 1: Software Hall of Shame (From Charette, 2005)

<table>
<thead>
<tr>
<th>Year</th>
<th>Outcome</th>
<th>Costs in US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Hudson Bay Co. (Canada)</td>
<td>Problems with Inventory system contribute to $33.3 million loss.</td>
</tr>
<tr>
<td>2004-05</td>
<td>UK Inland Revenue</td>
<td>Software errors contribute to $3.45 billion tax-credit overpayment.</td>
</tr>
<tr>
<td>2004</td>
<td>Avis Europe PLC (UK)</td>
<td>Enterprise resource planning (ERP) system canceled after $54.5 million Is spent.</td>
</tr>
<tr>
<td>2004</td>
<td>Ford Motor Co.</td>
<td>Purchasing system abandoned steer deployment costing approximately $400 million.</td>
</tr>
<tr>
<td>2004</td>
<td>J Sainsbury PLC (UK)</td>
<td>Supply-chain management system abandoned after deployment costing $527.</td>
</tr>
<tr>
<td>2004</td>
<td>Hewlett-Packard Co.</td>
<td>Problems with ERP system contribute to $160 million loss</td>
</tr>
<tr>
<td>2003-04</td>
<td>AT&amp;T Wireless</td>
<td>Customer relations management (CRM) upgrade problems lead to revenue loss of $100 million.</td>
</tr>
<tr>
<td>2002</td>
<td>McDonalds Corp.</td>
<td>The Innovate information-purchasing system canceled after $170 million Is spent.</td>
</tr>
<tr>
<td>2002</td>
<td>Sydney Water Corp. (Australia)</td>
<td>Billing System canceled after $33.2 million is spent.</td>
</tr>
<tr>
<td>2002</td>
<td>CIGNA Corp.</td>
<td>Problems with CRM system contribute to $445 million loss</td>
</tr>
<tr>
<td>2001</td>
<td>Nike Inc.</td>
<td>Problems with supply-chain management system contribute to $100 million loss</td>
</tr>
<tr>
<td>2001</td>
<td>Kmart Corp.</td>
<td>Supply-chain management system canceled after $130 million Is spent</td>
</tr>
<tr>
<td>1999</td>
<td>United Way</td>
<td>Administrative processing system canceled after $12 million is spent</td>
</tr>
<tr>
<td>1999</td>
<td>State of Mississippi</td>
<td>Tax system canceled after $11.2 million is spent; state receives $185 million damages.</td>
</tr>
<tr>
<td>1999</td>
<td>Hershey Foods Corp.</td>
<td>Problems with ERP system contribute to $151 million loss.</td>
</tr>
<tr>
<td>1998</td>
<td>Snap-on Inc.</td>
<td>Problems with order-entry system contribute to revenue loss of $50 million</td>
</tr>
<tr>
<td>1997</td>
<td>U.S. Internal Revenue Service</td>
<td>Tax modernization effort canceled after $4 billion is spent.</td>
</tr>
<tr>
<td>1997</td>
<td>State of Washington</td>
<td>Department of Motor Vehicle (DMV) system canceled after $40 million is spent.</td>
</tr>
<tr>
<td>1997</td>
<td>Oxford Health Plan Inc.</td>
<td>Billing and claim system problems contribute to quarterly loss; stock plummets, leading to $3.4 billion loss in corporate value.</td>
</tr>
<tr>
<td>1996</td>
<td>Arianespace (France)</td>
<td>Software specification and design errors cause $350 million Ariane 5 rocket to explode</td>
</tr>
<tr>
<td>1996</td>
<td>FoxMeyer Drug Co.</td>
<td>$40 million ERP system abandoned after deployment forcing company into bankruptcy.</td>
</tr>
<tr>
<td>1995</td>
<td>Toronto Stock Exchange (Canada)</td>
<td>Electronic trading system canceled after $25.5 million is spent.</td>
</tr>
<tr>
<td>1994</td>
<td>U.S. Federal Aviation Administration</td>
<td>Advanced Automation System canceled after $2.6 billion is spent.</td>
</tr>
<tr>
<td>1994</td>
<td>State of California</td>
<td>DMV system canceled after $44 million is spent</td>
</tr>
<tr>
<td>1994</td>
<td>Chemical Bank</td>
<td>Software error causes a total of $15 million to be deducted from 100 000 customer accounts.</td>
</tr>
<tr>
<td>1993</td>
<td>London Stock Exchange (UK)</td>
<td>Taurus stock settlement system canceled after $600 million is spent.</td>
</tr>
<tr>
<td>1993</td>
<td>Allstate Insurance Co.</td>
<td>Office automation system abandoned after deployment costing $130 million.</td>
</tr>
<tr>
<td>1993</td>
<td>Greyhound Lines Inc.</td>
<td>Bus reservation system crashes repeatedly upon introduction, contributing to revenue loss of $61 million.</td>
</tr>
</tbody>
</table>
Dissertation Objectives

This dissertation seeks to accomplish the following objectives: First, establish a theoretical foundation for the study of organizational information markets and the design and use processes of markets inside organizations. Second, define the relationships and interactions between information markets and their environment. Third, design an information market solution to help organizations overcome an important business problem; software project risk assessment. Fourth, evaluate the proposed information market’s efficacy in increasing assessment accuracy by empirically testing the market ability to:

1. Efficiently collect and combine information from the organization to provide an assessment based on “complete” information about the status of different project objectives, such as scope, quality, cost and schedule,
2. Respond to unfolding events by rapidly incorporating new information into the assessment to provide current and up-to-date assessment of risk,
3. Adjust for individual errors in perception of project status and risk assessment, and thus, provide more accurate assessment of risk.
4. Motivate those who are involved in the project or have access to information about its progress to faithfully report status information.
Research Approach

Technology and behavior are inseparable in an information system and thus ought to be inseparable in IS research (Hevner, March, Park and Ram, 2004). The IS field needs an interdisciplinary conceptualizations of the IT artifact that articulate what the technology is, how it interacts with the social context (Orlikowski and Iacono, 2001). “IT artifacts are broadly defined as constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems)” (Hevner et al., 2004, p. 77).

Hevner et al. (2004) argue that IS research is conducted in alternating cycles between design science (technology) and behavioral science (behavior). The design science paradigm in essence is a problem solving paradigm rooted in engineering and the sciences of the artificial (Simon, 1996). It is concerned with building innovative IT artifacts to solve an identified organizational problem or fulfill a business need. People’s perceptions, roles and capabilities within the organization, as well as the organization’s strategies, structures and cultures, and their existing and planned technologies form the problem space of business needs which warrants the relevance of design science research.

Design science is also concerned with evaluating the IT artifact based on the utility provided in solving those problems. Evaluation can be carried out via case or field studies, lab experiments or simulation. Evaluation then feeds back into the design process to improve current understanding of the problem, the designed artifact, and the design process itself (Hevner et al., 2004).
On the other hand, the behavioral science paradigm studies the IT artifact by developing and justifying theories to explain and predict its use and impact on individuals and organizations. The goal of behavioral science is truth that informs design, and the goal of design science is utility that informs theory (Hevner et al., 2004). Theories as well as designed artifacts are assessed for weaknesses, refined, and reassessed multiple times until they accomplish their intended goals (Figure 1).

![Figure 1: Information Systems Research Framework (From Hevner et al., 2004)](image)

Rigor is guaranteed by the application of existing knowledge such as foundational theories, frameworks, instruments, constructs, models, methods and instantiations in developing theories and building the artifact, and by the application of existing methodologies such as data collection and analysis techniques, measures and validation criteria in justifying theories and evaluating artifacts. The contributions of IS research are
assessed based on the applicability of the artifact in the problem space, its ability to meet the business need, and the research’s ability to add to our knowledge base (Hevner et al., 2004).

Thus, we are utilizing both the design science and behavioral science research paradigms to accomplish our research objectives. To establish a theoretical foundation for the study of information markets inside organizations, this research starts by re-conceptualizing markets as IT artifacts and presents an information systems research framework for information markets. It employs and extends several theoretical perspectives such as systems thinking concepts (Checkland, 1981) and structuration theory (Giddens, 1979) to facilitate investigation of the relationships and interactions between markets and their context of use, and the design and use processes of markets inside organizations.

The design science research paradigm is employed to design an experimental Web-based information market solution to aid organizations and project managers in assessing software project risks (Figure 2). Market design is informed by existing theories, methodologies, and empirical evidence in the information markets and software project management literatures. The proposed market design and its expected utility in the area of software project risk assessment are evaluated using controlled experiments.

Experimental studies on the use of information markets for business problems that use business-related tasks and scenarios are needed to advance the theory of organizational information markets to explain and predict information markets
performance in specific business settings. They provide sufficient degrees of control that allow us to draw conclusions about manipulation effects and causality, which in turn will allow us to build theoretical models to explain and predict the impact of various information markets designs on key business-related dependent variables. Experimental results can also be used to refine market design and will contribute back to our knowledge base.

![Figure 2: Design Science Approach for Designing and Evaluating an IT Solution for an Identified Business Problem](image)

Following the design science research guidelines proposed by Hevner et al. (2004), we advance a research approach for designing and evaluating IT artifacts developed to fulfill an identified business need (Figure 2). The proposed approach for conducting design science research starts by organizing research questions into two sets: IT artifact design and IT artifact design evaluation. IT artifact design research questions
ask about (1) the nature and the specific design of the proposed IT solution, and (2) its expected utility for the identified business need. After the nature and the proposed artifact design are articulated along with the theories and literature that inform the design, the IT artifact’s expected utility is stated in form of testable hypotheses.

IT artifact design evaluation research questions ask about the efficacy of the designed artifact in providing its hypothesized utility in a particular business domain. To test the hypotheses and answer design evaluation research questions, an appropriate evaluation method should be selected such as laboratory experiment or field studies supported with appropriate literature, and then the hypotheses can be tested by collecting the required data and analyzing it using appropriate data analysis techniques. Evaluation results can then be used to modify the artifact design and/or selected evaluation method, and will enhance our understanding of the problem either by developing or extending existing theories, or by adding empirical evidence to our knowledge base. The evaluated IT solution is then applied in a particular domain to help solve an identified business problem.

**Research Questions**

The IT artifact design research questions are:

**RQ1** - *What is the design of an information market for software projects risk assessment?*
**RQ2** - What is the expected utility of the designed information market for software projects risk assessment?

Information markets are expected to improve the accuracy of software projects risk assessment by improving the currency, accuracy and completeness of reported status information about projects various objectives such as scope, cost, quality and schedule.

IT artifact evaluation research questions:

**RQ3** - What is the efficacy of an information market providing complete, current, and accurate information about software project risks?

**Research Description and Contributions**

This dissertation contributes to the theory and practice in the information systems literature, software project management literature, and the information markets literature.

Research on information markets has increased significantly in the last 5 years and yet there have been few reviews that cover the theoretical underpinnings of information markets and synthesize existing studies to make this knowledge accessible to information systems researchers. The information markets literature review presented in this dissertation is considered a contribution because it seeks to stimulate more general interest in information markets and suggests fruitful areas for future research.
This dissertation establishes a theoretical foundation for organizational information markets by conceptualizing markets from an information systems perspective in four different ways; as IT artifacts, systems within bigger systems, business intelligent tools, and consensus making systems, and by developing a systems theory of information markets. These conceptualizations along with the developed theory facilitate investigation of the relationships and interactions between markets and their context of use, and are an important first step towards building new information systems theories about organizational information markets to describe, explain and predict their behavior and impacts on organizations.

Attaining a better understanding of the design, implementation and use processes of IT artifacts in organizations is vital to devise design, implementation and use guidelines and procedures that promote effective structuration process that leads to organization development. This dissertation proposes a structuration model for design and use of IT artifacts in organizations, and applies it to the study of information markets. It also provides guidance on the design of information markets, their interfaces and information visualization used by developing a framework of market users to guide market design to satisfy users’ motivational and informational needs.

This research extends Giddens’ structuration theory (Giddens, 1979) by developing the structuration model of technology-induced organization development that defines a goal and an ultimate outcome for the structuration process of IT artifacts. This model conceptualizes design as a group of decisions, envisions the design process as a
decision making process, considers technology as a catalyst for organization change and development, and views the structuration process as a continuous change process that objectifies changeability as an organizational permanent structure that leads to organization development.

A well-designed information market provides utility to organizations that over the long run might lead to their growth and development. This dissertation proposes various ways by which organizations can utilize information markets to improve their assessment of software project risks. For example, an information market can be designed to monitor the status of each project objective in addition to the project overall riskiness level. It can also be used to predict the impact of a range of risk factors or the likelihood of various impact levels of a particular risk factor.

To answer our research questions, this dissertation proposes an experimental information market design solution for software project risk assessment. The forecasting goal of the market is the project riskiness level. The outcomes being forecasted are “high risk”, “medium risk”, and “low risk”. Riskiness level is defined in terms of the number of unmet objectives. Project main objectives are cost, schedule, functionality and performance. Objectives are considered unmet when they exceed a certain threshold over their planned limit. For example, cost exceeds budget by more than 15%. The higher the number of unmet objectives, the higher the overall riskiness level of the project.

To test the designed information market efficacy in providing complete, current, and accurate information about software project risks, two controlled laboratory
experiments are conducted. The results of the experiments provide evidence to information market efficacy in improving risk assessment accuracy by aggregating information from all participants in the market to provide more complete, current and accurate assessment of risks than any individual group of participants. The results also prove that markets can increase employees’ willingness to report negative status information by reducing employees’ perception of information asymmetry, providing incentives for truthful revelation of status information, and by protecting employees’ identities from being exposed.

This research contributes to the software project risk management literature by proposing an innovative technology-based solution to risk assessment problems, along with a theoretical framework for the determinants of risk assessment accuracy. The results of the experiments improve our understanding of the factors that increase the accuracy of software projects status reports and consequently software project risk assessment and provide evidence to the market effectiveness in improving software risk assessment accuracy, which will consequently reduce software projects chances of failure and save organizations billions of dollars. This research highlights an additional benefit for information markets besides their anonymity and incentives offered for truthful trading; the ability to influence participants’ perceptions of information asymmetry which can be very useful to organizations if utilized properly.

This dissertation contributes to the information markets literature by first proposing a design-based solution to an important open question in the information
markets literature; how to generate sufficient uninformed trades required for information markets to function properly. Second, it provides a closer look at markets’ information aggregation and dissemination processes by conducting laboratory experiments using realistic information structure, business-related tasks and scenarios. Third, it evaluates an innovative application of information markets in business. This in turn will allow us to build theoretical models to explain and predict the impact of various information markets designs on key business-related dependent variables.

**Dissertation Organization**

The reminder of this dissertation is organized in three major chapters. Chapter Two reviews the literature and the theoretical underpinnings of information markets. Chapter Three establishes a conceptual foundation for the study of organizational information markets and employs several theoretical perspectives to define the relationship between markets and organizations. Chapter Four utilizes a design science approach to design a technology enabled information market solution to aid organizations in managing risks facing software development projects and evaluates the market’s efficacy in solving the identified problems using two controlled experiments. Chapter 5 completes the dissertation with a summary of the research contributions and observations on future research directions.
Chapter Two

Information Markets: Theory and Literature Review

Introduction

This chapter begins by reviewing the theoretical underpinnings for information markets. It then provides a closer look at information markets structure and design. Successful applications of markets in general areas such as politics, entertainment, and sports are reviewed next. We also review the few studies that empirically investigate the use of information markets in a business setting, to forecast sales and project delivery dates. The following section discusses the market advantages compared to other information aggregation and forecasting methods used in organizations today. This chapter concludes by identifying areas for future research.

Information Markets Theoretical Base

Hayek Hypothesis

Information markets are a distinct form of futures markets whose main purpose is to aggregate information about uncertain future events. The ability of markets to aggregate information dispersed among individuals can be traced back to Adam Smith (1776) and his invisible hand theory. The invisible hand process works via free markets and division of labor where outcomes are produced in a decentralized way with no
explicit agreement between thousands of independent, utility maximizing agents whose aims are neither coordinated nor identical with the actual outcome, yet bringing wealth to their nations. This vision of decentralized planning of economies that secures the best use of knowledge in society is what Hayek (1945) believed can only be maintained through the free markets price system.

Thus, according to the Hayek hypothesis, a society is composed of individuals, each spatially separated from others or decentralized, who have only partial local knowledge of a phenomenon. Each individual’s thoughts and beliefs are diverse and independent. It does not matter if only few know about a certain circumstance, as long as they all act and think independently seeking their self interest. Under these conditions, free markets can collect, coordinate, and ensure cooperation where the whole act as one bringing about, in form of prices, a collective wisdom purified from cognitive problems of those few (Surowiecki, 2004).

**Rational Expectations Theory**

The information aggregation property of prices is what gave rise to information markets. This property was formalized by Muth (1961) in the theory of rational expectations and price movement. According to rational expectations theory, individuals take all available information into account in forming expectations about future events.

In a perfectly competitive market, the rational expectation equilibrium is the intersection point of supply and demand curves. Buyers and sellers make sequential trades at discrete points in time with imperfect information bringing about the price
observed in the market. The process of acquiring information in the market advances traders through different states ranging from no information to perfect information. As traders discover and learn, they adjust their expectations, and the observed price consequently evolves in a series of disequilibrium price adjustments to an expected price which theoretically should soon become the equilibrium (Hess, 1972).

**Random Walk Theory**

Understanding prices’ behaviors and their formation process in order to predict future prices has attracted economists, market analysts, and investors’ attention for many years. It is a fascinating area of study and a great way of making money. There are three major schools of thought with regard to how prices form; technical, fundamental value, and random walk. While all agree that market prices form through series of successive price adjustments, it is why these adjustments take place and how independent they are, that make them disagree.

Technical analysts, also known as chartists, assume that the series of past price changes has memory and the past tends to repeat itself. They carefully analyze historical price changes to identify patterns to help them predict future prices and eventually increase their chances of making profit. On contrary to this implied dependency assumption, random walk theorists assume independence. In other words, patterns identified cannot be used to predict future changes and any profit made using technical analysis cannot exceed those made by chance, or by using a buy and hold trading strategy (Fama, 1965b). A Random Walk Down Wall Street (Malkiel, 1973) can even convince
investors that buy and hold strategy is best since attempts to outperform the market based on technical, fundamental, or any other forms of analysis are vain.

Fundamental value analysis is consistent with the random walk independence assumption. Fundamental value analysts believe that each security has an intrinsic value. They evaluate the company’s earnings, dividend policy, the riskiness of their investments, and the political and economic factors affecting them to estimate securities value and expected return. Changes in market prices can be caused by disagreement between traders on how valuable securities are, new information arriving at different points in time, or by the mere accumulation of random noise due to individuals’ impulsive betting behavior (Fama, 1965a). The arrival of new information or the noise created by irrational behavior can cause prices to change in a dependent way to levels above or below their intrinsic values. However, experienced intrinsic value analysts will shortly notice that activity and act quickly by selling or buying, thus, driving price levels back towards their intrinsic values and eliminating any dependence in successive price changes (Fama, 1965a).

Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) (Fama, 1970), which requires traders to have rational expectations, is connected to random walk theory. The EMH asserts that markets are informationally efficient, and thus are impossible to beat. In other words, prices of traded assets reflect all available information about future prospects of the asset. Since prospects are analogous to events. Prices in efficient information markets reflect all
available information about the likelihood of the events. Thus, information markets utilize market efficiency to harness the collective knowledge of participants to predict the likelihood of future events.

Modern behavioral finance has shown that people make systematic errors when predicting the future. This irrational behavior could also arise due to emotional errors (Clark, 2007), wishful thinking, or making mistakes, biased or not (Forsythe, Rietz, and Ross, 1999). These behaviors create market inefficiencies and anomalies in prices that may be inexplicable via any available hypothesis (Fox, 2002; Rosenberg, Reid and Lanstein, 1985).

However, information markets effectiveness seems to be immune to irrationality. Forsythe, Nelson, Neumann, and Wright, (1992) analyzed Iowa political stock market data to test the market ability to aggregate information about political events. Trader level analysis showed that some traders appeared rational while others exhibited substantial cognitive and judgmental biases, such as assimilation-contrast and false-consensus effects. In spite of that, the market forecasts were notably accurate.

**Marginal Trader Hypothesis**

In efficient information markets, it does not really matter if all traders are rational or not, as long as the marginal trader is rational and motivated by profit; the market generated forecast will be fairly accurate (Forsythe, Nelson, Neumann, and Wright, 1992; Wolfers and Zitzewitz, 2004). The marginal trader hypothesis claims that “marginal traders who are influential in setting market prices are all that is needed for the Hayek
hypothesis to succeed” (Forsythe et al., 1999, p. 84). The marginal traders are those who submit limit orders close to the market price. While those who are inactive, make only market orders, or make limit orders at prices far away from market prices are not considered marginal (Forsythe et al., 1999).

