WHAT DO YOU KNOW? RATIONAL EXPECTATIONS IN INFORMATION TECHNOLOGY ADOPTION AND INVESTMENT

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Last revised: May 16, 2003

Forthcoming in Journal of Management Information Systems, 20, 2, Fall 2003, in press.

ABSTRACT: This study examines the potential applications of the rational expectations hypothesis (REH) and adaptive learning theory in information technology (IT) investment and adoption decision-making. Although REH has been widely used in other areas of microeconomics and macroeconomics, we have not yet seen common use of the related theory in the Information Systems (IS) field. Despite the fact that rationality is commonly assumed in economic analyses, the REH’s rather strong assumptions make it a unique theory and allow us to offer new perspectives on IS/IT adoption and investment decisionmaking. In this paper, we discuss how REH and adaptive learning can be applied in IS/IT investment and adoption decisionmaking settings. Such settings require managers, as economic agents, to form a set of expectations about the values of various variables related to the business value of IT. We present a number of propositions that characterize this perspective, and discuss some illustrative examples which demonstrate the efficacy of the theoretical perspective that we present to characterize the business value expectations formation process in IT adoption.

KEYWORDS: Adoption, adaptive learning, business value, economic theory, herd behavior, informational cascades, IT investments, rational expectations hypothesis.

ACKNOWLEDGEMENTS: An earlier version appeared in R. Sprague (Ed.), Proceedings of the 36th Hawaii International Conference on Systems Science, IEEE Computing Society, Los Alamitos, CA, January 2003. The authors thank the participants in the Information and Decision Sciences Workshop at the University of Minnesota, for comments on an early version of this paper. We also acknowledge the input from anonymous reviewers for HICSS-36 and JMIS, and the co-chairs of the “Competitive Strategy and Information Technology” Mini-Track, Eric Clemons and Rajiv Dewan, and the participants in our presentation there. Thanks also are due to Xiaotong Li and Angsana Techatassanasoontorn for helpful comments, the MIS Research Center for its support, and Michael Feldman, whose National Public Radio show suggested the title for this paper. Any errors of fact and interpretation are the sole responsibility of the authors.
INTRODUCTION

In recent years, we have observed many instances where information technology (IT) adoption forces potential adopting firms to gain a lucid understanding of the extent to which other firms are willing or actually ready to adopt. This occurs for a number of reasons, including the limited extent to which value flows occur without relatively complete adoption among business partners, the uncertainties that occur around the introduction of new ITs in the marketplace, and the relatively different capacities that firms have to accurately interpret new information flowing into their business environments. As a result, there is value that can be captured by those firms that develop an appropriate reading of the signals—a market sensing capability for IT innovations—that other firms key off in the economy that will ultimately lead to market-wide adoption decisions. This isn’t an easy process though; signals associated with other firms’ understanding of the business value of new ITs may be hard for many firms to interpret.

Orientation to the Relevant Literature on Decisionmaker Expectations and IT Adoption

The assumption that economic agents know or can predict the values of certain economic variables is frequently made in the Economics literature. In analyzing timing of new technology adoption by firms, for example, economic agents are assumed to know about post-adoption benefits [e.g., Jensen, 1982], technology costs [e.g., Stoneman and Ireland, 1983], and network externalities [e.g., Farrell and Saloner, 1985; Katz and Shapiro, 1985, 1986; Choi and Thum, 1998]. In most cases, however, there is little discussion about how these economic agents (i.e., managers) obtain their knowledge or form their expectations about the future value of an economic variable that will help them make a decision on whether to adopt.