Each market trade is determined by two separate acts, or two trader roles: a market maker submitting a limit order and a price taker accepting it (submitting a market order). Traders self select into these two roles. Violations of the law of one price, the no-arbitrage assumption, and those of individual rationality, can be classified into price taking and market making violations (Oliven and Rietz, 2004). Even though average traders might exhibit judgment biases, marginal traders, or market makers, are who determine whether markets are efficient or not (Oliven and Rietz, 2004).

Studies have found that marginal traders appear to behave more rationally, exhibit less biased trades, and are more experienced and knowledgeable (Forsythe et al., 1992; Forsythe et al., 1999; Oliven and Rietz, 2004). It is worth noting though, that a market maker cannot exist without a price taker, otherwise the no-trade theorem will bind and traders will not agree to disagree (Aumann, 1976; Milgrom and Stocky, 1982). It is still an important open question in the information markets literature on how to attract those price takers, despite their possible irrational behavior, to participate in trading due to their critical role in executing trades (Wolfers and Zitzewitz, 2006).
A Closer Look at Information Markets

Information markets, often known as prediction markets, but also referred to as decision markets, event markets and idea futures, are an emerging form of futures markets created to aggregate information, rather than to hedge risks. Information markets can be organized into two main categories as shown in Figure 3 based on the market objective for which the information is aggregated (Jones, Collins, and Berndt, 2009). Verifiable outcomes information markets seek to predict the likelihood of future states of either a discrete or a continuous variable. Unverifiable outcomes information markets allow participants to either create or choose among alternative or courses of action.

Thus, information markets can be used to aggregate information about a wide range of events, such as sports outcomes, interest rates, marketing campaigns, and
research ideas. Although markets differ in many respects, such as market design and incentive structure, they generally consist of one or more events for which you would like a reliable forecast.

The standard contract in the market is the binary contract, aka winner-take-all. It costs a certain amount and pays off, for instance, $1 if and only if the event occurs, and nothing otherwise. Traders buy and sell contracts of future events based on their beliefs in the events likelihood of occurrence. For example, if a trader believes the event is going to happen, s/he will buy contracts in the event. But if a trader has information to the contrary, s/he will sell contracts in the event. Contract prices and events probabilities are positively correlated. The higher the likelihood of the event the higher its contract price and vice versa. The result is a trading price that tracks the consensus opinion (Hanson, 1992), and can be interpreted as market-aggregated forecast of the event probability (Wolfers and Zitzewitz, 2004). For example, if a contract price is selling for $70, that means there is a 70% chance of the event happening.

**Market Design**

Based on research results in the fields of experimental economics, financial markets, and political stock markets, Spann and Skiera (2003) grouped main aspects of information markets design into three categories, outlined in Figure 4.
**Forecasting Goal**

The choice of forecasting goal is concerned with the types of questions asked about future events. In other words, what is specifically being predicted. Predicted events must be easy to verify and future outcomes must be easy to measure.

Questions can be formulated to predict the occurrence/nonoccurrence of an event, such as whether a project will be delivered on a specific date or not. Other questions can predict numbers such as units sold, or sales in dollars or percentages such as market share, or election vote share. Questions must be clear, and easy to understand. They must be interesting enough to attract traders, and controversial enough to sustain trading.

**Portfolio Composition**

The designer of the market must decide on the composition of traders’ initial portfolios and on whether traders will use their own money to buy shares, or will be given an initial endowment of shares. Another related design issue is the use of real or play money. Real money might motivate traders to collect more information about the events. On the other hand, it might deter informed, but risk adverse, traders from
participating. Additionally gambling laws might restrict the use of real money markets, making the play money alternative plausible. In terms of predictive accuracy, studies have shown that real and play money markets result in equally accurate predictions (Servan-Schreiber, Wolfers, Pennock and Galebach, 2004).

**Incentive Structure**

Designers must also decide on an incentive structure to motivate traders to participate, and to truthfully reveal what they know about an event. After all, a trade requires a trader to put her money where her mouth is. The incentive structure, and the type of contracts used, can elicit the collective expectations of a range of different parameter, such as the probability, mean or median value of an outcome (Wolfers and Zitzewitz, 2004). For example, when the outcomes of an event are mutually exclusive, such as (yes/no), or (occur/not occur), the binary contract, described in the previous section, can be used to elicit the event’s probability of occurrence. The same applies to events with more than two mutually exclusive outcomes. State-contingent or winner-take-all contracts can be used, and their prices can be interpreted as the collective or the market forecast of the event probability. As long as the no arbitrage condition is satisfied though. In other words, the sum of prices of the traded state-contingent contracts should be exactly equal to the payoff of the winning contract (Chen, Fine and Huberman, 2001). For example, in case of binary contracts, if the winning contract pays off a $100, the sum of prices of the two traded contracts must be equal to a 100 (e.g. Yes →$40, No →$60).
Iowa Electronic Markets (IEM), a well-known real-money prediction market, used winner-take-all contracts to predict the outcomes of the 2008 U.S. presidential elections (Table 2). IEM’s winner-take-all prediction market opened in June 2006. The founder of the IEM, Professor Tom Rietz, said “the IEM traders saw Obama's win even before anyone knew who the two parties' nominees would be.” At midnight the day before the election, prices indicated a 90 percent probability that the Democratic candidate would win the popular vote (IEM press release, Nov 5, 2008).

Table 2: IEM 2008 US Presidential Election Winner Takes All Contracts

<table>
<thead>
<tr>
<th>Code</th>
<th>Contract Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEM08_WTA</td>
<td>$1 if the Democratic Party nominee receives the majority of popular votes cast for the two major parties in the 2008 U.S. Presidential election, $0 otherwise</td>
</tr>
<tr>
<td>REP08_WTA</td>
<td>$1 if the Republican Party nominee receives the majority of popular votes cast for the two major parties in the 2008 U.S. Presidential election, $0 otherwise</td>
</tr>
</tbody>
</table>

Figure 5: IEM 2008 US Presidential Election Winner Takes All Market
(Source: http://iemweb.biz.uiowa.edu/graphs/graph_PRES08_WTA.cfm)
In support for Professor Rietz statement, Figure 5 shows that for more than two years the democratic contract price never once dropped below the republican. Prices were exceptionally responsive to unfolding events on the campaign trail, and fluctuated around primary, caucus, and major party convention dates.

When forecasted outcomes are numbers or percentages, such as sales in dollars, vote count, or percentage of vote share, index contracts can be used that pay off proportionately to the outcomes (Wolfers and Zitzewitz, 2004). IEM vote share contracts (Table 3) are examples of index contract.

### Table 3: IEM 2008 US Presidential Election Vote Share Contracts

<table>
<thead>
<tr>
<th>Code</th>
<th>Contract Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDEM08_VS</td>
<td>$1.00 times two-party vote share of unnamed Democratic nominee in 2008 election</td>
</tr>
<tr>
<td>UREP08_VS</td>
<td>$1.00 times two-party vote share of unnamed Republican nominee in 2008 election</td>
</tr>
</tbody>
</table>

Prices on the IEM's Vote Share Market (Figure 6) predicted the percentages received of the two-party presidential popular vote to within half percentage point: the market predicted 53.55 percent for Barack Obama, and 46.45 percent for John McCain. After the ballots were counted, Obama received 53.2 percent of the vote, and McCain received 46.8 percent (IEM press release, Nov 24, 2008).
The price of index contract represents the market mean expectation of the outcome. On the other hand, a spread contract with even money bet represents the market’s expectation of median outcome, and is used to forecast whether outcomes will exceed a certain cutoff point, such as a candidate receiving more than a certain vote share (Wolfers and Zitzewitz, 2004). Table 4 summarizes the discussed contract types.

<table>
<thead>
<tr>
<th>Contract Type</th>
<th>Payoff</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winner-take-all</td>
<td>Pays $1, $0 otherwise</td>
<td>Probability</td>
</tr>
<tr>
<td>Index</td>
<td>Proportionate to outcome</td>
<td>Mean</td>
</tr>
<tr>
<td>Spread</td>
<td>Double money if outcome exceeds</td>
<td>Median</td>
</tr>
<tr>
<td></td>
<td>cutoff point; $0 otherwise</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Information Markets Contract Types

Figure 6: IEM 2008 US Presidential Election Vote Share Market
(Source: http://iemweb.biz.uiowa.edu/graphs/graph_PRES08_VS.cfm)


Trading Mechanism

The choice of market trading mechanism is another important aspect of market design. The dominant market trading mechanism is the continuous double auction (CDA), where bids, submitted by buyers, and asks, submitted by sellers, wait in queues to be executed. Bids are sorted by prices in descending order and then by posting time in ascending order; while asks are sorted by prices then by time, both in ascending order to facilitate matching with pending bids. The continuous double auction (CDA) mechanism poses no risk on the market institution, provides incentives for continuous incorporation of information, and offers the option of cashing out by selling shares at the currently offered bid price. However, CDA might suffer from illiquidity due to market thinness, or wide bid-ask spread (Pennock, 2004).

Continuous double auction with market maker (CDAwMM) are the bookie mechanisms used for sports betting. This trading mechanism guarantees liquidity by transferring the risk involved to the market institution. Pari-mutuel mechanism also guarantees liquidity without posing any risks on the market institution; however, unlike CDAwMM, it does not continuously incorporate information into the price, but rather waits until the event can be identified with certainty (Pennock, 2004).

Market scoring rule (MSR), invented by Hanson (2003, 2007), can elicit forecasts over many combinations of outcomes and from both individuals and groups. MSR combines the advantages of information markets and scoring rules while solving the thin market and irrational betting problems of standard information markets, as well as the
information pooling problems of simple scoring rules. MSR is currently used at Inkling Markets, the Washington Stock Exchange, BizPredict, and several other markets.

David Pennock (2004) developed a novel market mechanism called dynamic pari-mutuel market (DPM) that is used at Yahoo! Tech Buzz Game. DPM combines some of the advantages of both Pari-mutuel and CDA markets, yet like all other mechanisms has its own limitations. Table 5 summarizes the pros and cons for the various available market mechanisms as discussed by Pennock (2004).

<table>
<thead>
<tr>
<th>Market Mechanisms</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Double Auction (CDA)</td>
<td>2,3,4</td>
<td>Fails 1</td>
</tr>
<tr>
<td>Continuous Double Auction with Market Maker (CDAwMM)</td>
<td>1,3,4</td>
<td>Fails 2</td>
</tr>
<tr>
<td>Pari-Mutual (PM)</td>
<td>1,2</td>
<td>Fails 3 and 4</td>
</tr>
<tr>
<td>Dynamic Pari-Mutual (DPM)</td>
<td>1,2,3,4</td>
<td>5,6</td>
</tr>
<tr>
<td>Market Scoring Rule (MSR)</td>
<td>1,3,4</td>
<td>Fails 2, but risk is bounded</td>
</tr>
<tr>
<td>Bookie (Bookmaker)</td>
<td>1,3,4</td>
<td>Fails 2</td>
</tr>
</tbody>
</table>

1. Guaranteed liquidity
2. No risk for the market institution
3. Continuous incorporation of information
4. Ability to cash out by selling before the market closes
5. Pay off depends on the price at the time, and final pay off per share
6. One sided nature (only accept buy order)

**Information Markets Applications**

While research on information markets has witnessed an exponential growth in the number of published articles in the last ten years (Tziralis and Tatsiopoulos, 2007),
prediction markets have been around for a long time. Betting on political outcomes has a long tradition in the United States, with large and formal markets, such as the New York betting market, operating for over three-quarters of a century (Rhode and Strumpf, 2004). These markets have had a very large volume of activity and a notable predictive accuracy (Rhode and Strumpf, 2004).

Today, the Iowa Electronic Market (IEM), the most well known application of information markets, is offering markets in which traders can bet on a wide variety of events ranging from the outcomes of presidential elections, to the periodic interest rate decisions of the Federal Reserve’s Open Market Committee (Hahn and Tetlock, 2006). Since 1988, prices on the IEM have proved more accurate than traditional polls in forecasting elections more than 75 percent of the time, with an average absolute error of only 1.5 percentage point, compared to 2.1 percentage points for polls (Berg, Forsythe, Nelson and Rietz, 2003; Forsythe et al., 1992; Hahn and Tetlock, 2006).

Market forecasts can be used to inform decisions made by political parties, such as nominating presidential candidates that are likely to win, as well as decisions made by the candidates themselves regarding their campaigns strategy such as what issues to focus on. The idea of using markets for decision support was first introduced by Hanson (1999) when he used the concept of decision markets, or conditional markets, to illustrate how market forecasts can be used to inform decisions about an event, given market predictions of another. Berg and Rietz (2003) provided an elaborate analysis of the 1996 presidential election market, and described how market prices can be used to support decisions; for
example, market forecasts suggested that Dole was not the strongest candidate in the set, so the Republican Party could have used market prediction to support a stronger candidate with a better chance of beating Clinton (Berg and Rietz, 2003).

The Hollywood Stock Exchange (HSX) is another successful application of information markets. Traders in the HSX buy and sell shares of their favorite actors or movies causing securities’ prices to rise or fall. Traders evaluate movies by collecting information from movies websites, readings critics’ reviews and blogs, and interacting with fan communities to form beliefs about movies’ potential prospects. Prices of securities are used to predict Oscar, Emmy, and Grammy award winners and movie box office returns. The predictions have proved to be highly correlated with actual outcomes. In 2009, players correctly predicted 29 of 37 Oscar nominees for the 81st Annual Academy Awards, a 78.4% success rate, bringing HSX’s 11 year average to an impressive 82.1% (HSX press release, Jan 22, 2009).

The HSX is being used as a market research instrument where movies’ box-office prerelease forecasts are used to determine marketing budget, the number of movie screens, and related promotional activities (Eliashberg and Sawheny, 1996; Spann and Skiera, 2003). Spann and Skiera (2003) analyzed the HSX forecasting accuracy for 152 movies, and compared market predictions to two renowned experts’ predictions. They also analyzed the market performance in many other areas, such as predicting the number of movie visitors, and chart position of pop music singles in Germany, and even in predicting the usage of different mobile phone services of a large German mobile phone
operator. Market predictions were fairly accurate. Results showed that markets work well under different incentives structures and with small number of participants.

There are many other successful Web-based implementation of information markets designed to aggregate information and forecast events in many areas such sports, politics, finance, law, entertainment, and even the weather. Some examples of real money information markets include Intrade, TradeSports, Nadex and BetFair. Other examples of play money markets are NewsFutures, Inkling markets, and the Foresight Exchange.

In 2006, over 25 companies in the United States had started to experiment with information markets (King, 2006). Today the number has at least doubled and companies have moved beyond the experimentation stage. Microsoft is using the market to predict software quality issues, such as the number of bugs in new software application, Google is using it to predict dates of product lunches and GE is using it to choose the best new research ideas (Schonfeld, 2006). AT&T, Yahoo, Corning and Best Buy are just a few examples of the many Fortune 500 companies that have begun to seriously use the market in various areas.

In a series of experiments at Hewlett-Packard laboratories, markets outperformed official HP forecasts 75% of the time in predicting printer sales and the DRAM microchip prices (Chen and Plott, 2002; Schonfeld, 2006). Ortner (1997, 1998) conducted an experiment using information markets at Siemens Austria to forecast delays and reveal information about software project progress. Results showed that market prices anticipated delays long before the official release of information, proving the
usefulness of using markets in the software project management arena. The Milestone Market (www.milestonemarket.org) at the University of South Florida is being deployed for software cost estimation and software project management where market contracts are defined for each set of milestones, and are tied to defined cost and time estimates (Berndt, Jones and Finch, 2006).

Intel integrated an information market designed to forecast demand into the company’s standard forecasting processes. The results of early experiments showed that market forecasts are stable, responded well to demand fluctuations, and were at least as accurate as the official forecasts, with 75% of market forecasts falling within 2.7% of actual sales (Hopman, 2007).

In addition to aggregating information, and forecasting events, markets can be used to study how organizations process information (Cowgill, Wolfers, and Zitzewitz, 2008). The Cowgill et al. (2008) analysis of Google’s internal prediction market showed how markets can be used to track information flow within the organization and how it responds to external events.

**Information Aggregation Methods**

Organizations employ various methods to elicit forecasts and aggregate information held by members of a group. When the issues at hand are purely factual, statistical groups can be used by asking a large group of individuals and calculating the statistical mean or median of their answers (Sunstein, 2005).
However, when the group is anchored by a misleading number or the group members are ignorant to the issue at hand, the likelihood that the group will decide correctly decreases as the size of the group increases (Sunstein, 2005).

Alternatively, deliberation can be used to improve group decision making through discussions and debates, especially when the issues are normative rather than factual (Sunstein, 2005). Armstrong (2006) presented the case against face-to-face meetings, demonstrating how ineffective and inefficient traditional group meetings are at aggregating information. Groups often produce inaccurate outcomes because of informational and social influences (Sunstein, 2005).

Sunstein (2005) argued that informational influence occurs when group members announce their information by conduct, conclusions or by reason-giving; influencing other group members not to disclose any information to the contrary. On the other hand, social influence leads individuals to conform to higher status group members fearing disapproval, or social sanctions of various sorts. These influences impair group judgment by emphasizing shared information, creating hidden profiles, cascade effects, and group polarization (Sunstein, 2005).

Additionally, individual group members have limited information processing capabilities and therefore rely on heuristics such as representativeness, availability, framing, anchoring, and adjustment to reduce the cognitive load of predicting values or assessing probabilities (Tversky and Kahneman, 1974). The use of heuristics reduces
complex tasks to much simpler judgmental tasks, creating biases and errors in individual judgments that are propagated, and often amplified, in group settings.

The Delphi method is utilized to diminish the informational and social influences of deliberative groups. The Delphi technique uses a self-administered questionnaire and a system of controlled feedback wherein a group of experts participate in anonymous rounds of estimates and feedback until the degree of convergence reaches a desired threshold. Members are allowed to communicate their judgments and conclusions anonymously in the form of summary statistics along with their justification and reasoning behind them. Experts can then respond to the forecasts and justifications of others and revise their own based on the feedback they receive. Finally, individual judgments are statistically aggregated (Armstrong, 2001).

Rowe and Wright (1999) reviewed 25 empirical studies that evaluated the effectiveness of the Delphi method in terms of forecast accuracy and quality. Their review showed that Delphi outperformed both statistical and interactive groups roughly over 80% of the time. Although the Delphi technique proved to improve forecasting and decision making, it has its own limitations. In addition to the possible difficulty of recruiting experts in any area of interest, Delphi does not have an incentive structure to motivate experts to reveal their true beliefs. Also, Delphi does not allow incorporation of additional information into the forecasts because it offers results only at a certain point in time (Green, Armstrong, and Graefe, 2007).
Information Markets Advantages

Much of the enthusiasm for using information markets as a method of forecasting and information aggregation comes from the inadequacy of existing methods to accomplish this task. Information markets are being used to overcome the limitations of the various aforementioned methods. Green et al. (2007) discussed how information markets can avoid the drawbacks of Delphi. First of all, markets are not restricted by experts’ availability, instead, traders self select to participate in the market if they believe their private information is not yet incorporated into the market price. Second, markets offer incentives for true revelation of beliefs. Monetary incentives eliminate group pressure to conform, where traders can only benefit by trading according to their own beliefs. Third, unlike Delphi, markets are dynamic and responsive to changing circumstances. Prices in information markets incorporate new information almost instantly, providing continuous and up to date forecasts of events.

Information markets offer many other advantages over existing methods (Table 6). First, Web-based implementations of information markets are not restricted by location or time. Traders can participate from around the globe, 24-7. Second, markets are more cost effective and time efficient than other information aggregation methods. The process of price formation and discovery collects disparate information scattered around the organization or around the world in a matter of hours, and at relatively little to no cost. Third, market trading is anonymous. Anonymity plays a pivotal role in reducing social and informational influences that prevail in group settings. Fourth, trading
dynamics in a market setting cancel out individual biases and errors preventing cascading effects from impact forecasts (Forsythe et al., 1992; Forsythe et al., 1999; Oliven and Rietz, 2004).

The substantial body of experimental research on information aggregation (e.g. Forsythe and Lundholm, 1990; Sunder, 1992, 1995; Forsyth et al., 1992; Plott, 2000; Plott and Sunder, 1982; Plott and Sunder, 1988) suggests that markets seem to work fairly well in a wide variety of settings. Empirical studies on information markets prove the feasibility of using the market in a business setting to forecast a variety of events (Chen and Plott, 2001; Ortner, 1997, 1998). Further, research has shown that markets are robust to manipulation and insider trading (Hanson and Opera, 2004; Hanson, Opera, and Porter, 2006), and produce forecasts that are at least as accurate as existing alternatives, such as opinion polls and experts’ predictions (Berg, Nelson and Rietz, 2003; Chen and Pennok, 2005; Forsythe et al., 1992; Servan-Schreiber et al., 2004).