In Information Systems (IS), researchers have examined the role of network externalities in the adoption of information technology (IT). Brynjolfsson and Kemerer [1996], for example,
examined the market for microcomputer spreadsheet software. They found that network 
externalities significantly increased the price of spreadsheet products, indicating that the 
adopters and users were willing to pay more because they expected an increase in the value of 
the product as the number of users increased. In an empirical study on shared electronic 
banking networks, Kauffman, McAndrews, and Wang [2000] found that due to the network 
externalities, firm adoption decisionmaking was influenced by the expected size of the shared 
network. In addition, due to their individual strategic positions, bounded rationality regarding 
the potential of the technology in the changing marketplace and different levels of capacity to 
process information, firms typically have heterogeneous perceptions of the business value of a 
given technology that they are considering adopting. More recently, Au and Kauffman [2001] 
examined the adoption of electronic bill presentment and payment (EBPP) technologies in 
financial services. The authors show that depending upon the expected level of network 
externalities, billers may decide to adopt the existing technology sooner rather than wait for the 
next technology to come to market, even though the next technology may prove to be superior.

Taken together, this research shows the importance of expectations—in addition to network 
externalities—in the development of theories of technology adoption. This is in line with 
Shapiro and Varian [1999, p.181], who maintain that “… success and failure [of a technology 
product] are driven as much by consumer expectations and luck as by the underlying value of 
the product.” However, how potential technology adopters (including firms and consumers) 
reach a certain level of expectations about the overall benefit of a new technology and which 
factors affect the formation of expectations have not been fully understood.

The theoretical models presented in the existing literature [Choi and Thum, 1998; Au and 
Kauffman, 2001] employ a two-period game-theoretic setup. These models assume that there
are two potential adopters (e.g., firms). One is considering adopting a technology in the first period and the other one will only consider the adoption in the next period. The first firm, which is considering adopting an existing new technology in the first period, will try to predict the action the other firm will take in the next period, when another technology becomes available. If the first firm believes that the second will adopt the same technology, then it will be more likely to decide to adopt the technology in the first period due to its expectations about network externalities. Otherwise, the first firm will be more likely to wait until the next period.

In reality, there are typically multiple firms that consider adopting a new technology in a certain period of time. These firms may be categorized into several “sub-groups”, with each sub-group representing firms that share similar characteristics or serve similar markets, etc. For example, in the EBPP case, a sub-group (or subset) can include utilities, telecommunications, or financial services firms that serve the same geographical market. Therefore, they can expect network externalities benefits when they adopt the technology together since consumers will be more likely to adopt the EBPP service as the number of firms (i.e., billers) offering the service increases. But the IS economics technology adoption literature has not adequately addressed is how these firms form their expectations that lead to this kind of “sub-group” adoption.

**Adapting Rational Expectations for Understanding IT Adoption**

In this paper, we discuss the *rational expectations hypothesis* (REH) and *adaptive learning* as explanatory theories to be applied in IT investment and adoption decisionmaking settings that require managers (as economic agents) to have the ability to form certain levels of expectations about the values of certain economic variables. We see this kind of thinking applied in many non-IS/IT contexts, where decisionmakers gauge the benefits associated with different courses of managerial action related to their perceptions about how beliefs in the economy are shaping up.
Such contexts include interest rate policy formation, financial market forecasting and money market trading, manufacturing industry investments for the production of durable goods, and policies in labor market wage-setting. We believe that the theories can also be applied in many IT investment and adoption settings that involve the development of expectations on the part of decisionmakers. For example, although the “bandwagon” phenomenon has been discussed in a series of papers [e.g., Farrell and Saloner, 1986; Choi, 1997], we offer an alternative perspective using the REH. If the REH holds, then the “bandwagon” phenomenon should be due to the adopters’ beliefs that they have learned enough and are comfortable with their predictions about the future state of the economy with regard to the technology. Of course, their learning processes also involve information related to prior adoption of the technology.

Our adaptation of these theoretical perspectives to the IT adoption context—the first time in the IS literature to our knowledge that REH has been used to examine the mechanism for business value expectations formation—will allow us to treat the investment and adoption issues using a perspective that is based on a longer time horizon. This is in line with the fact that most ITs have a multi-year lifecycle, making it essential to consider investment and adoption decisionmaking relative to them as an on-going process that involves long observation in the marketplace rather than a quick profit-maximizing decision. We believe this represents the actual challenge that managers face in their IT investment and adoption decision process. Consequently, we offer a new theoretical approach to improve our understanding of IT investment and adoption issues. The REH’s rather strong assumptions make it a unique theory and allow us to offer new perspectives on IS/IT adoption and investment decisionmaking. The theory is applicable to the fast-changing environment of IT where forward-looking decisions are
of the essence. It helps to better understand the complex nature of technology adoption in a dynamic way beyond what can be offered by the traditional views.