Table 6: Information Markets’ Advantages

<table>
<thead>
<tr>
<th>Why Information Markets?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Web-based</td>
<td>Robust to manipulation</td>
</tr>
<tr>
<td>No time or place restrictions</td>
<td>Anonymous</td>
</tr>
<tr>
<td>No experts required</td>
<td>Save time and money</td>
</tr>
<tr>
<td>Offer continuous up to date forecasts</td>
<td>Biases and errors proof</td>
</tr>
<tr>
<td>Versatile</td>
<td>Dynamic and responsive to unfolding events</td>
</tr>
<tr>
<td>Offer Incentives for honesty</td>
<td>High forecasting accuracy</td>
</tr>
</tbody>
</table>

Information markets’ impressive performance holds great potentials for the business world. Studies that test the usefulness of information markets in various areas of business are greatly needed.

40
Future Research Directions

Research on how information markets are used inside organizations is still in its infancy. Little is known about the impact of the business environment on market design, incentive structure, and types of questions asked in the market, or more simply put, what works and what does not. Little is also known about the impact of the market on work processes, corporate culture, and formal and informal reporting mechanisms in the organization.

Future research should investigate the impact of different incentives structures and the type of market mechanism used (e.g. pari-mutuel, continuous double auction, market scoring rules) on the market’s forecasting accuracy. Studies should also investigate the impact of incentive structures and market design on organizations’ decisions to adopt the market and traders’ motivations to participate in it. For example, different trading mechanisms have different associated learning curves which may affect the market perceived ease of use, and consequently, organizations’ decisions to adopt the market. It may also require traders to employ different trading strategies that involve a greater cognitive effort to analyze information and to participate in market trading; thus discouraging them from participating in the market.

Moreover, future research should empirically compare information markets to other methods of information aggregation, such as the Delphi method, not only in terms of forecasting accuracy but also on multiple other dimensions, such as the nature of forecasting problems appropriate for each method, sources of relevant information (e.g.
external, internal, or a mix of both), the availability of public information to attract participants, the availability of experts in certain areas, and the costs involved in recruiting experts, acquiring the market, training, trading time, incentives, etc.

Comparative studies seek to fill in gaps in the literature, satisfy researchers’ curiosity, and help put everything in perspective. One might argue that the value of new innovations can be better appreciated relatively rather than in absolute terms. However, we caution against using forecasting accuracy as the sole basis for comparison between markets and other existing methods. It is important to keep in mind when evaluating the effectiveness of information markets what made them attractive in the first place. Available methods of forecasting and information aggregation such as polls, surveys and the Delphi method have their own limitations, and produce inaccurate forecasts all the time. So are we really doing markets justice by comparing them to error-prone benchmarks?

Further, unintended uses of markets might emerge that bring additional benefits to organizations, rendering them incomparable to other methods. Markets bring about a unique mix of involvement and enjoyment that other methods do not provide. By promoting democratic participation in decision making and idea generation, organizations might be able to increase employees’ loyalty, job satisfaction, and retention rates. Research is needed to study such questions.

Information markets impact on organizations’ hierarchy and control structures and on their relationships with employees, customers, partners, and strategic allies might
change the way business is done forever. These unanticipated benefits might create a
stronger motivation to adopt information markets than their predictive accuracy.
Information markets are innovative tools to harness the collective intelligence buried in
organizations. They hold great promises for business that are only limited by our own
innovation to realize them.
Chapter Three

A Foundation for the Study of Organizational Information Markets

Introduction

The term “collective intelligence” has long been associated with non-human societies such as bacteria, insects, and animals. Perhaps human pride has deterred individuals from admitting that “none of us, is smarter than all of us”, until advanced communication technologies, the World Wide Web, and the Internet have made this fact evident to the world (Servan-Schreiber, 2008). Google, Wikipedia, and information markets are three examples of human collective intelligence enabled by the Web that are designed to aggregate existing information to enhance existing knowledge. However, information markets have the additional benefit of generating new reliable knowledge about the future (Servan-Schreiber, 2008).

Information markets, also known as prediction/decision markets, are a form of futures markets designed to aggregate disparate information and intuitions about the likelihood of uncertain future events. Traders bet on the chances of the event by buying shares if they believe the event is going to happen and selling shares if they believe otherwise. The price of the traded shares in the event can be interpreted as the market consensus forecast of the event’s probability (Wolfers and Zitzewitz, 2004). Once the
event’s outcomes (e.g. occur/not occur) can be determined with certainty, shares payoff according to the actual outcome.

The most well known application of information markets is the Iowa Electronic Market (IEM), established at the University of Iowa in 1988, to predict the outcomes of the U.S. presidential elections. Since its inception, IEM has demonstrated an impressive predictive performance with an average absolute error of only 1.5 percentage points compared to 2.1 percentage points for Gallup polls (Berg, Forsythe, Nelson, and Rietz, 2003). Over the long run, the market predictions were closer to the actual election result 74% of the time when compared to 964 polls over the five Presidential elections since 1988 and outperformed the polls in every election when forecasting more than 100 days in advance (Berg, Nelson, and Rietz, 2008).

The Hollywood Stock Exchange (HSX) is another successful application of information markets used to predict Oscar, Emmy, and Grammy award winners and movie box office returns. In 2009, Hollywood Stock Exchange announced a 78.4% success rate in predicting the 81st Annual Academy Awards nominations, bringing its 11 years average to a remarkable 82.1% (HSX press release, Jan 22, 2009).

Market forecasts can be used to inform decisions about forecasted events. For example, IEM forecasts can be used to inform decisions made by political parties, such as nominating presidential candidates that are likely to win, as well as decisions made by the candidates themselves regarding their campaigns strategy and the issues to focus on (Berg and Rietz, 2003). Similarly, HSX forecasts can be used by movie production
companies to determine marketing budget, the number of movie screens, and related promotional activities (Eliashberg and Sawhney, 1996; Spann and Skiera, 2003).

Information markets’ outstanding performance in predicting future events such as elections outcomes and other issues of public interest, coupled with an increasing interest in finding more efficient alternatives for information aggregation, has inspired the corporate world to start experimenting with information markets. Yahoo, Google, Microsoft, GE, HP, Intel and many other fortune 500 companies are now using information markets to forecast business related issues, such as product delivery dates, product sales, market demand, and software quality issues.

Although the number of companies adopting information market technology is on the raise, it is still less than 1% of the target audience (Gartner, 2008) and despite the enthusiasm for using information markets for business forecasting, research on information markets used inside organizations is still in its infancy. It is expected that information markets will reach main stream adoption within 5 to 10 years (Gartner, 2008) and yet little is known about the impact of the business environment on market design, incentive structure, and types of questions asked in the market, or more simply put, what works and what does not. Little is also known about the impact of the market on work processes, corporate culture, and formal and informal reporting mechanisms in the organization.

Information markets are, in essence, IT artifacts. To make the best out of this innovative technology, we must first theorize about the technology itself and about the
reciprocal relationship between markets and their environment to develop an understanding of how information markets’ use impacts organizations, how the business setting impacts market design, and how design impacts use and consequently the market objectives.

As a first step to systematically investigate the design and use processes of markets inside organizations, this chapter theorizes about information markets from an information systems perspective. The next section presents an information systems research framework for information markets, and re-conceptualizes markets as IT artifacts. Section three employs systems thinking concepts to develop a systems theory of information markets to facilitate investigation of the relationships and interactions between markets as systems and their context of use.

Section four briefly reviews Giddens’ structuration theory and its use in the information systems field and defines information markets from a structuration perspective. Section five proposes a structuration model for design and use of IT artifacts in organizations and applies it to the study of information markets. A closer look at information markets design and use is presented in the following two sections, where a framework of market users is proposed to guide market design to satisfy users’ motivational and informational needs.

Our conceptualization of the structuration process of IT artifacts in general and information markets in particular is summarized in the structuration model of technology-induced organization development, that extends Giddens’ structuration theory by
considering technology as a catalyst for organization change and development and the structuration process as a continuous change process that objectifies changeability as an organizational permanent structure that leads to organization development. Conclusions and future directions conclude this chapter.

Markets as IT Artifacts

Information markets are at the frontier of predictive futures and collective intelligence research. Their impressive performance holds great potentials for the business world in areas such as forecasting, decision making, and risk management. However, the relationship between information markets and organizations has not been fully investigated.

The information systems research framework (Figure 7) and the design science research guidelines suggested by Hevner et al. (2004) can be used to structure the methods and activities performed by IS researchers designing/studying organizational information markets. The information systems research framework encompasses two complimentary, however distinct paradigms: the behavioral-science and the design-science paradigms. The behavioral-science paradigm provides guidance “to develop and justify theories that explain or predict organizational and human behavior involved in the analysis, design, implementation, management, and use of information systems” (Hevner et al. 2004, p. 76).
The design-science paradigm is a problem solving paradigm that seeks to develop innovative technological solutions (i.e. IT artifacts) to identified business problems that exist in the problem space as defined by its surrounding environment (Simon, 1996). IT artifacts can be constructs, models, methods, or instantiations that provide utility in addressing those problems and are produced via two design processes: build and evaluate (March and Smith, 1995). Foundational theories inform the artifacts’ design and evaluation, and are developed following the artifacts’ implementation and use to explain their impacts on the environment (Hevner et al., 2004).

![Figure 7: Information Systems Research Framework for Information Markets (Adapted from Hevner et al., 2004)](image)

Information markets are fundamentally IT artifacts designed to provide more effective and efficient solutions to identified business problems such as information.
aggregation, forecasting, and decision making under uncertainty. However, the build and evaluate loops used to produce the information market are informed by foundational theories and methodologies rooted in reference disciplines such as economics (experimental and behavioral), finance, psychology, and political science. As a result, current studies tend to view information markets through reference disciplines lens: as a financial market, or an economic entity (e.g. Forsythe, Nelson, Neumann and Wright, 1992).

The tendency to study the IT artifact, and its intimately related issues, through varied reference disciplines lens is particularly concerning in the IS field. Orlikowski and Iacono (2001) argue that although the information systems field is premised on the centrality of information technology in everyday life, IS research does not live up to this premise. The authors observed that IS researchers tend to under-theorize their field’s core subject matter, the IT artifact, and instead give central theoretical significance to the context where the technology is absent or black boxed, to the processing capabilities of the technology abstracted from its socioeconomic context, or to the deterministic impact of the technology on some dependent variable.

IS studies that investigate the design and use processes of *organizational* information markets and their interactions with the business environment are greatly needed. However, existing literature on information markets and its current knowledge base might tempt IS researchers to black box the market, undermine the importance of its interaction with the environment, or downplay the impacts of its technological and
structural aspects on the effectiveness and efficiency of organizations adopting information markets.

Although markets are socially constructed, focusing too much on the socioeconomic context, or treating the market as either an independent or a dependent variable, rather than focusing on the technology itself, moves us away from our main role of investigating IS specific phenomena, and makes it easy to substitute the IS in our research with anything else; making our contributions indistinct from those of other disciplines (Benbasat and Zmud, 2003).

Thus, the first step in studying organizational information markets is to reconceptualize markets as technology-enabled information systems (i.e. IT artifact). Technology is limited to the hardware and the software components of the market, and the information system encompasses the design, development, implementation, and use processes of the market, as well as the dynamic interaction between the market, people, and its environment to accomplish a certain task. This conceptualization “white boxes” the market, in the sense that it clears some of the doubts surrounding information markets that are mainly due to the black box nature of markets and organization’s lack of general understanding of its internal workings. It also serves as grounds for theorizing about information markets from an information systems perspective.
A Systems Theory of Information Markets

Systems thinking framework (Checkland, 1981) is a useful theoretical lens through which markets as systems can be defined, and the structures underlying these systems and their emergent properties can be understood. It can also be employed to investigate the relationship between IT artifacts and their context of use such as the organization. Systems thinking framework is being applied to study organizations, analyze organizational problems, and develop solutions by viewing organizations as systems operating within a bigger system (e.g. industry) and in continuous interaction with their external environment (e.g. competitors) and internal subsystems (e.g. departments) (Checkland, 1981; Davis and Olson, 1985; Senge, 1990).

Systems thinking’s holistic analysis approach enables organizations to see the big picture that helps them solve complex problems effectively (Senge, 1990). Instead of isolating the problematic parts of the system, systems thinkers examine interaction patterns and interrelationships between systems and subsystems which allow them to uncover dependencies among actions and to understand how problems, as well as solutions, propagate from one system to the other. As a result, systems thinkers choose actions that result in better long terms solutions, instead of those that result in temporary desirable effects that may, over the long run, worsen the problem (Checkland, 1981; Senge, 1990).

At the center of systems thinking is the concept of the “adaptive whole” (Checkland, 1999) which can be useful in understanding the relationship between IT
artifacts, such as information markets, and their context of use. An adaptive whole is an entity that has “emergent properties” in its own right that make the whole larger than the sum of its parts. It can be part of a larger whole, or contain smaller wholes, each with its own emergent properties, organized in some form of a “layered structure”. An adaptive whole survives in a changing environment by having automatic or man-made “communication and control” mechanisms with its environment that allows it to sense changes and adapt accordingly (Checkland, 1999).

Figure 8: A Systems Theory of Organizational Information Markets

A systems perspective on organizational information markets views the market as an adaptive whole organized as part of a layered structure of adaptive wholes.
encapsulating each other (Figure 8). An information market is a subsystem of the organization system in which it is used. The organization in turn operates within an industry, all of which operates in the largest system of all: the world.

Recent research has attempted to reshape current thinking about information markets, and called for investigating markets from a business intelligence perspective. Yassin (2009, p.2) argued that “the spirit of business intelligence lies at the heart of information markets” and that markets used within organizations are in essence business intelligence tools that aggregate and summarize intelligence from multiple sources to enable accurate forecasting about future market trends and potential risks, and consequently make better informed decisions.

Intelligence is “information acquired to aid the purposeful execution of business processes” and business intelligence is “inferences and knowledge discovered by applying algorithmic analysis to acquired information” (March and Hevner 2007, p.1032). The market aggregation mechanism (e.g. continuous double auction, pari-mutual, scoring rules) does not only collect and aggregate intelligence from multiple sources but also determines how the information is collected, which makes it an adaptive whole that has its own structures and properties (Figure 8).

An information market encapsulates the aggregation system and its emergent properties (e.g. intelligence), along with the market incentives and contracts structures, and produces an emergent property that makes the market larger than the sum of its parts; collective intelligence in form of equilibrium price. An organization then analyzes the
intelligence stored in the market such as historical price trends, trading volume, buying and selling transactions, in addition to the collective intelligence produced by the market (i.e. equilibrium price) to draw inferences and make interpretations and predictions about future events, industry trends, and potential risks.

Each system engages in a process of cybernetic information exchange with its environment and has its own ways of responding to and communicating with the system in which it operates, as well as with other systems. For example, an information market communicates information to traders, to decision makers, and to the organization in form of demand and supply cues and trading prices. It also controls participation by means of incentives offered and contracts used in the market.

The organization impacts market participation and traders’ beliefs in the events being forecast through industry reports, official forecasts, project status reports, and the feedback it receives from the industry regarding its performance relative to competitors. Similarly, market information can be used to measure organization performance by comparing market forecasts to official forecasts. Thus, a systems theory of information markets facilitates theorizing about the relationship between markets and organizations and about the impact of the business environment on market design and use by focusing on the big picture and analyzing interactions between systems, subsystems and their emergent properties.
Structuration Theory in Information Systems

Structuration theory (Giddens, 1979, 1984) is another useful theoretical lens through which *markets as IT artifacts* can be defined and the relationship between the market and its environment can be understood. Among social theories, Giddens’ structuration theory has received substantial attention in the information systems field due to its rejection of traditional dualistic views of social phenomena as either determined by society (structure) or individuals (agency).

This rejection of both positivism and strong interpretivism is seen in the IS literature as a rejection of both subjective and objective views of organizations (Orlikowski, 1992) and that of technological and social determinism (Jones and Karsten, 2008). It was also seen as an opportunity to resolve inconsistent definitions of technology (i.e. technology scope), and those of the interaction between technology and organizations (i.e. technology role) (Orlikowski, 1992).

Giddens attempted to reconcile the dichotomous perspectives of social systems (society vs. individual, structure vs. agency, objective vs. subjective) by focusing on the social processes or individual actions that are based on social structures, but at the same time serve to produce and reproduce social structures. The duality of structure or the dynamic conceptualization of structure as both a medium and an outcome of interaction is a central concept in Giddens’ structuration theory.
Although technology is completely absent in structuration theory, its focus on structures and the dynamic processes by which humans use and modify structures through situated practice is of particular interest to IS researchers seeking to understand structures as properties of technology, work groups, and organizations and how an individual’s use of technology is shaped by its features and yet reshapes them (Poole and DeSanctis, 1990, 1992, 1994).

More than 330 IS papers have employed structuration concepts either to offer insight into IS phenomena, to explore its limitations in comparison to other theoretical perspectives, or as a source for developing IS-specific structuration theories that take technology into account (Jones and Karsten, 2008). Two IS variants of Giddens’ structuration theory; the structuration model of technology (Orlikowski, 1992) and adaptive structuration theory (DeSanctis and Poole, 1994) were developed to facilitate investigation of the relationship between technology and organizations.

The structuration model of technology is premised on a recursive notion of technology called the duality of technology; that technology is the outcome of human actions, yet is used by humans to accomplish some action and, thus, is both structurally and socially constructed (Orlikowski, 1992). In other words, technology in and of itself has no significance; it is only through ongoing appropriation by humans that it gains significance. In practice, technology use is conditioned by its material properties and built in structures. However, this conditioning is both enabling and constraining (Orlikowski,
and although use is shaped by technology properties and structures, it also reshapes them causing new structures to emerge (Orlikowski, 2000).

Therefore, technology design, use and interpretations are rather flexible. The degree to which a user can exercise influence over technology construction, either physically or socially, is termed “the interpretive flexibility of technology” and it depends on the characteristics of the technology, human agents involved, and the institutional properties of organizations (Orlikowski, 1992).

Organizations as well as technology users tend to “black box” technologies over which they have no control. Orlikowski (1992) argued that researchers tend to view technology as either objective or subjective depending on the temporal stage the technology is currently at in the technology’s lifecycle. For example, researchers studying the design of a technology recognize its dynamic and constructed nature and view it as a product of human action. On the other hand researchers investigating technology’s use and impacts are more likely to view technology as a fixed object, ignoring the ongoing process of physical and social construction (Orlikowski, 1992).

The time-space discontinuity between design and use of technology, which typically occurs at different organizations, is to blame for the conceptual dualism of technology dominating the IS literature (Orlikowski, 1992). However, the structuration model of technology posits that this disjuncture between design and use is artificial and assumes that technology is designed and used recursively where design and use stages are tightly coupled. In other words, technology is potentially modifiable through users’
ongoing interaction with it and, besides users’ engagement in the initial design and development of technology, users can redesign technology at any point in time by means of the different ways they interpret, appropriate, and manipulate it (Orlikowski, 1992).

Thus, understanding the technology-action relationship is critical in confronting structuration’s central paradox of why technologies with identical structures cause different outcomes that lead to different effects on organizations (Orlikowski, 1992; DeSanctis and Poole, 1994). Adaptive structuration theory extends Giddens’ structuration theory by considering the recursive relationship between technology and action, where technology social structures and the social structures that emerge in human actions iteratively shape each other.

Technology social structures include features and capabilities provided by the technology and the “spirit” or “the general intent with regard to values and goal” of those features (DeSanctis and Poole 1994, p.126). Other sources of social structures that enable and constraint the appropriation process of technology are the nature of the tasks performed using the technology such as task complexity and interdependence and the organizational setting such as hierarchy, corporate information, and cultural beliefs.

The two central processes in adaptive structuration theory are appropriations and structuration processes. Appropriations are “the immediate, visible actions that evidence deeper structuration processes” (DeSanctis and Poole 1994, p.128). Structuration is the process by which social structures within technology, tasks, organizational environment or their outputs are produced and reproduced in social life (i.e. their rules and resources
are brought into action) which causes new social structures to emerge. The use and reuse of existing and new emergent social structures lead over time to their acceptance and institutionalization; bringing organizational change (DeSanctis and Poole, 1994).

Outcomes and changes brought about by technology use are contingent on many factors such as the organizational environment, the “appropriation move” chosen by human agents, the faithfulness of their actions to the spirit and structural features of the technology, the reasons for bringing the technology or other structures into action, and their attitudes towards using the technology (DeSanctis and Poole, 1994).

Although adaptive structuration theory has been mainly applied to the study of group (decision) support systems (GDSS/GSS) and computer-mediated communications (CMC), it has established a legitimate link between mainstream IS research and social theories in general and structuration in particular (Jones and Karsten, 2008). Thus, it can be applied to investigate the social processes involved in appropriating any class of advanced information technologies in organizations.

**Markets as IT Artifacts: A Structuration Perspective**

As defined above, information markets are technology-enabled information systems. Thus, from a structuration perspective, an information market can be defined in terms of its social structures: spirit and feature set. An information market is a consensus making system that provides information about the degree of convergence in its users’ beliefs about the likelihood of uncertain future events. It seeks to measure, quantify and
consolidate its users’ beliefs, as manifested by their trading behavior, in form of probabilities (i.e. trading price constrained between 0-100).