THE THEORY OF RATIONAL EXPECTATIONS AND ADAPTIVE LEARNING

The rational expectations hypothesis (REH) has attracted as many supporters as critics since it was first formulated by Muth in his 1961 seminal article [Muth, 1961]. Its most well-known applications are found in the works of Lucas, Sargent, and others in the early 1970s (e.g., Lucas [1972, 1975], and Sargent and Wallace [1976]) on the new classical explanations of output and inflation. The REH makes some rather strong assumptions and, as a result, is very different from another popular theoretical perspective called adaptive expectations.

Adaptive Versus Rational Expectations: Basic Concepts

Expectations are related to past information available to economic agents or firms. A classic example involves a lag of production, where a farmer must estimate the price of corn “tomorrow”—at which time the corn will be harvested—in order to decide how much to plant “today.” Nerlove [1958] uses an adaptive expectations model to show that farmers’ planting decisions depend upon and are adapted to the prices they expect to receive when the crop is marketed. In turn, the actual price for the crop depends on the amount finally harvested and the current level of demand. A basic model is formulated, with the corn price anticipated by a farmer in period \( t \) is given by

\[
p^a_t = p^a_{t-1} + \eta (p^a_{t-1} - p^a_{t-1}),
\]

where \( p^a_{t-1} \) is the anticipated price in period \( t-1 \) (as of \( t-2 \)), \( p^a_{t-1} \) is the actual spot price in period \( t-1 \), and \( 0 < \eta < 1 \).

Grossman [1981] reminds us that this is a distributed lag model with the form:

\[
p^a_t = \eta \sum_{j=0}^{\infty} (1-\eta)^j p_{t-j-1}.
\]

To see how Muth’s rational expectations notion differs from Nerlove’s adaptive expectations model, let us suppose that the stochastic process generating
prices \( \{p_t\} \) is given by \( p_t = \begin{cases} 1 & \text{for } t \leq 1 \\ 2 & \text{for } t \geq 2 \end{cases} \). Then, following a distributed lag model we have

\[ p_2^a = 1, \quad p_3^a = (1 - \eta) + 2\eta, \quad \text{and} \quad p_4^a = (1 + \eta)(1 - \eta) + 2\eta, \quad \ldots, \lim_{t \to \infty} p_t^a = 2 \] under adaptive expectations. However, with rational expectations, \( p_2^a = 2 \) since \( p_2 = 2 \).

This illustrates that under adaptive expectations, agents need time before they learn that the price has changed from $1 to $2 since all they do is look at past prices. On the other hand, the rational expectations notion assumes that people know the stochastic price process in Equation 3 so they know that after \( t = 1 \), the price will have changed permanently from $1 to $2.

**The Rational Expectations Hypothesis (REH)**

The essence of Muth’s [1961] rational expectations is that economic agents form their expectations on the basis of the “true” structural model of the economy in which their decisions are made. So, expectations are essentially the same as predictions of the relevant economic theory: their expectations are informed predictions of future events. The REH equates agents’ subjective, psychological expectations of economic variables to the mathematical conditional expectation of those variables. REH treats subjective expectations on average as equal to the variables’ true values, and is a central tenet of the theory. Muth suggests we should expect economic actors to change the way they form their expectations if the underlying economic system changes and, thus, should not be satisfied with adoption evaluation functions and models with fixed expectations that do not allow change.

Lucas [1975] interprets the REH as an hypothesis that assumes every economic agent optimally utilizes available information in forming expectations. He proposes the minimum mean square error criterion for assessing the optimality of individual expectations. Using this optimality criterion, individual agents are assumed to form their forecasts by minimizing the
expectation (based on the equilibrium probability distribution) of the forecast error conditional on information available to them. The rational expectations solution is based on the assumption that individuals behave optimally [Fryman, 1982].