![Figure 9: Infographic for Information Markets Consensus Making Mechanism on Design and Use of IT Artifacts](image)

Traders express their beliefs in form of market transactions (e.g. buying and selling). Each transaction has two quantifiable properties: strength and direction. Strength is the amount of money offered, and direction is positive for bids (the event is likely to occur), or negative for asks (the event is unlikely to occur) (Figure 9-A). As positive transactions get stronger, or demand increases, contract price increases signaling a higher
degree of convergence in market users’ beliefs about the likelihood of future events (Figure 9-B). Similarly, as negative transactions get stronger or supply increases, price decreases signaling a lower degree of convergence in market users’ beliefs about the likelihood of future events (Figure 9-C).

An information markets’ surrounding environment and the context in which it operates shape the market objectives and its statement of purpose, also known as the technology “spirit” (Figure 10). Organizations adopting the market should first and foremost create a mission statement and list of objectives for the market and accordingly develop instruments to measure market performance over time. Further, organizations should create an information sharing channel between market traders and executive management to share information about market performance, how its predictions are being used, and the benefits both gained and expected from its predictions. This will give the market a heightened sense of purpose and will consequently encourage market participation.

**Information Markets Design**

It is only after defining market objectives, setting forecasting goals, and formulating forecasting problems in form of questions that markets can be properly designed (Figure 10). The business environment imposes unique challenges on all aspects of information markets design; design of the market itself, design of market interfaces, and design of visualizations for market information. For example, markets designed for business forecasting might involve estimating sales figures for a range of different
products and, thus, the contracts used in those markets are more complex than those used in presidential election markets where outcomes are usually binary.

Further, interest in using markets to aggregate information dispersed among a group of people came out of the desperate need for a mechanism that eliminates judgment biases and other social and informational influences that are commonly present in a group setting (Sunstein, 2005) to generate an honest consensus (Hanson, 1992). Markets have an inherent advantage over traditional information aggregation and group consensus making methods by offering incentives for true revelation of beliefs; market participants put their money where their mouths are.

To utilize this valuable feature, an adopting organization must pay special attention to the design of the market’s incentive structure. Unlike markets designed for predicting issues of public interest such as election outcomes or sports events,
organizational markets are usually thin with a relatively small number of trades and require a well designed incentives structure to attract traders and to motivate active participation and information gathering especially when information relevant to the forecasted events is not readily available, or easy to find.

Other design elements of the market itself include: the trading mechanism, anonymity of traders, composition of initial traders portfolios, the use of real money or play money, duration of the market, trading hours, and whether participation is open or restricted to certain individuals. These design features of the market are shaped by the context of use and the market objectives. For example, gambling laws in certain states or countries might restrict the use of real money trading and depending on the questions asked in the market and the expected amount of participation, a trading mechanism that ensures liquidity (e.g. scoring rules) might be used instead of a one that does not (e.g. continuous double auction).

The business environment and market objectives shape the design of market interfaces and the various visualizations used for market information in addition to shaping the design of the market itself. Similar to other information and communication technologies, information markets design effectiveness depends on its ability to satisfy users’ needs and on users’ ability to appropriately use it. Thus, we propose that the design of information markets, market interfaces, and visualizations be driven by three factors (Shown in Table 7): (1) Market users –Who; (2) Use motivation –Why; and (3) Market information –What.
Table 7: Guiding Aspects for Design of Information Markets

<table>
<thead>
<tr>
<th>Market Aspect</th>
<th>Question to Ask</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market users</td>
<td><em>Who</em> is using the market?</td>
<td>Employees, customers, partners decision makers</td>
</tr>
<tr>
<td>Use motivation</td>
<td><em>Why</em> do users use the market? Focus on goals and motivations</td>
<td>Entertainment, profit, inform decision</td>
</tr>
<tr>
<td>Market information</td>
<td><em>What</em> information do users need to accomplish their goals/satisfy their needs?</td>
<td>Trading volume, price trends, pending offers</td>
</tr>
</tbody>
</table>
department/organization’s employees and external users are those who are not employed in the department/organization at which the market operates (e.g. customers, partners).

<table>
<thead>
<tr>
<th>Knowledge Level</th>
<th>Participation Level</th>
<th>Active</th>
<th>Passive</th>
<th>Active</th>
<th>Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informed</td>
<td></td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Uninformed</td>
<td></td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
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</table>

**Figure 11: A Framework for Information Market Users**

*Use Motivation*

Understanding what causes behavior and why that behavior varies in its intensity is the ultimate goal of motivation studies (Reeve, 2005). Although there are a wide variety of motivation theories, they generally focus on identifying sources of motivation and explaining their impacts on behavior (Reeve, 2005). According to affordance theory (Gibson, 1977), humans perception of the environment drives their behavior, as they perceive the properties of the objects surrounding them as “affordances” that indicate possibilities for action. Affordance theory has contributed to our understanding of human-computer interaction processes and of what constitutes a good design. For example, good design makes the range of possible actions, or ways of interaction (i.e. affordances), visible and readily perceivable (Norman, 1999).

Design theories inform design by emphasizing goals to be achieved and actions that might help achieve them (Malone, 1985). There are a number of theoretical
perspectives for designing organizational interfaces, such as information processing, economic, political and motivational perspectives (Malone, 1985). Utilizing affordance theory of human perception as well as motivational theories of human behavior to understand technology use behavior, allows us to develop motivational design principles and eventually theories to guide the design of high “motivational affordance” technologies (Zhang, 2008a).

Information markets with high motivational affordances fulfill the motivational needs of market users. Each group of users in the framework proposed above (Figure 11) has its distinct motivational needs and goals that require different designs, information, or information visualizations to be fulfilled. Informed active users (Groups 1 and 5) are motivated by either extrinsic rewards such as money or prizes or by intrinsic rewards such as recognition. Uninformed active traders (Groups 2 and 6) are risk loving individuals who are mainly motivated by the thrill of the game and the entertaining aspects of betting on the future.

In case of active users, market designs should continually meet users’ expectations and fulfill their informational needs to at least sustain their activity level. However, the real design challenge comes in case of passive market users; because organizational information markets are usually thin and might suffer from illiquidity issues due to low activity levels. Thus, markets should be properly designed to turn passive users into active ones, attract as many traders as possible, and increase users’ involvement and participation level. Special attention must be given to three types of
passive user as each type has different informational needs and can be influenced, targeted, or attracted by different aspects of market design:

I. Internal and external informed users (Groups 3 and 7).

II. Internal and external uninformed users (Groups 4 and 8).

III. Internal informed and uninformed decision makers (Groups 3 and 4).

Type I users are interested market readers who do not participate in market trading mainly because they are risk-averse. Type I users are valuable because they hold information that can improve the accuracy of market forecasts and generate significant trading activity. They can be attracted by offering an anonymous trading option, a well designed incentive structure that, for example, allows them to cash out of the market at any point in time or by using play money instead of real money.

Type II users are also risk-averse market readers who feel they do not have enough information to trade and read the market out of curiosity. Type II users are vital for information markets to work due to their role in executing informed trades. Since type II users are likely to be motivated by non-economic factors, finding ways to attract them is still an open question in the information markets literature (Wolfers and Zitzewitz, 2006).

We propose a design-based solution to generate sufficient uninformed trades. Market designs should be intuitive, simple, and easy to use to attract uninformed trades. They should also be attractive to induce positive emotions that affect users’ desire to use
the system (Norman, 2004) and, importantly, they should be perceived as fun, entertaining, and to some degree “safe”. Using play money instead of real money may decrease perceived riskiness of market trading and give it a fun game-like feeling.

Malone (1982) argued that for interfaces to be enjoyable, they should provide performance feedback to users, be emotionally appealing, and capitalize on users’ desire to have a well informed knowledge structure.

Thus, enjoyable market interfaces should keep track of users’ gains and losses and display relative and historical performance evaluation to traders. It should introduce new information when users feel their information is incomplete or inconsistent (Malone, 1982) by displaying updates, announcements, or links to potential sources of information, such as meeting minutes and the department bulletin board. Motivating market interfaces also support social and psychological needs for relatedness (Zhang, 2008b) by providing the ability to communicate with other market traders through market chat rooms or market blogs.

Type III users’ knowledge level in the issues is irrelevant to market trading, as designers do not seek to turn them into active users. Type III users are decision makers who use the market for the sole purpose of informing their decisions and, thus, the designers’ goal is to identify ways of making the market information more useful to managers. Decision makers’ focus is on the intelligence stored in the market and the collective intelligence produced by the market; how to turn it into business intelligence that gives their organization a competitive edge in the industry. Due to decision makers’
capacity in making intelligence actionable, special attention must be paid to the informational needs of decision makers to create managerial dashboards that provide them with greater control and visibility of what is going on in the market and allow them to act in a timely manner.

**Market Information**

There are an infinite number of ways of processing, aggregating, manipulating, and visualizing market information. Thus, there are an infinite number of ways of designing market interfaces. Although the design of markets, markets interfaces, and information visualizations can be guided by various theoretical perspectives, the optimal set of information or information visualization to display on a market interface can only be identified through the accumulation of empirical evidence.

The main piece of information needed by market users is the price of the last traded contract in the outcome being forecasted. The last trade price represents the degree of convergence in users’ beliefs about the likelihood of the outcome. It can also be interpreted as the outcome’s probability of occurrence (Wolfers and Zitzewitz, 2004). Other price related information that can be useful to market users include: historical price trends, contract prices offered by other market traders, and the average, max, and min prices over a specified trading period.

It is important to note, however, that price, and price-related information are noisy signals that might not aggregate and transfer all the available information in the market (Grossman and Stiglitz 1976; Noeth, Camerer, Plott, and Webber, 1999; Plott, 2000),
may suffer manipulation (Hansen, Schmidt and Strobel, 2004; Hanson, Oprea and Porter, 2006; Rhode and Strumpf, 2006) and bubbles (Plott, 2000), and, thus might not, at some points in time, be an accurate representation of traders beliefs.

Therefore, it is important to supplement prices with other non-price information, such as volume weighted price average and trading volume both in terms of money and number of shares, when making judgments about market conditions. Further, it is important to monitor the amount of trading activity regardless of the trading volume in a particular event because it signals the release of updates about its status and gives traders as well as decision makers an indication about the event’s importance and degree of controversiality.

Aside from trading information, announcing winners’ names in each trading round provides timely and positive feedback that satisfies traders’ cognitive motivational needs for competition, competence, achievement, and recognition (Malone 1985; Zhang, 2008b). This also motivates other traders to gather information and engage in future trading. To satisfy social and psychological needs for relatedness and cooperation, market designs should facilitate human-human interaction (Malone 1985; Zhang, 2008b) by allowing traders to post comments and chat with other traders in the market.

As for decision makers, additional market information can be utilized to allow for greater visibility of market activity. In an attempt to identify ways of making market information more useful to managers, Yassin (2009) proposed a novel decision heuristic for traders’ beliefs about the likelihood of forecasted events that utilizes pending
transactions in the market. Pending transactions are valuable because they contain information that is not yet incorporated into market forecasts.

The goal of forecasts is to enable managers to see ahead and take appropriate actions in advance. However, the accuracy of market forecasts cannot be judged until the market closing date or until the outcomes can be determined with certainty. Information that supplements market forecasts is important because it improves the quality of input to the decision process and allows managers to act in a timely manner.

A managerial dashboard on the market allows managers to filter trading volume by departments or user group and to create traders’ profiles and rank traders according to their activity level, money invested, historical performance, and other available data. Managers can use this capability to identify influential trades and information sources; thus, judging their credibility.

**Information Market Use**

An information market is embedded in conditions of its use and that, in turn, is embedded in an organizational environment. There is a recursive relationship between market design and use, between use and the market context of use, and between use and the market intended objectives (Figure 10), each shaping the other iteratively until new physical and social structures emerge. In other words, markets are designed purposefully according to a list of objectives which are created based on an analysis of users’ needs. Markets are designed with a set of intended uses in mind. Use is shaped by current
organizational practices, communication channels, and hierarchy of control existing in the market’s context of use.

However, continued use of the market can uncover unattended needs and create new ones causing new technological features to be added to the market, thus, altering the design of the market interfaces and the information visualizations used. Continued use can also generate a wave of redistribution of power in adopting organizations where market participants at all levels in the organizational hierarchy contribute to the decision making process and, consequently, influence the decisions being made.

Further, continued use can alter formal and informal reporting mechanism in the organization, create new communication channels, empower informal leaders, and form informal information generating and sharing groups of market participants. These factors may cause new social structures to emerge which over time become institutionalized structural properties of the organization. Also, market users might appropriate the market in unconventional ways through their different interpretations of market objectives and the different meanings they assign to it; creating unintended uses for the market which over time can become parts of the market objectives.

**Structuration Model of Technology-Induced Organization Development**

The dynamic interactions between organizations, market participants, and the market, as well as among participants themselves will keep redefining the market design objectives in a continuous cycle of define-design-use. Existing structures are used and reused causing new structures to emerge and these in turn will be used and reused until
change becomes an organizational habitual routine and the ability to adapt to change, or organizational changeability, becomes the only objectified and institutionalized organizational structural property (Figure 12).

![Figure 12: Structuration Model of Technology-Induced Organization Development](image)

The structuration model of technology-induced organization development (Figure 12) extends the two IS versions of Giddens’ structuration theory: adaptive structuration theory (AST) (DeSanctis and Poole, 1994) and the structuration model of technology (Orlikowski, 1992) by moving beyond the traditional structuration process via a recursive relationship between technology and action. This model defines the relationship between technology and organizations to consider technology as a catalyst for organization change and development and the structuration cycle as a continuous change process that objectifies changeability as an organizational permanent structure that leads to the ultimate goal of the structuration process of IT artifacts: organization development (OD).
The structuration model of technology-induced organization development (Figure 12) posits that:

1. Effective structuration process of IT artifacts in organizations does not produce permanent structures.
2. Existing and emerging physical and social structures involved in the structuration process of IT artifacts (including the technology “spirit” or objectives) are temporary and potentially modifiable.
3. Effective structuration process of IT artifacts in organizations produces habitual routines.
4. Nurtured technology-induced habitual routines become over time reified and institutionalized organization structures.
5. Reified organization structures lead to permanent structuration outcomes.
6. The ultimate goal of the structuration process of IT artifacts in organizations is organization development.
7. Technology-induced change should be nurtured as a habitual routine by organizations seeking development and growth.
8. Nurtured habit of change causes organizational changeability to become institutionalized organization structure.
9. Changeability leads to long lasting and continuous organizational development and growth.
Organization development is defined as “an effort, planned, organization-wide, and managed from the top, to increase organization effectiveness and health through planned interventions in the organization's processes, using behavioral-science knowledge” (Beckhard 1969, p.9). Action research is used to carry out these behavioral interventions (French and Bell, 1990) through a cyclical change process of planning, action, and fact-finding (Lewin, 1946).

Action research cycles of behavioral intervention and evaluation has moved traditional behavioral-science research from being reactive with respect to technology to being a proactive problem solving paradigm where IT artifacts, such as information markets, can be adopted and used as interventions to improve organization effectiveness and efficiency. However, it is important to note that although the decision to adopt and use an IT artifact as a solution is a behavioral intervention, the subsequent group of decisions regarding the technology’s design, which features to use, and even the choice of which technology to adopt, is a design-science intervention.

**Design as a Group of Decisions**

Organizations faced with a problem can develop in-house solutions, buy custom made solutions developed by other organizations, or buy commercial-off-the-shelf (COTS) IT artifacts. The effectiveness of the structuration process of IT artifacts (define-design-use) depends in some part on how much influence the users have over the technology’s design. Orlikowski (1992) argued that even if a technology was not developed in-house, users can still exercise influence over technology’s design by means
of the different ways they interpret, appropriate, and manipulate it. We extend
Orlikowski’s argument by proposing that users can exercise influence over technology’s
design even before they have any interaction with it.

Conceptualizing design as a group of decisions and the design process as a
decision making process diminishes “the time-space discontinuity” between design and
use of IT artifacts in the sense that users can still choose among alternative solutions
available in the market and between various configurations and settings provided by each
solution. For example, organizations seeking to improve their sales forecasts can choose
from a variety of information market solutions available in the marketplace without
having to develop one in-house and yet retain a sufficient amount of control over their
design to ensure an effective structuration process.

Some market platforms allow users full control over their design by providing
them the option to choose from a range of trading mechanisms, contract types, incentive
structures, anonymity levels, trading hours, and many other market design features. Each
group of settings constitutes a unique IT artifact design that can be evaluated using
common design-science evaluation methods and the impacts of existing structures, such
organization policies and culture, on the decision making process can be analyzed as a
surrogate for the analysis of the design and development processes for in-house
developed solutions.

The structuration process of IT artifacts (Figure 12) combines both design science
design-evaluate loops with proactive behavioral science adopt/use–evaluate loops to
create an occasion for an ongoing process of organization change and development. The traditional views on the structuration process of technology acknowledge the change caused by the technology-action relationship and its interaction with organizations (DeSanctis and Poole, 1994). However, this change is not planned but rather a natural result of situated practice and unless managed its effects on people, groups, and organizations are random and may or may not lead to organization development.

The change resulting from the structuration process of IT artifacts (Figure 12) is planned in the sense that technology is designed or adopted as an intervention to induce change. However, the structuration process itself takes its own path and progresses in unplanned manner. For example, we do not instruct people how to appropriate the technology. But we do manage the process by first encouraging users to explore and experiment with the different ways of using the technology; second, by designing or choosing to adopt IT artifacts that are malleable and can be redesigned or modified as needed; and third, by creating flexible organizations rules and policies that give some degree of freedom to technology users to experiment allowing for change to eventually take place. It is important to note though that change is not the aspired for outcome but rather the planned continuous change that leads to organization development.

Conclusions and Future Directions

Conceptualizing information markets as an IT artifact using a structuration lens and placing it in a business environment as a system within a bigger system is an important first step towards building information systems theories about organizational
information markets to describe, explain, and predict their behavior and impacts on organizations. Attaining a better understanding of the design, implementation, and use processes of information markets in organizations is vital to devise design, implementation, and use guidelines and procedures that promote an effective structuration process that leads to organization development.

Future research should investigate the structuration and appropriation processes of information markets in organizations where markets are used as an intervention to induce organizational change and development. Future research should also characterize the decision making and cognitive processes involved in analyzing/using market information from both the trader and the decision maker perspectives, to design effective market interfaces that meet users’ motivational and informational needs.

Evaluations of market design’s usefulness and efficacy in satisfying users’ needs by cognitive walkthroughs, focus groups, surveys, or experiments will provide valuable feedback into the design and will add to our knowledge base by providing a better understanding of the design and use processes of markets inside the organization. It will also improve our understanding of the decision making and cognitive processes of various market users when analyzing market information.

The design of information markets, market interfaces, and information visualization should fit the task at hand to accomplish market objectives. However, fit is moderated by traders and organizational factors. The accumulation of empirical evidence will provide guidance on how to design highly motivating information markets that
satisfy users’ needs and will suggest the optimal feature set that best fits the problem at hand in order to result in desirable outcomes.
Chapter Four
Information Markets for Software Projects Risk Management

Introduction

Software projects are characterized by high failure rates. In 2006, 19 percent of initiated software projects in the US were outright failures; canceled before completion or not deployed. 46 percent of projects failed to meet user requirements, had cost overruns, or were not delivered according to schedule (Rubinstein, 2007). In 2007, an independent market research firm surveyed 800 IT managers across eight countries. The results demonstrated that failure rates are universal; 62 percent of IT projects failed to meet their schedules, 49 percent exceeded their budget, and 41 percent failed to deliver the expected business value and return on investment (Dynamic Markets Limited, 2007).

One dominant reason leading to software project failures is management’s inability to manage the risks in the early stages of the software development process (Boehm, 1991). Software project risk is an uncertain event that may have negative effects on the processes and/or outcomes of software projects, such as software quality, scope, costs and schedule (Project Management Institute, 2004). In order to guard against or mitigate the negative effects of the various risks facing software projects, management must first identify relevant risk factors, assess their likelihood of occurrence, and their potential impacts on project objectives (Boehm, 1991). A risk matrix can then be
constructed that assigns a risk score to each factor; which is the product of its likelihood and impact (Charette, 1989).

Several approaches for assessing risk factors’ probabilities and impacts on project objectives have been proposed, such as brainstorming, interviewing, the Delphi method, and scenario analysis (Project Management Institute, 2004). However, these methods require expert participation and are time and resource intensive. In addition, getting objective and accurate estimation of risk probability and impact at the beginning of software development projects is very difficult. Thus, recent research has proposed using fuzzy logic and software metrics to assess risks (Liu, Kane and Bambroo, 2006). Although software metrics, such as requirement volatility and cyclomatic complexity, can lead to more objective assessment of risks, they are difficult to measure and expensive to collect and update periodically particularly in small organizations with limited resources.

Checklist analysis is another popular method for identifying risk factors that has received much attention in the literature due to its simplicity and low cost relative to other methods (Iversen, Mathiassen and Nielsen, 2004). Checklist analysis relies on historical data and knowledge of similar projects to create a list of potential risks and their likelihood of occurrence. Several lists of risk factors have been published in the software project management literature (Bohem and Ross, 1989; Barki, Rivard, and Talbot, 1993; Keil, Cule, Lyytinen, and Schmidt, 1998; Moynihan, 1996; Ropponen and Lyytinen, 2000). Other approaches such as risk-action list (Alter and Ginzberg, 1978;
Bohem, 1991; Jones, 1994), risk portfolio model (McFarlan, 1981), and requirements risk analysis (Davis, 1982) have also been popular among software development managers.

Each approach has its limitations (Lyytinen, Mathiassen and Ropponen, 1998; Moynihan, 1997) and thus hybrid methods have been proposed to provide a more comprehensive, context-sensitive risk management approach (Lyytinen et al., 1998). However, it is important to note that although current risk management approaches can be useful in identifying and prioritizing risks, assessing risks’ probabilities and impacts, as well as in suggesting mitigation strategies, none of them addresses the fundamental problem behind software projects failure; communication.

Further, the initial risk assessments provided by current approaches are ineffective in reducing software project chances of failure unless there are methods that continuously provide complete, current, and accurate information about the status of project objectives as events unfold. Otherwise managers are left with unrealistic, dated assessments of project risks, and as a result fail to take appropriate actions to mitigate them.

Many large scale software disasters have been attributed to inaccurate status reporting, such as the case of the CONFIRM project (Oz, 1994). Reluctance to transmit bad news (Kiel, Smith, Pawlowski and Jin, 2004), status misperception, deliberate misrepresentation by software developers and project managers (Snow and Keil, 2002), and escalation of commitment; where resources are continued to be expended on software projects destined for failure (Keil, 1995), are some of the reasons that lead to inaccurate status reports, and consequently, inaccurate assessments of risks and eventually project
failure. These issues call for creative approaches to improve communication of project status information in order that senior management can terminate failing projects, salvage or redirect valuable resources in a timely manner.

This chapter introduces information markets to the software project management domain as an approach to risk management. Markets may prove to be invaluable in minimizing software projects chances of failure. By aggregating status information from all levels of the organization and providing early warning signals about risks, markets can assume the difficult task of “blowing the whistle” on challenged projects. We draw on the design science research paradigm (Hevner et al., 2004) to design an experimental information market solution for software project risk assessment. We evaluate the market’s efficacy in solving the identified problems using two controlled experiments.

This chapter is organized as follows: section two reviews the literature on software project risk assessment and discusses the challenges faced by software project managers that justify the need for the proposed information market approach. We then propose a theoretical framework along with propositions for the determinants of software project risks assessment accuracy.

Section three introduces the research approach and research questions. Section four focuses on artifact design and addresses the first two research questions by proposing an information market solution and research hypotheses about its expected utility for software projects risk assessment. Section five describes two controlled experiments that used a role-playing scenario to evaluate the proposed information
market design and answer the design evaluation research questions. Section six describes data analysis, scale validation and results. A discussion of the findings and their implications for theory and practice are described next. This chapter ends with conclusions and future directions.

**Challenges to Software Projects Risk Assessment**

The dynamic nature of the software industry and the high volatility of software project requirements add complexity to the inherently complex task of risk assessment. The intangible nature of software and the lack of visible signs of progress make it hard for management to ascertain true project status or to uncover problems until the project is well over budget or has passed schedule deadlines (Zmud, 1980; Abdel-Hamid and Madnick, 1991).

Further, traditional project management and control techniques for acquiring status information to assess project risks, such as meetings, surveys and status reports, have been proven to be ineffective at revealing risks. Abdel-Hamid, Sengupta and Ronan (1993) showed that project managers tend to anchor on initial perceptions of status that affects their decisions to re-adjust project plans down the road, even when the situation requires readjustment. Also, Snow and Keil (2002) showed that software project managers make significant errors in assessing status and may not faithfully report their true beliefs causing reported status to be very different from reality.
In many organizations valuable information that could potentially save millions of dollars is distributed at lower levels of the hierarchy and oftentimes fails to be communicated to project sponsors who have the power to change the direction of the project (Keil and Roby, 1999). Employees’ reluctance to “blow the whistle” is impacted by their sense of personal responsibility to report the bad news which is influenced by their perception of whether bad news ought to be reported or not (Dozier and Miceli, 1985).

Additional factors that were proven to impact employees’ willingness to report true status information are organizational climate and information asymmetry (Keil et al., 2004). Unhealthy organizational climate can produce the so-called “mum effect” where employees refrain from reporting unpleasant information to management because they fear penalties of various sorts. Research has shown that in organizations where there is reluctance to either reporting and/or hearing negative information, silence will prevail even when an employee is an auditor or assumes a formal role of reporting problems (Keil and Robey, 2001).

Organizational culture that does not encourage open communication creates an incentive to shirk issues and reduces employees’ sense of responsibility to report bad news because the interests of employees are no longer aligned with the interests of the organization (Keil et al., 2004). Similarly, when perceived information asymmetry between management and employees is high and where individuals think that negative information can be hidden from management, they will be less likely to perceive negative
information as ought to be reported and eventually their reluctance to report it will increase (Keil et al., 2004).

The central whistle blowing decision model (Dozier and Miceli, 1985; Smith, Keil and Depledge, 2001) assumes that reporting an observed organizational wrongdoing is a choice that is left to an individual judgment and depends on whether or not s/he perceives the wrongdoing as ought to be reported and so assumes the responsibility for reporting it. However, in software development projects, as in many organizations, reporting project status information is an obligation not a choice. And is generally part of employees’ job responsibilities and formal role in the organization.

In organizations where all information ought to be reported and each employee is personally responsible for reporting what s/he knows, factors that directly impact individuals reluctance to report bad news become of central focus. Further, there are many other problems that lead to ineffective communication of project status information other than reluctance to report bad news, such as status misperception, individual biases, deliberate misrepresentation, reporting incomplete or dated status information, and organizational silence (Park and Keil, 2009). These problems contribute to inadequate assessment of software project risks that causes escalation of commitment to a failing course of action, also known as project “runaways”, costing organizations hundreds of billions of dollars every year.

Thus, organizations are in desperate need for information gathering and sharing mechanisms that adjust for subjectivity in individual judgment, cancel individual biases
out, offer incentives for faithful revelation of status information, and are capable of rapidly moving project status information from those who have it to those who need it to assess risks and make decisions.

**Research Framework and Research Questions**

The project status report is a key element in the software project risk assessment process. Current studies have focused on the accuracy of reported status information and bad news reporting in the context of IT projects (Snow and Keil, 2001; Keil et al., 2004). However, accuracy is only one attribute of project status information. Little research attention has been given to factors that impact other attributes of information, and consequently the accuracy of risk assessment. For example, accurate information can be incomplete and does not reflect the whole picture, or not up-to-date and does not incorporate the latest development progress updates or problems.

Thus, we propose a theoretical framework to explain the variance in accuracy of software projects risk assessment (Figure 13). We incorporate the factors identified in the literature that are proven to impact the accuracy of reported status in the proposed model. Table 8 summarizes the model propositions. There are three main factors that determine the accuracy of risk assessment: (1) currency of reported status information, (2) completeness of reported status information, and (3) accuracy of reported status information.
Figure 13: Theoretical Framework for the Determinants of Software Projects Risk Assessment Accuracy

Table 8: Theoretical Framework Propositions

<table>
<thead>
<tr>
<th>Propositions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P1:</strong> More current status information leads to higher accuracy of risk assessment</td>
</tr>
<tr>
<td><strong>P2:</strong> Higher accuracy of status information leads to higher accuracy of risk assessment</td>
</tr>
<tr>
<td><strong>P3:</strong> More complete status information leads to higher accuracy of risk assessment</td>
</tr>
<tr>
<td><strong>P4:</strong> Higher individual willingness to report bad news leads to higher accuracy of status information</td>
</tr>
<tr>
<td><strong>P5:</strong> Lower individual errors of perception of project status leads to higher accuracy of status information</td>
</tr>
</tbody>
</table>

As currency, accuracy, and completeness of reported status information increases, the accuracy of risk assessment will also increase. The accuracy of status information depends on (1) individuals’ willingness to report negative status information or “bad news” and is positively correlated with it, and (2) individuals’ errors of perception of true project status and is negatively correlated with it (Snow and Keil, 2001; Keil and Robey, 2001; Kiel et al., 2004).
Based on the proposed framework (Figure 13) the greatest improvement in software risk management will come from tools that increase the accuracy of risk assessment by improving the currency, accuracy, and completeness of reported status information. Information accuracy can be improved by adjusting for individual errors in perception of the project true status due to having access to only partial knowledge about the project and by increasing individuals’ willingness to report negative status information.

Existing tools for identifying and assessing risks are only effective in reducing software projects’ chances of failure if they are supplemented with a mechanism that (1) efficiently collects and combines information from around the organization to provide complete assessment about the status of different project objectives, such as scope, quality, cost and schedule, (2) responds to unfolding events by rapidly incorporating new information into the assessment to provide current and up-to-date assessment of risks, (3) adjusts for individual errors in perception of project status and risk assessment, and (4) motivates those who are involved in the project or have access to information about its progress to faithfully report status information.

The design science paradigm (Hevner et al., 2004) is concerned with the design and evaluation of technological solutions, or IT artifacts, to fulfill an identified business need. Thus, we are utilizing the design science research paradigm to design an experimental Web-based information aggregation mechanism, known as an information market, to aid organizations and project managers in assessing software project risks.
Market design is informed by existing theories, methodologies, and empirical evidence in the information market and software project management literatures. The proposed market design and its expected utility in the area of software project risk assessment are evaluated using controlled experiments. Experimental results can be used to refine market design and will contribute back to our knowledge base.

**Figure 14**: Design Science Approach for Designing and Evaluating an Information Market Solution for Software Project Risk Assessment

Following the design science research guidelines proposed by Hevner et al. (2004), and our proposed research approach (discussed in chapter 2) for designing and evaluating IT artifacts developed to fulfill an identified business need, our research questions are organized into two sets: IT artifact design and IT artifact design evaluation.
IT artifact design research questions are:

**RQ1** - What is the design of an information market solution for software projects risk assessment?

**RQ2** - What is the expected utility of the designed information market for software projects risk assessment?

IT artifact design evaluation research questions are:

**RQ3** - What is the efficacy of an information market in providing hypothesized utility for software projects risk assessment?

**Information Markets Design**

An information market is a form of futures markets where individuals trade contracts whose payoff depends on the outcomes of uncertain future event. According to rational expectations theory (Muth, 1961), individuals take all available information into account in forming expectations about future events. In strongly efficient markets (Fama, 1970) prices of traded assets reflect all available information about future prospects of the asset. Since prospects are analogous to events, prices in efficient information markets reflect all available information about the likelihood of the events.

Information markets utilize market efficiency and the information aggregation property of prices (Hayek, 1945) to harness the collective knowledge of participants about the likelihood of future events. Although information markets differ in many
respects, such as trading mechanism, payoff function, composition of initial portfolio, and incentive structure, they generally consist of one or more events for which you would like a reliable forecast.

The standard contract in the market is the binary contract, aka winner-take-all. It costs a certain amount and pays off, for instance, $1 if and only if the event occurs and nothing otherwise. Traders buy and sell contracts of future events based on their beliefs in the events likelihood of occurrence. The higher the likelihood of the event the higher its contract price and vice versa. The result is a trading price that tracks the consensus opinion (Hanson, 1992) and can be interpreted as market-aggregated forecast of the event probability (Wolfers and Zitzewitz, 2004). For example, if a contract price is selling for $60 that means there is a 60% chance of the event happening.

In addition to forecasting events probability, the type of contract used in the market and its payoff function can elicit the collective expectations of a range of different parameters such as the mean or median value of an outcome (Wolfers and Zitzewitz, 2004). For example, the price of index contract with payoff proportionate to the outcome represents the market mean expectation of the outcome and the price of a spread contract with even money bet represents the market’s median expectation of the outcome.

Experimental research on information aggregation suggest that markets can aggregate and disseminate information fairly well (Forsythe and Lundholm, 1990; Plott and Sunder, 1988) and many successful implementations of information markets demonstrate their ability to aggregate information and generate reasonably accurate
forecasts about a wide variety of events, such as presidential election outcomes (Forsythe, Nelson, Neumann, and Wright, 1992), project delivery dates (Ortner, 1997, 1998), product sales (Chen and Plott, 2002; Hopman, 2007), and movie box office returns (Spann and Skiera, 2003).

We propose a Web-based information market solution to help organizations in assessing risks facing software development projects. Table 9 summarizes the major design decisions that organizations must consider before implementing an information market.

<table>
<thead>
<tr>
<th>Design Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market forecasting goal</td>
</tr>
<tr>
<td>Contract payoff function</td>
</tr>
<tr>
<td>Trader composition of initial</td>
</tr>
<tr>
<td>portfollos/endowment</td>
</tr>
<tr>
<td>Incentive mechanism</td>
</tr>
<tr>
<td>Trading mechanism</td>
</tr>
<tr>
<td>Trading anonymity</td>
</tr>
<tr>
<td>Trading synchronicity</td>
</tr>
<tr>
<td>Trading duration</td>
</tr>
</tbody>
</table>

Following a design science research approach, market design is refined iteratively based on evaluation results. So organizations can experiment with various design configurations, such as implementing different incentive structures, payoff functions, and trading durations, until a design that suits their needs and provides the expected utility is achieved.
In the project management literature, project failure has generally been associated with not meeting four main objectives; cost, time, quality and scope (Atkinson, 1999; Lyytinen and Hirschheim, 1987; Project Management Institute, 2004; Shenhar, Levy and Dvir, 1997). Consequently, any factor that causes the project to go over one or more of its planned objectives is a risk that should be mitigated. The higher the number of unmet objectives, the higher the project overall riskiness level and its chances of failure. Information markets can be used to monitor the status of the software projects main objectives and the overall riskiness level of the project.

The questions asked in the market are directly related to its forecasting goal and are designed to reveal the true status of the project, or in other words, its riskiness level. An information market for each project objective can be launched to predict how likely each objective is to go over its planned limit, and another information market can be used to predict the riskiness level of the project or how likely it is that one or more of its objectives are currently unmet. The more unmet objectives the higher the riskiness level of the project. Questions asked in the markets take into account the impact definition of risks on major project objectives and seek to assess the collective forecast of the likelihood of these risks. Figure 15 provides some examples of risk impact definitions on cost, time, scope and quality objectives.

Organizations can choose to keep track of only high or medium impact risks on the four main project objectives. For example, an information market designed to monitor high impact risks on the status of a project cost objective will predict the likelihood of 20-
40% cost increase. Another market designed to monitor medium impact risks on the status of the time objective will predict the likelihood of 5-10% time increase. Same applies to scope and quality objectives.

<table>
<thead>
<tr>
<th>Project Objective</th>
<th>Very low (0.05)</th>
<th>Low (0.10)</th>
<th>Medium (0.20)</th>
<th>High (0.40)</th>
<th>Very High (0.80)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>Insignificant cost increase</td>
<td>&lt; 10% cost increase</td>
<td>10-20% cost increase</td>
<td>20-40% cost increase</td>
<td>&gt;40% cost increase</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>Insignificant time increase</td>
<td>&lt;5% time increase</td>
<td>5-10% time increase</td>
<td>10-20% time increase</td>
<td>&gt;20% time increase</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Scope decrease barely noticeable</td>
<td>Minor areas of scope affected</td>
<td>Major areas of scope affected</td>
<td>Scope reduction unacceptable to sponsor</td>
<td>Project end item is effectively useless</td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td>Quality degradation barely noticeable</td>
<td>Only very demanding applications are affected</td>
<td>Quality reduction requires sponsor approval</td>
<td>Quality reduction unacceptable to sponsor</td>
<td>Project end item is effectively useless</td>
</tr>
</tbody>
</table>

Figure 15: Definition of Impact Scales for Four Project Objectives (from PMBOK® Guide)

Market generated probabilities of high or medium impact risks on different project objectives can then be used to assess the status of objectives using a risk matrix setup with risk impact definitions numeric scales (Figure 16). Risk definitions and interpretations can vary from one organization or project to the other. For example, if the market generated probability of a high impact risk (0.40) (such as having 20% cost increase) reaches 50%, the cost objective is considered unmet and warrants immediate managerial attention.
The forecasting goal of the proposed experimental information market (Table 10) is the project riskiness level. The status of the project main objectives can be used to make an assessment of the project overall riskiness level using a simple status reporting approach similar to the “traffic light reporting” scale (Coulter, 1990; Snow and Keil, 2001). For example, if all four main project objectives are currently met, the project is considered low risk or “green”. And if only two or three objectives are met to date, the project is considered medium risk or “yellow”, and if only one or none of the objectives is currently met, the project is considered high risk or “red”.

Thus, there are three possible outcomes to the question asked in the market (High Risk, Medium Risk and Low Risk). The market implements winner takes all payoff function. So after the market closing date, market prices can be interpreted as outcomes probabilities, and when the project true status can be determined with certainty, each contract bought in the actual outcomes will pay off a $100 virtual dollar and all others will pay off nothing.
The traders’ initial portfolios consist of no shares in any of the outcomes and a sufficiently large amount of virtual money to guarantee liquidity and sustain trading activity as events unfold. Contracts are cashed out when the market closes, and incentives will be distributed depending on traders’ net worth after subtracting the initial endowment.

The trading mechanism used in the proposed market design is automated market maker (AMM). Automated market maker has several advantages over its widely used counterpart; continuous double auction (CDA) that makes it particularly suitable to use in organizational markets. Markets used in organizations tend to be thin with a relatively small number of traders which can cause liquidity problems that negatively impact market forecasts. Unlike CDA, AMM guarantees liquidity because it does not require matching sellers to buyers but instead it let traders buy and sell contracts directly from the market, and as a result, transfer some of the financial risk to the market institution.

Web-based implementations of information markets are not restricted by location or time and thus allow for both synchronous and asynchronous trading. Asynchronous trading can be particularly useful for organizations because employees, developers, customers and other project stakeholders can participate in trading or have access to the market from anywhere and at anytime. Synchronous trading via the web in multiple sessions is chosen because design evaluation experiments are conducted in a controlled environment where experimental task requires all subjects to be in the same place at the same time to facilitate training and distribution of information. Further, synchronous
trading in a controlled environment allows us to simulate real events at a more expedited pace than what a field study would allow and yet be able to achieve the same desired effects.

**Table 10: Experimental Information Market Design for Software Project Risk Assessment**

<table>
<thead>
<tr>
<th>Design Aspect</th>
<th>Selected Experimental Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasting goals</td>
<td>Project riskiness level (Low, Medium or High)</td>
</tr>
<tr>
<td>Payoff function</td>
<td>Winner takes all ($100 if true, $0 if not)</td>
</tr>
<tr>
<td>Composition of initial portfolios/endowment</td>
<td>No shares; $10,000 virtual money</td>
</tr>
<tr>
<td>Incentive mechanism</td>
<td>Reward highest (Net worth - $10,000)</td>
</tr>
<tr>
<td>Trading mechanism</td>
<td>Automated market maker</td>
</tr>
<tr>
<td>Trading anonymity</td>
<td>Anonymous</td>
</tr>
<tr>
<td>Trading synchronicity</td>
<td>Synchronous</td>
</tr>
<tr>
<td>Trading duration</td>
<td>8 rounds 3 minutes each</td>
</tr>
</tbody>
</table>

**Information Markets Expected Utility**

The second IT artifact design research question focuses on the expected utility of the proposed information market solution for software projects risk assessment. Since project status information is the main input used by project sponsors to assess risks facing software projects, an information market is expected to provide utility by improving the currency, accuracy, and completeness of reported status information that will in turn increase the accuracy of project risk assessment.

The proposed information market is expected to improve the completeness of status information by aggregating information about project objectives from all individuals involved in the project or who have information or even intuition about
project progress, regardless of their formal role or level at the organizational hierarchy. Information markets disseminate gathered information in form of prices that can be interpreted as a status report or collective assessment of project risks. Thus, in a properly designed information market, price or market-generated risk assessment should be equal to the reported status or assessment of a hypothetical person who has access to all project information.

**H1:** An information market’s reported assessment of project risks will approximate the reported assessment of a single person in possession of all the information.

The information aggregation property of market prices provides a cost-effective alternative to existing methods of information gathering such as surveys, periodic status reports and meetings. Further, information markets are dynamic and responsive to changing circumstances. Prices in information markets prove to incorporate new information almost instantly (Forsythe et al., 1992) and, therefore, can improve the currency of aggregated status information and provide continuous and up-to-date assessment of risks. Thus, information market price is expected to quickly move up or down in response to new information and so provide up-to-date assessment of risks.

Individuals often misperceive the true status of the project due to having partial information about its progress which biases their assessments of risks. The process of price formation and discovery provides a solution to the complex task of aggregating individual assessments of risks. Trading dynamics in a market setting cancel individual
biases and errors out, preventing them from impacting predictions (Forsythe et al., 1992; Forsythe, Rietz, and Ross, 1999; Oliven and Rietz, 2004) and therefore can improve the accuracy of aggregated status information.

**H2: An information market’s reported assessment of project risks will be more accurate than any individual reported assessment of project risk**

Thus, in an organization where disparate project status information is dispersed among many people, a well-designed information market can collect this information bringing about, in form of prices, a complete and up to date collective assessment of project risks purified from individual biases and errors.

However, prior research has identified several factors that impact the accuracy of reported status information, such as deliberate misrepresentation of status information (Snow and Keil, 2002). Although a well designed aggregation mechanism, such as an information market, can adjust for individual errors caused by inaccurate perceptions of project progress, accounting for information misrepresentation, or individuals reluctance to report accurate information remains a challenging task.

In the context of IT projects, research adopting the whistle blowing theoretical perspective (Dozier and Miceli, 1985) has identified situational, organizational and personal variables that directly or indirectly influence employees’ willingness to report negative information. Those factors are useful in predicting communication effectiveness.
in certain organizations as well as employees’ inclination to accurately report status information. However, some situational factors such as project risk (Smith et al., 2001) and impact of information technology failure (Park, Keil and Kim, 2009), organizational factors such as organization climate (Keil et al., 2004), and personal factors such as individual morality, ethics, and willingness to communicate (Park et al., 2009) cannot be easily adjusted or controlled.

Research that aims to identify factors that can be controlled is critical because it enables organizations to target these factors to improve communication effectiveness, and increase employees’ willingness to accurately report status information regardless of current situational, personal, or organizational conditions. We propose three “adjustable” factors that can be controlled by organizations seeking to improve communication and increase individual willingness to report accurate status information, and consequently increase the accuracy of project risk assessment (Figure 17). In the context of software project status reporting “bad news” refers to negative status information.

Organizational conditions and employees’ fear of retribution contribute to the problem of information misrepresentation and individuals’ unwillingness to report negative status information (Keil and Robey 1999, 2001). Keil et al. (2004) extended the basic whistle blowing model (Dozier and Miceli, 1985, Smith and Kiel, 2003; Smith et al., 2001) by adding two constructs derived from agency theory to explain individuals’ reluctance to report bad news: organizational climate and information asymmetry. They found that when organizational climate is not conducive to openness about problems,
individuals have an incentive to shirk and their reluctance to report bad news will increase.

Figure 17: Conceptual Model: Willingness to Report Bad News

Table 11: Conceptual Model Propositions

<table>
<thead>
<tr>
<th>Propositions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P6</strong>: Higher perceived anonymity of reporting mechanism increases individual willingness to report bad news</td>
</tr>
<tr>
<td><strong>P7</strong>: Higher perceived self-interest in truthful reporting increases individual willingness to report bad news</td>
</tr>
<tr>
<td><strong>P8</strong>: Lower perceived information asymmetry between employees and management/clients increase individual willingness to report bad news</td>
</tr>
</tbody>
</table>

According to agency theory, agents are risk averse and will avoid any encounters that might jeopardize their jobs (Harrell and Harrison, 1994). Establishing an organizational climate that promotes openness might provide a long term solution. However, it is not always possible and is certainly not an easy task. Thus we propose that higher perceived anonymity of communication mechanisms increases individual
willingness to report negative status information regardless of the organizational climate (Table 11), and is a factor that can be easily adjusted or controlled by organizations.

Anonymity is a complex and influential aspect of communications medium that has received much attention in the study of collaborative technologies and group support systems (GSS) (Valacich, Leonard, Dennis and Nunamaker, 1992). An evaluation of 54 case and field studies of organizations using group support systems (GSS) technology to improve decision making, identified anonymity as a characteristic of successful GSS implementations (Fjermestad and Hiltz, 2001).

Anonymity features of the communication medium improves the communication process, and the overall group satisfaction with the technology compared to face-to-face meetings where group members are identified (Fjermestad and Hiltz, 2001), broadens participation and encourages diversity of thought (Bikson, 1996), improves the effectiveness of the communication process (Dennis, Heminger, Nunamaker and Vogel, 1990), and increases group meetings quality (Dennis, Tryan, Vogel and Nunamaker, 1997). Thus, a reporting mechanism that shields employees’ identities from being exposed will provide employees with a sense of security and consequently will increase the accuracy of their reports.

Employees participating in an information market report status information through their market trades. The proposed information market design allows for anonymous trading, where participants post bids or asks and perform market transactions
using pseudo names. Thus, it is expected to increase their perceived anonymity of the market reporting mechanism (Figure 18).

**H3:** An information market in which trading is anonymous will increase employees’ perception of reporting mechanism’s anonymity.

![Figure 18: Research Model: Information Market Impact on Willingness to Report Bad News](image)

Additionally, based on agency theory, employees are utility maximizers and seek their self-interest. So if employees feel that hiding information or remaining silent is in their best interest, they will shirk from reporting bad news. We propose that a higher perceived self-interest in reporting accurate information will increase employees’ willingness to report bad news (Table 11). Thus organizations should focus on factors that directly impact employees’ perception of their self-interest, and at the same time, can be
easily controlled. Incentives improve goal congruence between employees and organizations (Eisenhardt, 1989). Therefore we propose that a communication mechanism that offers incentives to employees for revealing true status information will increase their perception of self-interest and as a result their willingness to report negative status information (Figure 17). An information market offers incentives for faithful trading since contracts payoff depends on the outcomes of the forecasted events. So if employees have negative information about project progress, it is in their best interest to trade based on this information because they will benefit when events eventually occur (Figure 18).

\textbf{H4: An information market that provides incentives for faithful revelation of information will increase employees' perceived self interest in reporting true status information}

In addition to perceived anonymity and perceived self-interest, we propose that adjusting perceived information asymmetry between employees and management can increase employees’ willingness to report accurate information (Figure 17). When perceived information asymmetry is high (ability to hide bad news is high) individuals’ reluctance to report bad news will increase (Keil et al., 2004). We propose that a communication mechanism that reduces employees’ perceptions of information asymmetry (by making them feel that they cannot hide negative information from management) will increase their willingness to report bad news (Table 11).
Monitoring projects’ progress reduces privately-held information and employees’ perception of information asymmetry. An organizational information market acts like a project monitoring tool that facilitates identification of risks early enough to mitigate them. Further, an information market encourages employees to seek their self-interest (because money is involved), so employees will soon realize that they are better off utilizing their information advantage by trading on what they know because if they do not, others will, and consequently the market will reveal this information to management or the client. In other words, an information market acts as a control mechanism and will decrease employees perceived information asymmetry between them and management/client (Figure 18).

**H5: An information market will reduce employees’ perceptions of information asymmetry between them and management/client**

Ineffective monitoring and failing to manage goal conflict, shirking, and privately-held information are among the primary reasons for software development projects failure (Mahaney and Lederer, 2003). Organizations can design communication mechanisms, such as information market, that allow for anonymous reporting, offer incentives, and act as a monitoring tool of the project that creates low perceived information asymmetry in the organization, to improve the accuracy of employees’ reports by increasing their willingness to report negative information.
**H6:** An information market in which trading is anonymous and provides incentives for truthful revelation of information will increase employees’ willingness to report bad news

Now we describe design evaluation research questions and the experiments conducted to evaluate the proposed information market design and to test hypotheses about its expected utility for software projects’ risk assessment.

**Information Markets Design Evaluation**

Despite the empirical evidence on markets’ ability to aggregate information, the details of the information aggregation and dissemination process are not yet fully understood (Plott and Sunder, 1982; 1988; Forsythe and Lundholm, 1990). And although the results of laboratory experiments on security markets are useful in informing information markets design, information aggregation tasks used in lab experiments lack realism and their results are difficult to interpret and generalize to business settings.

The results of pilot studies in the field are encouraging by their demonstration of the feasibility of using information markets in organizations, but they do not provide sufficient levels of internal validity and control required to advance a rigorous theory of organizational information markets.

There is a need for more controlled experimental studies on the use of information markets for business problems that use business-related tasks and scenarios. Such experimental studies are needed to advance the theory of organizational information
markets and to improve our understanding of their utility to organizations. Experiments should provide sufficient degree of control that allows us to draw conclusions about manipulation effects and causality which, in turn, will allow us to build theoretical models to explain and predict the impact of various information markets designs on key business-related dependent variables, and to explain and predict information markets performance in specific business settings.

Experimental results are important to build a fundamental understanding of how information markets work, what are their expected impacts and benefits, and why they are expected to work well in some organizations but not as well in others. Such an understanding will allow organizations to better utilize information markets. Field studies can then be used to test developed theories and research models.

Thus, to answer design evaluation research question we conducted a laboratory experiment using the proposed experimental information market (Table 10) to test the market efficacy in providing complete, current and accurate information about software project risks. We used Inkling prediction markets platform (www.inklingmarkets.com) to setup the proposed risk assessment market. Given the developed theoretical framework (Figure 13) and hypotheses outlined in the previous section, we developed preliminarily experimental materials that include a business case, five different information structures that include different software development progress updates, and five different versions of a software project risk assessment survey.
The surveys included a section in which the subjects were asked to provide comments and suggestions to improve the clarity and understandability of the case and the survey. Each survey included a different information structure, or in other words, different development progress updates that give information about the status of the four main project objectives (functionality, quality, cost and schedule). It also included four manipulation check questions that asked participants to evaluate whether each project objective is currently met or not. The manipulation check questions tested the participants understanding of the case and the progress updates. The preliminarily case and surveys were administered to a group of 25 graduate students and their responses, comments and suggestions were used to strengthen the manipulations and improve the clarity of the case.

Seven doctoral students pilot tested the risk assessment experiment using the information market. The results were used to improve several design aspects of the experiment; including trading sessions duration, incentive structure, and the distributed experimental materials (progress updates). The reminder of the section describes final experiments and instruments.

**Information Market Experiment**

The final business scenario asked participants to play the role of a member of the design and development team in a large consulting firm that is developing a new reservation system for an association of hotels and car rental corporations (the client). The scenario and development updates are inspired by the events of a real software
development project; the CONFIRM project (Oz, 1994). The scenario described four main objectives for the development project in terms of functionality, performance, budget and schedule. It also described conditions under which these objectives are considered unmet. Appendix A shows the information markets experimental scenario.

Five different information structures were created that include software development progress updates to help participants verify whether project objectives are currently met or not, and to help them assess the riskiness level of the project. Appendix B shows the information structures. Each information structure was manipulated to provide information about the status of two or more of project objectives (Table 12).

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Information Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>Functionality and schedule objectives are unmet</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>Schedule and budget objectives are unmet</td>
</tr>
<tr>
<td>C</td>
<td>11</td>
<td>Functionality and performance objectives are unmet</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>Public information- All four project objectives are met</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>Public information and groups A, B and C information advantage</td>
</tr>
</tbody>
</table>

Information structures were created to simulate the case of a real software development project. Groups A, B and C represent groups of people who have private information about different aspects of the project and thus have only partial knowledge about the project overall status. Group D represent those who are not directly involved in the project and have access only to information that is publicly available which does not
always reflect the true status. Group E represents the hypothetical person (that H1 refers to) who possesses all available information about the project.

Five versions of the risk assessment survey were created and administered to a different group of participants. Each survey included the business scenario shown in appendix C, and one of the developed information structures that include the development progress updates (Table 12). The survey had four manipulation check questions that asked about the status of the four main objectives. It also included the risk assessment question that asked participants to assign a probability score to each of the three risk states outlined in Table 13 to describe the project riskiness level based on the information they have about the status of the project objectives. Participants were told that the sum of three probabilities should be equal to 1.

<table>
<thead>
<tr>
<th>Project Riskiness Level</th>
<th>Probability %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low risk:</strong> All four objectives are met to date</td>
<td></td>
</tr>
<tr>
<td><strong>Medium risk:</strong> Two or three objectives are met to date</td>
<td></td>
</tr>
<tr>
<td><strong>High risk:</strong> One or no objectives are met to date</td>
<td></td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>100%</td>
</tr>
</tbody>
</table>

The risk assessment survey question is identical to the question asked in the proposed experimental information market (Table 10). The market forecasting goal was to predict the riskiness level of the software project described in the same business case described above. Seven graduate students participated in market trading. Table 14 shows the market participants demographics. The experiment lasted 24 minutes. Development
progress updates were distributed in 6 of the 8 trading sessions. Each session lasted around 3 minutes. Participants were randomly assigned to one of four groups (Group D had one participant). Groups A, B C, and D received identical development progress updates to the updates provided to the participants who completed the surveys.

<table>
<thead>
<tr>
<th>Table 14: Market Participants Demographics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subjects Demographics</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Age (Years)</td>
</tr>
<tr>
<td>Work Experience (Years)</td>
</tr>
<tr>
<td>Experience in Software Projects (Years)</td>
</tr>
<tr>
<td>Gender (%)</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>7</td>
</tr>
</tbody>
</table>

The true riskiness level of the project described in the experimental business case scenarios was “high risk”, where all project objectives are currently unmet. Each participant in the market had access to only partial knowledge about the true status of the project (Table 12) in addition to the predictions of four information markets each designed to monitor the status of one of the project’s four main objectives (shown in Appendix C). Market participants were expected to use their private information and the information they learned from markets’ predictions to trade in the risk assessment market. At the end of trading, the market was expected to aggregate the private information distributed to all participants to reveal the true status of the project.
Publishing private information in form of market predictions allows participants to benefit from their information advantage and at the same time accounted for internal communication channels among them.

In organizations, private information about the status of different project objectives becomes known to others as project due date approaches, or simply because employees choose to share it with others or report it to management. This practice of making private information public was proven not to detract from information markets effectiveness in aggregating private information. To the contrary, it was shown to outperform settings where private information is not disclosed or where all information is publicly available (Almenberg, Kittlitz, and Pfeiffer, 2009). Also this practice suggests the information market usefulness in organizations that foster transparency and encourages open communications about issues and problems.

The goal of the experiment was to test H1 and H2 by (1) comparing the market generated assessment of project risk to the average assessment of group E who received all available information about the project, and (2) comparing the accuracy of market generated assessment of project risk to the accuracy of average assessment of groups A, B, C, and D.

To test the market efficacy in increasing individuals’ willingness to report bad news, and as a result improve the accuracy of their status reports, we administered a survey to a sample of 72 graduate and undergraduate business students enrolled in information systems classes in a large metropolitan university in the United States. Table
15 describes participants’ demographics. Participants’ work experience suggests that they are appropriate subjects for this type of experiment since the manipulations and treatment conditions are associated with organizational dynamics and decision making.

Table 15: Subjects Demographics

<table>
<thead>
<tr>
<th>Subjects Demographics</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>65</td>
<td>21</td>
<td>44</td>
<td>28.31</td>
<td>5.99</td>
</tr>
<tr>
<td>Work Experience (Years)</td>
<td>71</td>
<td>0</td>
<td>26</td>
<td>8.46</td>
<td>7.04</td>
</tr>
<tr>
<td>Experience in Software Projects (Years)</td>
<td>71</td>
<td>0</td>
<td>20</td>
<td>2.80</td>
<td>5.17</td>
</tr>
<tr>
<td>Gender (%)</td>
<td>70</td>
<td>76%</td>
<td>24%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The subjects were told that the survey is part of a study that examines business decision making, and that it consisted of two parts. The subjects were informed that the survey is anonymous and their participation is completely voluntary. The first part of the survey described a business scenario and asked the participants to play the role of a member of the design and development team in a consulting firm involved in the development of a transaction processing system for a department store (the client). The scenario described negative project status information that according to the signed agreement between the company and the client allows the client to break out of their contract with the company. Appendix D shows the survey experimental scenario.

The scenario was manipulated to reflect conditions of high information asymmetry, low self-interest in reporting negative information, and non-anonymous reporting mechanism in the organization. For the condition of high information
asymmetry between the client and the organization, the subjects were informed that unless employees report negative status information, the client will not become aware of them until the project due date. For conditions of low self-interest in reporting negative information, the subjects were informed that employees are expected not to mention problems in their status reports because management shares them with the clients, and those who mention problems in their reports get in trouble. For the non-anonymous reporting condition, the subjects were informed that status reports must include the employee’s name and signature.

After reading the case, subjects were asked to express how strongly they agree or disagree with a series of manipulation check statements that measured their perceived information asymmetry, perceived self interest and perceived anonymity of reporting mechanism in the organization. Then they were asked to express how likely they would report the negative status information. The second part of the survey introduced additional information to the case. The subjects were told that the client decided to use an information market to track the development progress of its transaction processing system.

Subjects were informed that information markets are known for their ability to quickly incorporate new updates and information to provide up-to-date assessment of the status of project objectives. This property is expected to bring negative status information to the client attention very quickly. Subjects were also informed that trading in the information market is anonymous, and all transactions, bids and asks are maintained by
an independent third party organization. Employees can report negative status information or system problems in an information market without being identified. The market offers incentives for true revelation of status information. So if employees are reporting honestly they will benefit financially. All profits will be directly deposited by the independent company into the employees’ bank accounts to protect their identities. All individuals involved in the design and development of the system, or have any information about its progress, are participating in market trading.

Subjects were then asked to respond to the same questions they answered in the first part to test the market impact on their perceived information asymmetry, perceived self-interest in reporting bad news, perceived anonymity of reporting mechanism in the organization, and their willingness to report bad news.

The four constructs of interest were measured using multiple-item scales using pre-validated instruments wherever possible. Appendix E shows all measurement scales organized by construct. Perceived information asymmetry was measured using two likert scaled items developed and validated by Kiel et al. (2004). Items were reworded to fit the context of the scenario. Perceived self-interest was measured using three likert scaled items designed specifically for this study. Perceived anonymity was measured using two likert scaled items which were also designed specifically for this study. Willingness to report bad news was measured using a modified version of the three likert scaled items developed and validated by Kiel et al. (2004) and Park and Kiel (2009).
Data Analysis and Results

Data analysis was performed in two phases. In the first phase, the reliability and construct validity of all measurement scales were tested using confirmatory factor analysis (CFA). Confirmatory factor analysis was chosen over alternative statistical techniques such as exploratory factor analysis because a priori theory about the number of factors and the relationships between factors and indicator variables exists. Amos 18 was used to perform the confirmatory factor analysis. Amos stands for “Analysis of Moment Structures” and is a software tool distributed by SPSS Inc. All measured items were modeled as reflective indicators of their corresponding factors.

Scale Validation

Scale validity can be demonstrated through measures of convergent and discriminant validity. Fornell and Larcker (1981) recommended three measures to assess convergent validity. (1) Standardized item-to-factor loadings ($\lambda_i$) should exceed 0.70. However, item loadings of 0.5 or 0.6 may still be acceptable if other items have high loadings on the same factor (Chin, 1998). (2) Composite reliability for each construct should exceed 0.80. However, reliability score of 0.70 indicates “extensive” evidence of reliability (Bearden, Netemeyer and Mobley, 1993), and (3) average variance extracted (AVE) for each construct should exceed 0.50, meaning that 50% of variance of the indicators is accounted for by the construct.

Composite reliability scores are calculated using the following formula (Chin 1998, p.320) where $\lambda_i$ is the standardized loading of the item (i) on the factor.
Average variance extracted (AVE) scores are calculated using the following formula (Fornel and Larcker, 1981) where $\lambda_i$ is the standardized loading of the item (i) on the factor.

\[
\text{Composite Reliability} = \frac{(\sum \lambda_i)^2}{(\sum \lambda_i)^2 + \sum_i (1 - \lambda_i^2)}
\]

\[
\text{Average Variance Extracted} = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum_i (1 - \lambda_i^2)}
\]

As seen in Table 16 standardized item-to-construct loadings for all scale items exceeded 0.70 except for the first anonymity item which has a 0.56 loading. However, the second item within the same block has a very high loading of 1. In addition, the composite reliability for perceived anonymity construct is higher than 0.70 threshold value, and its average variance extracted is higher than the recommended value of 0.50. Therefore, the first anonymity item loading was deemed acceptable.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Item Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived information asymmetry (IA)</td>
<td>IA1</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>IA2</td>
<td>0.92</td>
</tr>
<tr>
<td>Perceived self-interest (SI)</td>
<td>SI1</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>SI2</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>SI3</td>
<td>0.82</td>
</tr>
<tr>
<td>Perceived anonymity (AN)</td>
<td>AN1</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>AN2</td>
<td>1.00</td>
</tr>
<tr>
<td>Willingness to report bad news (WL)</td>
<td>WL1</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>WL2</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>WL3</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Composite reliability and Cronbach’s alpha is used to measure constructs reliability or the internal consistency of each constructs items. The recommended threshold is 0.70 for Cronbach’s alpha, and 0.80 for the composite reliability. However, a score of 0.70 or higher is sufficient to demonstrate extensive evidence of construct reliability. As shown in Table 17, all constructs have Cronbach’s Alpha and composite reliability of 0.70 or higher, and the average variance extracted for all construct is higher than the recommended threshold of 0.50. Thus, all three conditions of convergent validity were met.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Composite Reliability</th>
<th>Cronbach’s Alpha</th>
<th>Average Variance Extracted (AVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived information asymmetry (IA)</td>
<td>0.80</td>
<td>0.79</td>
<td>0.68</td>
</tr>
<tr>
<td>Perceived self-interest (SI)</td>
<td>0.85</td>
<td>0.84</td>
<td>0.66</td>
</tr>
<tr>
<td>Perceived anonymity (AN)</td>
<td>0.78</td>
<td>0.70</td>
<td>0.66</td>
</tr>
<tr>
<td>Willingness to report bad news (WL)</td>
<td>0.90</td>
<td>0.90</td>
<td>0.74</td>
</tr>
</tbody>
</table>

To assess the constructs discriminant validity, we used Fornell and Larcker (1981) recommendation that the average variance extracted for each construct exceeds the square of correlations between that construct and all other constructs. As shown in Table 18, the highest square of correlations is 0.48 between perceived self-interest and willingness to report bad news and is lower than the lowest average variance extracted of 0.66 for perceived self-interest. Thus, the recommended condition for discriminant validity was met.
Table 18: Discriminant Validity

<table>
<thead>
<tr>
<th>Construct</th>
<th>Average Variance Extracted (AVE)</th>
<th>Squares of Correlations Between Constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>0.68</td>
<td>IA 0.09  SI 0.07  AN 0.07  WL 0.07</td>
</tr>
<tr>
<td>SI</td>
<td>0.66</td>
<td>IA 0.09  SI 0.07  AN 0.07  WL 0.48</td>
</tr>
<tr>
<td>AN</td>
<td>0.66</td>
<td>IA 0.17  SI 0.07  AN 0.07  WL 0.05</td>
</tr>
<tr>
<td>WL</td>
<td>0.74</td>
<td>IA 0.07  SI 0.48  AN 0.05  WL --</td>
</tr>
</tbody>
</table>

Hypotheses Testing

The market generated assessment of the project riskiness level was (High Risk 86.23%, Medium Risk 8.46% and Low Risk 5.30%). These probabilities are equal to the average price for the transactions posted in the last minute of trading in each of the three states. Figure 19 shows the price curves of the project three riskiness states for the entire duration of the experiment. Since “high risk” is the true status of the project, the rest of the data analysis will focus on the market generated assessment of the “high risk” state.

Figure 19: Price Curves of the Project Riskiness States
All three risk states started with equal probabilities (33.33%) of being the actual state at the beginning of the experiment. The price curve fluctuated according to the development progress updates. The updates were manipulated in such a way as to test the market responsiveness to negative status information. At the beginning of the experiment all updates and market predictions indicated that the project is within planned objectives. Thus, “low risk” probability started to increase. At the beginning of the third trading session, updates indicated that only two objectives are being met so “medium risk” probability went up. Around minute 15 (beginning of trading session 6), updates started to show that other project objectives are going over their planned goals, and consequently the “high risk” probability spiked when the updates confirmed that the project is currently well over its planned objectives until it reached a near certain probability.

It is worth noting that trading slowed down during the second and fifth trading sessions where no updates were distributed to participants, and speeded back up in the following sessions where updates indicated a change in project status. This demonstrates the market responsiveness to updates and its ability to provide current information about project risks.

To test H1, a t-test was conducted to compare the market generated assessment of the “high risk” state probability (test value = 0.8623) to the mean assessment of participants in group E who received all available information about the project.
### H1 Statistical Hypotheses

<table>
<thead>
<tr>
<th></th>
<th>H0: $\mu_E = P_m$</th>
<th>H0: $\mu_E = 0.8623$</th>
<th>Ha: $\mu_E &lt;&gt; P_m$</th>
<th>Ha: $\mu_E &lt;&gt; 0.8623$</th>
</tr>
</thead>
</table>

We assume that the population from which all samples in the five groups are randomly drawn is normally distributed. Although the t-test is fairly robust against violation of normality assumption, we will not be able to test the assumption because of the relatively small sample size in each of the groups. Thus, we also report the results of the non-parametric equivalent to the t-test: one-sample Wilcoxon test (also known as Wilcoxon signed rank test) as a complementary test.

The one-sample Wilcoxon test does not make any assumptions about the sampling distribution and is used to test whether the sample median is equal to a specified value or not. Table 19 shows descriptive statistics of the five groups’ assessment of the “high risk” state probability.

### Table 19: Groups Assessment of High Risk Probability

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean (High Risk %)</th>
<th>S.D.</th>
<th>Median (High Risk %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>7</td>
<td>0.2214</td>
<td>0.20587</td>
<td>0.2500</td>
</tr>
<tr>
<td>Group B</td>
<td>8</td>
<td>0.0438</td>
<td>0.09039</td>
<td>0.0000</td>
</tr>
<tr>
<td>Group C</td>
<td>11</td>
<td>0.2318</td>
<td>0.36351</td>
<td>0.0000</td>
</tr>
<tr>
<td>Group D</td>
<td>6</td>
<td>0.0983</td>
<td>0.14148</td>
<td>0.0250</td>
</tr>
<tr>
<td>Group E</td>
<td>10</td>
<td>0.9500</td>
<td>0.12693</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
Given the sample data from Group E, the t observed value (2.185) was less than the critical value (2.262). Thus, we fail to reject the null at 5% significance level (p-value = 0.057). In other words, the results of the t-test failed to reveal a statistically reliable difference between the market assessment and the true mean assessment of project risk made by individuals in possession of all the information. The power of the t-test is 0.747 indicating that given our sample data, the probability of detecting a mean significantly different from the market assessment given such a difference actually exists is reasonably high. Since no significant difference was detected in the t-test, the result is much more likely to be due to a zero difference (supporting H1) rather than to a Type II error.

In addition, at 5% significant level, the results of Wilcoxon test have also failed to reveal a statistically reliable difference between the market assessment (test value = 0.8623) and the true median assessment of project risk made by individuals in group E (p-value = 0.59). Thus, H1 was supported.

To test H2, a series of t-tests were conducted to compare the accuracy of the market to the accuracy of the groups (A, B, C, and D) mean assessment of the project “high risk” state.

<table>
<thead>
<tr>
<th>H2 Statistical Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$: $\mu(A_i) \leq A_m$</td>
</tr>
<tr>
<td>$H_a$: $\mu(A_i) &gt; A_m$</td>
</tr>
<tr>
<td>$i = A, B, C$ or $D$</td>
</tr>
</tbody>
</table>

The accuracy of the groups and the market assessment equals the absolute difference between market/groups generated assessments of “high risk” probability and
the mean assessment made by group E (Assuming \( P_E = \mu_E \)). Table 20 shows the market vs. groups risk assessment accuracy.

<table>
<thead>
<tr>
<th>Groups</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Assessment ( 0 \leq P_i \leq 1 )</td>
<td>0.2214</td>
<td>0.0438</td>
<td>0.2318</td>
<td>0.0983</td>
<td>0.9500</td>
<td>0.8623</td>
</tr>
<tr>
<td>Mean Accuracy ( A_i =</td>
<td>P_E - P_i</td>
<td>)</td>
<td>0.7286</td>
<td>0.9063</td>
<td>0.7182</td>
<td>0.8517</td>
</tr>
<tr>
<td>Median Assessment ( 0 \leq P_i \leq 1 )</td>
<td>0.2500</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0250</td>
<td>1.0000</td>
<td>0.8623</td>
</tr>
<tr>
<td>Median Accuracy ( A_i =</td>
<td>P_E - P_i</td>
<td>)</td>
<td>0.7500</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.9750</td>
</tr>
</tbody>
</table>

Table 21 shows the results of the t-tests. The \( t \) critical values for all the groups are less than the observed \( t \) values, the \( P \)-values are less than 5% significance level, and the upper and lower bound of all confidence intervals are positive. Thus, we reject the null hypothesis and accept the alternative at 5% significance level. We conclude that the market assessment accuracy of the project actual riskiness level is greater than the true mean assessment accuracy of any group of individuals with only partial knowledge about the project.

<table>
<thead>
<tr>
<th>Test Value Information</th>
<th>Market Accuracy = 0.0877</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t ) observed</td>
<td>( t ) critical</td>
</tr>
<tr>
<td>Group A</td>
<td>8.207</td>
</tr>
<tr>
<td>Group B</td>
<td>25.543</td>
</tr>
<tr>
<td>Group C</td>
<td>5.732</td>
</tr>
<tr>
<td>Group D</td>
<td>13.187</td>
</tr>
</tbody>
</table>
The one-sample Wilcoxon test results have also found sufficient evidence to reject the null at 5% significance level (Table 22) indicating that the market assessment accuracy of the project actual riskiness level is greater than the median assessment accuracy of any of the four groups (assuming that group E median assessment of risk is equal to true population median).

### Table 22: Groups Risk Assessment Accuracy Wilcoxon tests

<table>
<thead>
<tr>
<th>Test Value</th>
<th>Information Market Accuracy = 0.1377</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>P-value</strong></td>
</tr>
<tr>
<td><strong>Group A</strong></td>
<td>0.018</td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td>0.008</td>
</tr>
<tr>
<td><strong>Group C</strong></td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Group D</strong></td>
<td>0.026</td>
</tr>
</tbody>
</table>

Table 23 shows descriptive statistics of survey items. The mean values for the three manipulated variables (IA-High, SI-Low and AN-Low) in the first part of the survey indicate that manipulations were effective.

### Table 23: Scale Properties

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived information asymmetry (IA)</td>
<td>IA1</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>4.29</td>
<td>2.21</td>
<td>1.81</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>IA2</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>4.43</td>
<td>2.13</td>
<td>2.17</td>
<td>1.20</td>
</tr>
<tr>
<td>Perceived self-interest (SI)</td>
<td>SI1</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>2.88</td>
<td>2.03</td>
<td>5.67</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>SI2</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>2.38</td>
<td>1.60</td>
<td>5.28</td>
<td>1.58</td>
</tr>
<tr>
<td></td>
<td>SI3</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>3.28</td>
<td>2.16</td>
<td>5.35</td>
<td>1.60</td>
</tr>
<tr>
<td>Perceived anonymity (AN)</td>
<td>AN1</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>1.85</td>
<td>1.12</td>
<td>5.43</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>AN2</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>2.07</td>
<td>1.49</td>
<td>5.82</td>
<td>1.49</td>
</tr>
<tr>
<td>Willingness to report bad news (WL)</td>
<td>WL1</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>3.44</td>
<td>2.03</td>
<td>5.58</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>WL2</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>3.18</td>
<td>1.86</td>
<td>5.44</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>WL3</td>
<td>72</td>
<td>1</td>
<td>7</td>
<td>3.44</td>
<td>1.91</td>
<td>5.06</td>
<td>1.56</td>
</tr>
</tbody>
</table>
Also, the mean values for all the variables move in the expected direction from the first part of the survey where employees used traditional status reporting mechanisms to the second part of the survey where employees used the information market mechanism to report project status. Mean perceived information asymmetry is lower in the information market condition than in the traditional reporting condition. Perceived self-interest, perceived anonymity and willingness to report bad news are higher in the market condition than in the traditional condition.

To test, H3, H4, H5 and H6, a series of paired t-tests were conducted. Our sample size (n=72) is large enough to assume that mean differences are normally distributed because for large samples (n > 30), the central limit theorem ensures the t-test robustness against violations of the normality assumption. Table 24 shows the results of the paired tests. Support of the hypotheses was determined by examining the sign of the mean difference, t-values and the p-values at 5% significance level.

<table>
<thead>
<tr>
<th>Statistical Hypotheses</th>
<th>H3</th>
<th>H0: IA - MIA &lt;= 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ha: IA - MIA &gt; 0</td>
<td></td>
</tr>
<tr>
<td>H4</td>
<td>H0: MSI - SI &lt;= 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ha: MSI - SI &gt; 0</td>
<td></td>
</tr>
<tr>
<td>H5</td>
<td>H0: MAN - AN &lt;= 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ha: MAN - AN &gt; 0</td>
<td></td>
</tr>
<tr>
<td>H6</td>
<td>H0: MWL - WL &lt;= 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ha: MWL - WL &gt; 0</td>
<td></td>
</tr>
</tbody>
</table>
For the first pair, the mean difference as well as the upper and lower bound of the confidence interval are positive. The t-value is positive as well and greater than the critical value at 5% significance level indicating that the mean perceived information asymmetry in the information market condition (MIA) is lower than the mean perceived information asymmetry in the traditional reporting condition (IA). Thus, H3 was supported. For pairs 2, 3, and 4, the mean difference is positive, the upper and lower bound of the confidence interval are positive, and the t-values are positive and greater than the critical value at 5% significance level indicating that the mean perceived self-interest (MSI), mean perceived anonymity (MAN) and mean willingness to report bad news (MWL) in the market condition are greater than their corresponding means in the traditional condition. Thus, H4, H5 and H6 were supported.

Table 24: Paired Samples Test

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>S.D</th>
<th>95% Confidence Interval of the Difference</th>
<th>Mean</th>
<th>S.D</th>
<th>95% Confidence Interval of the Difference</th>
<th>Mean</th>
<th>S.D</th>
<th>95% Confidence Interval of the Difference</th>
<th>Mean</th>
<th>S.D</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 IA - MIA</td>
<td>2.458</td>
<td>2.101</td>
<td>1.965 - 2.952</td>
<td>2.66</td>
<td>61</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 2 MSI – SI</td>
<td>2.822</td>
<td>2.077</td>
<td>2.334 - 3.310</td>
<td>2.66</td>
<td>71</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 3 MAN - AN</td>
<td>3.625</td>
<td>2.040</td>
<td>3.146 - 4.104</td>
<td>2.66</td>
<td>71</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 4 MWL - WL</td>
<td>2.005</td>
<td>2.137</td>
<td>1.502 - 2.507</td>
<td>2.66</td>
<td>71</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion and Implications

The variance in risk assessment accuracy, according to the proposed theoretical framework, depends on the completeness, currency and accuracy of reported status.
information where accuracy of status information depends in turn on individuals’
misperceptions of project status and their willingness to report bad news. Figure 20
shows a summary of the framework propositions.

Figure 20: Summary of Theoretical Framework Propositions

The results of the experiment provide empirical evidence on information markets
efficacy in improving risk assessment accuracy by aggregating information from all
participants in the market to provide more complete and accurate assessment of risks than
any individual group of participants. Table 25 provides a summary of the hypotheses,
results and implications. The information market assessment approximated the mean
assessment of individuals who have access to all available information about the project.
Those individuals rarely exist in organizations. Otherwise, an information market, or any
other information aggregation and reporting mechanism, will not be needed.
Table 25: Summary of Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H1</strong>: An information market’s reported assessment of project risks will approximate the reported assessment of a single person in possession of all the information</td>
<td>Supported</td>
<td>Demonstrates information markets efficacy in aggregating information about project status from all market participants to provide “complete” assessment of project risk</td>
</tr>
<tr>
<td><strong>H2</strong>: An information market’s reported assessment of project risks will be more accurate than any individual reported assessment of project risk</td>
<td>Supported</td>
<td>Demonstrates information markets efficacy in adjusting for individuals’ misperceptions of project risk due to partial knowledge about project status and as a result improve risk assessment accuracy</td>
</tr>
<tr>
<td><strong>H3</strong>: An information market in which trading is anonymous will increase employees’ perception of reporting mechanism’s anonymity</td>
<td>Supported</td>
<td>Demonstrate the effects of a major design aspect of information markets; anonymity of trades, on employees perceptions of the anonymity of the market as a reporting mechanism which in turn is proposed to increase their willingness to report bad news</td>
</tr>
<tr>
<td><strong>H4</strong>: An information market that provides incentives for faithful revelation of information will increase employees’ perceived self-interest in reporting true status information</td>
<td>Supported</td>
<td>Demonstrate the effects of a major design aspect of information markets; incentive structure, on employees perceptions of self interest in truthful reporting of status information which is proposed to increase their willingness to report bad news</td>
</tr>
<tr>
<td><strong>H5</strong>: An information market will reduce employees’ perceptions of information asymmetry between them and management/client</td>
<td>Supported</td>
<td>Demonstrate an additional benefit for information markets; decrease employees perception of information asymmetry, or their ability to hide information from management or clients, which is proposed to increase their willingness to report bad news</td>
</tr>
<tr>
<td><strong>H6</strong>: An information market in which trading is anonymous and provides incentives for truthful revelation of information will increase employees’ willingness to report bad news</td>
<td>Supported</td>
<td>Demonstrate information markets efficacy in increasing individuals willingness to report negative status information and as a result improve risk assessment accuracy</td>
</tr>
</tbody>
</table>

As is the case with most software development projects, status information are distributed among all individuals involved in the project and does not exist in
concentrated form. Management as well as the clients relies on traditional project management techniques such as status reports and periodic meetings to monitor the status of the project and to check on its progress. However, traditional monitoring and reporting techniques have proven ineffective time and time again due to employees misperceptions of true project status and their reluctance to report negative information.

The results of the experiment prove that information markets can adjust for individuals’ risk perception errors due to incomplete information about the true status of the project. Market assessment of project risk proved to be more accurate than any individual group of people with access to incomplete information about the project. Additionally, the results provide evidence on information markets efficacy in increasing individual willingness to report negative status information via the market, and consequently improving the accuracy of the market generated assessment of project risks.

Information markets ability to increase individual willingness to report bad news can be attributed to major design features of information markets such as anonymity of trades and incentive structures. Markets offer anonymity and provide incentives for honest reporting. The results of the experiment showed a significant increase in individuals’ perceived self-interest in reporting true status information and in their perceived anonymity of the market reporting mechanism.

Further, an information market is proven to decrease employees’ perception of information asymmetry, or in other words, their perceived ability to hide information from management/clients. Information markets efficiency in responding to updates and
their proven ability to collect all available information about an event are believed to be the driving reasons behind the observed significant decrease in individuals’ perception of information asymmetry.

These results have important theoretical and practical implications. At the conceptual level, the decreased information asymmetry suggest that regardless of information markets’ predictive accuracy, their mere existence in the organization might have a psychological impact that levels the playing field between management or clients and employees. As a result an information market can also increase employees’ willingness to report bad news via other more traditional reporting mechanisms, and consequently improve risk assessment accuracy.

Perhaps information markets’ indirect positive effects on transparency of communications might encourage some organizations to adopt them more than the market’s actual assessment accuracy. Also, markets may prove to be invaluable in minimizing software projects’ chances of failure particularly in organizations where reporting of negative status information are not encouraged. By providing early warning signals about risks, markets can assume the difficult task of “blowing the whistle” on challenged projects.

Limitations

Although laboratory experiments provide high degrees of internal validity and control, they provide lower degrees of external validity compared to field studies. To
improve generalizability of the results, the experimental information aggregation task used in this study was based on a realistic business scenario. However, the scenario and the progress updates that were distributed to participants throughout the experiment were manipulated to achieve high degree of control over the information structure that will allow us to test the market efficacy in aggregating information, and to investigate its effect on the market assessment of risk.

In organizations the actual distribution of information among employees might not be as clear, and there might be other context-specific or extraneous variables, such as internal communication sharing channels between market participants that affect the market generated assessment that have not been investigated or accounted for in this study.

Additionally, the survey measured behavioral intentions rather than actual behavior, and was manipulated to measure employees’ willingness to report negative status information under certain conditions. The focus on few variables allowed us to investigate the impact of certain market design features on participants’ perceptions and consequently their behavioral decision to report negative information. The goal was to shed light on some important factors that can improve the accuracy of risk assessment by increasing employees’ willingness to report bad news, and at the same time, can be controlled by organizations, such as anonymity and incentives. However, there might be other factors that can be controlled by organizations that we did not investigate here.
Control of treatment conditions provided high internal validity that allowed us to examine causal relationships by measuring the difference in participants’ perceptions of information asymmetry, anonymity and self-interest caused by the information market treatment. Anonymous market trading proved to increase employees’ perception of the anonymity of the reporting mechanism. However, in organizations, markets might not be perceived as anonymous reporting mechanisms even when trading is.

Depending on the forecasting goal and the size of the organization, traders in the market might not feel that their identities are protected because of the specialized knowledge they have about the project. So if small number of employees has access to status information about a certain objective, their trades in the market might be identified even when their real names are not attached to their trades. Thus, caution must be taken when generalizing this result to some organizations because perception of anonymity might be moderated by the size of the organization and employees’ job responsibilities. Having said that, the market can still improve their willingness to report negative information because of the incentives it offers for truthful reporting, and the market effects on their perceptions of information asymmetry.

**Contributions and Future Directions**

This research makes several contributions to the software project risk management literature. First, it develops a theoretical framework for the determinants of risk assessment accuracy. This framework broadens our perspective by focusing on
important but under-investigated attributes of information that directly impact the accuracy of risk assessment, such as information currency and completeness.

Second, it proposes an innovative technology-based information market solution to risk assessment problems to improve the accuracy, currency and completeness of reported project status information and consequently the accuracy of risk assessment.

Third, it evaluates the efficacy of the proposed solution by conducting two controlled experiments. The risk assessment experiment provides a closer look at information aggregation and dissemination in information markets by using a realistic information structure and business scenario.

The results of the experiments highlight an additional benefit for information markets besides their anonymity and incentives, which is the ability to influence participants’ perceptions of information asymmetry. This effect can be very useful to organizations if utilized properly. The results also provide evidence to the market effectiveness in improving software risk assessment accuracy, by improving the currency, accuracy and completeness of reported status information, which will consequently reduce software projects chances of failure and save organizations billions of dollars.

Fourth, this research develops and validates measures for several important constructs such as perceived self-interest in reporting bad news and perceived anonymity of reporting mechanism. It also re-validates modified versions of existing measures such as willingness to report bad news and perceived information asymmetry.
Finally, this research highlights the importance and impacts of three variables derived from agency theory on employees’ willingness to report bad news. These variables are information asymmetry, self-interest and anonymity. The difference between our proposed conceptual model of willingness to report bad news (Figure 17) and existing models in the literature is that it focuses our attention on factors that not only impact willingness but also can be adjusted and controlled by organizations. The proposed information market solution is proven to decrease employees’ perception of information asymmetry, and to increase their perception of the anonymity of the reporting mechanism and their perceived self-interest in reporting negative status information.

Future research should investigate the impact of these three factors individually on individuals’ willingness to report bad news. It should also seek to identify other factors that can be adjusted by organizations or influenced by the use of technology. Future research should investigate the impact of different information structures on market generated assessment of risk, and then test information market effectiveness in improving risk assessment accuracy in the field.
Chapter Five

Summary and Future Directions

Information markets are a form of futures markets whose primary purpose is to aggregate disparate information which is expensive to collect using other commonly used methods. Participants in the market trade contracts that payoff depending on the outcomes of future event. Contract prices can be interpreted as a forecast of the event probability and can be used by organizations to support a wide variety of decisions.

Despite the corporate world’s enthusiasm for information markets, the relationship between markets and organizations has not been fully investigated yet. There are many open questions and unknowns when it comes to the design and use of markets in a business environment. Markets are fundamentally technology-enabled information systems designed to provide efficient and effective solutions to identified business problems, such as forecasting, information aggregation and decision making under uncertainty.

Technology is limited to the hardware and the software components of the market, and the information system encompasses the design, development, implementation, and use processes of the market, as well as the dynamic interaction between the market, people, and its environment to accomplish a certain task. This
dissertation employs two theoretical perspectives to investigate the relationship between information markets as IT artifacts and their context of use.

Systems thinking framework (Checkland, 1981) is employed to develop a systems theory of information markets to facilitate investigation of the relationships and interactions between markets as systems and their context of use. An information market is viewed as a subsystem of the organization system in which it is used. The organization in turn operates within an industry, all of which operates in the largest system of all: the world.

An information market encapsulates the aggregation system and its emergent properties or the “intelligence” stored in the market, along with the market incentives and contracts structures, and produces an emergent property that makes the market larger than the sum of its parts; collective intelligence in form of equilibrium price. Each system engages in a process of cybernetic information exchange with its environment and has its own ways of responding to and communicating with the system in which it operates, as well as with other systems. A systems theory of information markets allow us to choose design and use processes that result in better long term benefits to organizations in light of existing interactions and interrelationships between the market and its subsystems, such as the aggregation mechanism and the incentives structure, and the bigger system(s) in which it operates, such as the organization and its various departments and the industry.
The second theoretical perspective is structuration theory (Giddens, 1979, 1984). This research proposes a structuration model for design and use of IT artifacts in organizations and applies it to the study of information markets. The context in which the market operates shapes the market objectives and all aspects of market design. There is a recursive relationship between market objectives, design, use and context of use, each shaping the other iteratively.

Just like any other information and communication technology, market success depends on users’ abilities to effectively use it, and on the market’s abilities to satisfy users’ needs. The business environment imposes unique challenges on the market design. Thus, we propose that the design of information markets, market interfaces, and visualizations be driven by three factors: (1) Market users – Who; (2) Use motivation – Why; and (3) Market information – What.

This dissertation develops a multidimensional framework of market users to guide market design to satisfy users’ motivational and informational needs. The framework classifies users according to three dimensions: 1) knowledge level in the issues being forecasted, as informed or uninformed users; 2) participation level in market trading, as active or passive users; and 3) externality level to the department/organization at which the market operates, as internal or external users.

Each group of market users has its own motivational needs and goals that can be satisfied using different information and market designs. Thus, information markets, market interfaces, and information visualizations can be designed specifically to target
and attract any group of users depending on careful analysis of their motivations and needs. Thus, uninformed traders who are needed for markets to function properly can be attracted using markets designs that are intuitive, enjoyable, induce positive emotions that affect users’ desire to use the system, and most importantly, they should be perceived as fun, entertaining, and to some degree “safe”.

This research extends Giddens’ structuration theory (Giddens, 1979, 1984), adaptive structuration theory (AST) (DeSanctis and Poole, 1994), and the structuration model of technology (Orlikowski, 1992), by moving beyond the traditional structuration process and the recursive relationship between technology and action that defines the relationship between technology and organizations, to consider technology as a catalyst for organization change and development. The structuration cycle is viewed as a continuous change process that objectifies changeability as an organizational permanent structure that leads to the ultimate goal of the structuration process of IT artifacts: organization development (OD).

A well-designed information market can generate several benefits to organizations which contribute to their growth and development. Software development organizations are in desperate need of better risk management tools due to their role in reducing software project chances of failure. This dissertation develops a theoretical framework for the determinants of software project risk assessment accuracy and proposes an information market design solution to help organizations better assess
software project risks. It evaluates the information market efficacy in increasing risk assessment accuracy using two controlled experiments.

The first experiment compares the market generated assessment of risk for a given software project to the mean assessment of a group of individuals with access to all available information about the project. The results showed that the market assessment of risks approximated the mean assessment of the group demonstrating the market efficacy in aggregating available information about the project from all market participants to provide an assessment based on “complete” information about the project status which leads to higher accuracy of risk assessment.

It also compares the market generated assessment of risk to the mean assessment of four groups of individuals each of whom has access to partial information about the project status. The results showed that the market assessment of risk is more accurate than the assessment generated by any of the groups demonstrating the market efficacy in adjusting for individuals’ errors of perception of project risk due to their incomplete information about its status.

The second experiment focuses on three factors derived from agency theory that can be “controlled” by organizations or influenced by the use of technology and are proposed to impact individuals’ willingness to report negative status information, and as a result, the accuracy of reported status and risk assessment. These factors are information asymmetry between employees and management/clients, anonymity of the reporting mechanism, and self-interest in truthful reporting.
The results of the experiment demonstrated the effectiveness of major design features of information markets, such as the incentive structure and anonymity of trades, in influencing participants’ perceptions of (1) information asymmetry between them and management/clients, (2) market anonymity as a reporting mechanism, and (3) self-interest in truthful reporting. The results also demonstrated the market efficacy in increasing participants’ willingness to report negative status information, and as a result increasing the accuracy of reported status and risk assessment.

Future research should investigate the impact of these three factors independently on an individual’s willingness to report bad news. It should also seek to identify other factors that can be adjusted by organizations or influenced by the use of technology.

Future research should investigate the impact of different contracts, incentive structures and market mechanisms such as pari-mutuel, continuous double auction, and market scoring rules on the market’s assessment accuracy. It should also investigate the impact of different information structures on market generated assessments of risk, and then test information market effectiveness in improving risk assessment accuracy in the field.

This dissertation suggests other fruitful areas of research. There is a great need for studies that empirically compare information markets to other methods of information aggregation, such as the Delphi method, not only in terms of forecasting accuracy but also on multiple other dimensions, such as the nature of the forecasting problems appropriate for each method, sources of relevant information (e.g. external, internal, or a
mix of both), the availability of public information to attract participants, the availability of experts in certain areas, and the costs involved in recruiting experts, acquiring the market, training, trading time and incentives.

Further, there is a need for studies that investigate the structuration and appropriation processes of information markets in organization where markets are used as an intervention to induce organizational change and development. Additionally, there is a need for research that seeks to characterize the decision making and cognitive processes involved in analyzing and using market information, from both the trader and the decision maker perspectives. Research is also needed on the design of effective market interfaces that meet users’ motivational and informational needs.
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Appendix A: Information Markets Experimental Scenario

Innovations & More Corporation (IMC)

Information Markets for Software Project Risk Management

You are a member of the design and development team in a large consulting firm; Innovations & More Corporation (IMC). Your firm is developing a new reservation system for an association of hotels and car rental corporations (the client). Your firm and the client signed an agreement describing the four main objectives for the development project in terms of functionality, performance, budget and schedule. It also describes conditions under which these objectives are considered unmet.

<table>
<thead>
<tr>
<th>Project Objective</th>
<th>Objective is considered UNMET if</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functionality</strong></td>
<td>Integrate airline, rental car and hotel information in a central database. System fails integration test</td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>Transaction response time is 1 second Transaction response time exceeds 2 seconds</td>
</tr>
<tr>
<td><strong>Budget</strong></td>
<td>$55 million Cost exceeds budget by 10% ($5.5 million)</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td>Design phase: 12 months (1 year) Development phase: 48 months (4 years) Schedule exceeds deadline by 15% (9 months)</td>
</tr>
</tbody>
</table>
Appendix A: (Continued)

Your firm and the client agreed to set up 5 information markets to track the development progress of the reservation system. One market is created to monitor the status of each project objective (total of 4 markets), and the fifth market to monitor the project overall status (riskiness level). The project riskiness level depends on whether project objectives are met or not:

- Low risk: All four objectives substantially met to date
- Medium risk: Two or three objectives substantially met to date
- High risk: One or zero objectives substantially met to date

<table>
<thead>
<tr>
<th>Market</th>
<th>Forecasting Goal</th>
<th>Price (%)</th>
</tr>
</thead>
</table>
| 1      | Will the project meet its functionality objective?  
i.e. System pass integration test | Yes | 50%  
No | 50%  
**Sum** | **100%** |
| 2      | Will the project meet its performance objective?  
i.e. Transaction response time is less than 2 seconds | Yes | 50%  
No | 50%  
**Sum** | **100%** |
| 3      | Will the project meet its budget objective?  
i.e. Budget increase is less than 10% | Yes | 50%  
No | 50%  
**Sum** | **100%** |
| 4      | Will the project meet its schedule objective?  
i.e. Schedule increase is less than 15% | Yes | 50%  
No | 50%  
**Sum** | **100%** |
<table>
<thead>
<tr>
<th>Market</th>
<th>Forecasting Goal</th>
<th>Price (%)</th>
</tr>
</thead>
</table>
| 5      | Which state best describes the project riskiness level? | **Low risk:** All four objectives substantially met to date | **33.3%**  
Medium risk: Two or three objectives substantially met to date | **33.3%**  
**High risk:** One or zero objectives substantially met to date | **33.3%**  
**Sum** | **100%** |
Appendix A: (Continued)

You will be provided with development progress updates to help you verify whether project objectives are currently met or not. Progress updates provide information to help you better assess the riskiness level of the project. You will also be provided with the predictions of the four information markets that monitor the status of the project objectives. Based on progress updates and the market predictions provided to you, you will participate in an information market designed to predict the riskiness level of the project.
Appendix B: Information Structures

GROUP A

**Update 0** - The project is going great. Currently there is no reason to believe that the project will not meet any of its objectives.

**Update1** - 4 months after signing the agreement, base design is completed and presented to the client. Base design describes expected functionality in general terms, and does not provide sufficient details for developers to understand what the user is expecting.

**Update2** - 1 year after signing the agreement, the design phase is completed. However, the quality of the specification is questionable, and might cause serious delays down the road.

**Update3** - IMC circulated a preliminary development plan. The client requested some revisions.

**Update4** - Development plan was revised and sent to the client. Revisions to development plan were unexpected and delayed the project by at least 10 months (resulting in more than 15% schedule overrun).

**Update5** - IMC admits some technical difficulties, and that the system failed integration tests.
Appendix B: (Continued)

GROUP B

**Update 0** - The project is going great. Currently there is no reason to believe that the project will not meet any of its objectives.

**Update 1** - 4 months after signing the agreement, base design is completed and presented to the client.

**Update 2** - 1 year after signing the agreement, the design phase is completed. However, the quality of the specification is questionable, and might cause serious delays down the road. IMC circulated a preliminary development plan. The client requested some revisions.

**Update 3** - Development plan was revised and sent to the client.

**Update 4** - Revisions to development plan were unexpected and delayed the project by at least 10 months (resulting in more than 15% schedule overrun).

**Update 5** - IMC guaranteed that the project will deliver expected functionality and performance. However, the firm hired some experts to help with technical problems. This increased the budget by at least 15%.
Appendix B: (Continued)

GROUP C

**Update 0** - The project is going great. Currently there is no reason to believe that the project will not meet any of its objectives.

**Update1** - 4 months after signing the agreement, base design is completed and presented to the client.

**Update2** - 1 year after signing the agreement, the design phase is completed. However, the quality of the specifications is questionable. IMC circulated a preliminary development plan. The client requested some revisions.

**Update3** - The requested modifications to the development plan increased transaction response time to more than 2.0 seconds.

**Update4** - Development plan modifications did not affect the project budget or schedule.

**Update5** - The technical team found that the airline, rental car and hotel databases cannot be integrated. A major functionality cannot possibly be delivered.
Appendix B: (Continued)

GROUP D (PUBLIC INFORMATION)

Update 0 - The project is going great. Currently there is no reason to believe that the project will not meet any of its objectives.

Update 1 - 4 months after signing the agreement, base design is completed and presented to the client. Your firm (IMC) guaranteed the client that the final specifications will provide all necessary details to meet users’ needs, and the design phase will be completed on time.

Update 2 - 1 year after signing the agreement, the design phase is completed on time. IMC circulated a preliminary development plan. Client requested some revisions.

Update 3 - 6 months later, development plan is revised and sent to the client.

Update 4 - IMC guaranteed that the project will still be delivered on time and with promised functionality.

Update 5 - Two months later, IMC admits some technical difficulties, but is confident that it will deliver the project within budget and with expected performance.
# INFORMATION MARKET PREDICTIONS

<table>
<thead>
<tr>
<th>Market</th>
<th>Outcomes</th>
<th>Updates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Yes</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>35%</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>35%</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>35%</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>35%</td>
</tr>
</tbody>
</table>
Appendix C: Risk Assessment Survey

Innovations & More Corporation

Business Case and Risk Assessment Survey

INSTRUCTIONS: The following business case is part of a study that examines software project risk assessment. The case describes four main objectives for a software development project in terms of functionality, performance, budget and schedule. It also describes conditions under which these objectives are considered unmet. You will be provided with development progress updates to help you verify whether project objectives are currently met or not. Progress updates provide information to help you better assess the riskiness level of the project.

Please read the following case and development progress updates and complete the survey that follows.

Innovations & More Corporation (IMC)

You are a member of the design and development team in a large consulting firm; Innovations & More Corporation (IMC). Your firm is developing a new reservation system for an association of hotels and car rental corporations (the client). Your firm and the client signed an agreement describing the four main objectives for the development project.
Appendix C: (Continued)

<table>
<thead>
<tr>
<th>Project Objective</th>
<th>Objective is considered UNMET if</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Design phase: 12 months (1 year) Development phase: 48 months (4 years)</td>
<td>Schedule exceeds deadline by 15% (9 months)</td>
</tr>
</tbody>
</table>

**Risk Assessment Survey**

<table>
<thead>
<tr>
<th>Based on all the information and updates provided to you</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the project currently meet its functionality objective?</td>
<td></td>
</tr>
<tr>
<td>Does the project currently meet its performance objective?</td>
<td></td>
</tr>
<tr>
<td>Does the project currently meet its budget objective?</td>
<td></td>
</tr>
<tr>
<td>Does the project currently meet its schedule objective?</td>
<td></td>
</tr>
</tbody>
</table>

The client asked your firm to conduct a survey to assess the overall riskiness level of the project using discrete reporting scale (high risk, medium risk and low risk). Riskiness level is defined in terms of the number of unmet objectives. When all project objectives are met to date the project is considered low risk. When only two or three objectives are met to date, the project is considered medium risk. When one or no objectives are met, the project is considered high risk.
Appendix C: (Continued)

Depending on the information you have about project status, assign a probability score to the state that best describes the project riskiness level. In other words, how likely the project is to achieve its objectives? For example, if your information indicates that all four project objectives are met to date, you will assign a 100% to low risk, 0% to medium risk, and 0% to high risk.

<table>
<thead>
<tr>
<th>Project Riskiness Level</th>
<th>Probability %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low risk:</strong> All four objectives are met to date</td>
<td></td>
</tr>
<tr>
<td><strong>Medium risk:</strong> Two or three objectives are met to date</td>
<td></td>
</tr>
<tr>
<td><strong>High risk:</strong> One or no objectives are met to date</td>
<td></td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Appendix D: Survey Experimental Scenario

INSTRUCTIONS: This business case is part of a study that examines business decision making. Please read the following case and answer the questions that follow based on the information presented in the case.

Digit Dash & Beyond Corporation

You are a member of the design and development team in a major consulting firm; Digit Dash & Beyond Corporation (DDB). For the last year you have been involved in the development of a transaction processing system for a large department store; Chars.com. DDB and Chars signed an agreement stating project objectives in terms of expected system’s functionality, performance, estimated budget and schedule. The agreement also stated that the client can withdraw when two or more objectives are unmet during the first year of system development. The system has been under development for almost a year. The project is over budget, over schedule, system has performance issues and initial integration tests showed that the system will fail to deliver expected functionality. In other words, the project four main objectives are currently unmet.

Unless employees report the status of project objectives, the client will not become aware of these issues until the project due date. Your firm has an implicit policy of not reporting negative status information to clients to keep them from withdrawing, and instead tries to arrange new agreement with the client before the project due date.
Appendix D: (Continued)

Employees are required to submit a periodic status report to management. *Management shares these reports with the client. The report must include the employee’s name and signature.* Employees are expected not to mention problems in their status reports because clients will see them. *Employees who mention problems in their reports get in trouble.* In the past an employee reported performance issues in his formal report and got reprimanded by the project manager. Later he was denied a promotion, and lost his job. Rumor has it that his negative status report is behind it.

**NOTE:** The above scenario represents the treatment used to manipulate high information asymmetry, high anonymity and low self-interest in reporting negative information. The scenario that follows was used in the second part of the survey to introduce the information market treatment.

**Digit Dash & Beyond Corporation (continued)**

The client decided to use a risk assessment tool to track the development progress of its transaction processing system. This tool is known as information market. An information market main goal is to collect information about the status of project objectives from *all over the company* to reveal whether or not they are being met. The more unmet objectives, the higher the riskiness level of the project. Information markets are known for their ability to *quickly incorporate new updates and information* to provide up-to-date assessment of the status of project objectives.
Appendix D: (Continued)

This property is expected to bring system problems, performance issues or negative status information to the client's attention very quickly. Trading in the information market is anonymous, and all transactions, bids and asks are maintained by an independent third party organization. Employees can report negative status information or system problems in an information market without being identified. The market offers incentives for true revelation of status information. So if employees are reporting honestly they will benefit financially. All profits will be directly deposited by the independent company into the employees’ bank accounts to protect their identities. All individuals involved in the design and development of the system, or have any information about its progress, are participating in market trading.
Appendix E: Constructs and Measures

**Perceived information asymmetry** (7 point likert scale, 1 = strongly disagree, 4 = neutral or unsure, 7= strongly agree)

IA1: Negative status information will become apparent to the client very quickly (Reversed)

IA2: Whether or not I report negative status information, the client will become aware of it very soon anyway (Reversed)

**Perceived self-interest in reporting bad news** (7 point likert scale, 1 = strongly disagree, 4 = neutral or unsure, 7= strongly agree)

SI1: It is in my interest NOT to report negative status information in my report (Reversed)

SI2: I will benefit from reporting negative status information in my report

SI3: I have nothing to gain from reporting negative status information in my report (Reversed)

**Perceived anonymity** (7 point likert scale, 1 = strongly disagree, 4 = neutral or unsure, 7= strongly agree)

AN1: If I mention negative status information in my status reports, management will know my name (Reversed)

AN2: Project status reports at my firm are anonymous (i.e. reports have no names attached to them)
Appendix E: (Continued)

Willingness to report bad news (7 point likert scale, 1 = very unlikely, 4 = neutral or unsure, 7 = very likely)

WL1: How likely are you to report negative status information in your status report?

WL2: How likely are you to report negative status information to client?

WL3: How likely it is that you would avoid reporting negative status information to client? (Reversed)

NOTE: The questions asked in the second part of the survey under the treatment condition were identical except that “status report/report” was replaced with information market.
About the Author

Areej M. Yassin received her B.S. degree in Computer Science with a minor in Business Administration from Yarmouk University in Jordan, where she was on the Dean’s Honor List several times and was awarded the University Graduate Scholarship. Dr. Yassin earned both her M.S. in Management Information Systems and MBA degrees from the University of South Florida, where she maintained a 4.0 GPA. She is member of Phi Kappa Phi and Beta Gamma Sigma honor societies. Before pursuing her academic career, Dr. Yassin held several positions in industry. She is an Oracle Certified Professional (OCP), Cisco Certified Network Associate (CCNA), and Microsoft Certified Office User Specialist (MOUS Master).