**Information Requirements and Assumptions in REH**

Although the information requirements that REH makes on agents are no more than in models with lags, the theory presupposes they know the stochastic process generating the equilibrium condition, so they know a great deal about the economy. This is in addition to the belief that every economic agent optimally utilizes available information to form expectations. Application of the ideas came with theory development for agent reactions to adjustments in macroeconomic and monetary policy variables that have been characterized by noted economic theorists, Lucas [1972, 1975], Sargent and Wallace [1976], and Sims [1980] in the *rational expectations economics* literature [Lucas and Sargent, 1981; Pesaran, 1987; Sheffrin, 1996].

However, this assumption often is considered as too strong. Why? It requires economic agents have full knowledge of the structure of the relevant models and their parameter values. It also requires that random shocks affecting economic agents’ expectations are independent and identically distributed. A weaker assumption is more appropriate: that economic agents act like econometricians when they make forecasts about the future—they update their expectations about relevant parameter values on the basis of newly-received information. So, even if economic agents may not know the true model *a priori*, they eventually learn enough about it through efficient use of available information over time to make their expectations virtually identical to those based on the true model. This perspective, based on a form of bounded rationality, is called *adaptive learning*, and allows agents to adjust their forecast rule as new data become available [Sargent, 1993; Evans and Honkapohja, 2001].
Simon [1957] argues that bounded rationality exists because economic agents have limited cognitive resources and capabilities, and it is often hard for them to obtain the solution algorithms required to deal with all available information. So they cannot figure out how to optimize by the time a decision is to be made. With bounded rationality, agents are assumed to learn to use reasonable model specifications (and choose meaningful parameters), which are appropriate in the observed outcomes but misspecified when there is learning.1

Adaptive expectations and adaptive learning are two different notions. In adaptive expectations, economic agents form their expectations purely based on past information, but adaptive learning is a variant of REH. It assumes economic agents know the structural model of the economy or the marketplace but provides some flexibility by allowing learning to take place. The result is that although agents initially may not know the exact models, they can learn about the parameter values and eventually make good forecasts about the future.

Rational expectations are often justified as the point of convergence of a recursive learning process, and the problem of “learning” has been studied mainly in the context of microeconomic models that involve a rational expectations equilibrium (REE). Pesaran [1987] refers to REE as a condition where all acts of learning are complete, in the sense that there is no incentive on the part of economic agents to change the beliefs they hold about their economic environment. He characterizes an REE by three main features: all markets clear at equilibrium prices; every economic agent knows the relationship between equilibrium prices and private information of all other agents; and the information contained in equilibrium prices is fully exploited by all agents in making inferences about the private information of others. Thus, understanding the

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1 However, we note that there are limitations to this way of thinking, as illustrated by the large body of literature that deals with decisionmaking anomalies and cognitive biases. See, for example, Conlisk [1996].
mechanism for information transmission is critical to understanding the interactions among
agents that lead to observed outcomes in the market.\(^2\) The characteristics of an REE imply that
everybody “knows” (in a probabilistic sense) everything about the way the economy functions,
and the adaptive learning models assume that economic agents know the correct specification of
the equilibrium relationships between market prices and private signals but are uncertain about
some of the parameters of those relationships.

Learning about equilibrium relationships can prove to be complicated because it involves
learning about other agents in the economy. Since other agents are also learning, agents are
learning about others’ learning and so on [Routledge, 1999]. This complexity is what makes the
adaptive learning theory appealing though. Adaptive learning does not require assumptions of
boundless rationality or that individuals have a complete and correct model of the economy.

Herd Behavior

During the learning process, there are numerous situations in which people are influenced by
what others are doing. When visiting another city, for example, we often decide on which
restaurant to try based on our perception about the popularity of each restaurant in the vicinity.
Banerjee [1992] uses an illustration in which 100 people have to choose between two restaurants,
A and B, which are next to each other. These people do not have much information about the
restaurants except for some initial signals—which may not be correct—about the quality of each.
They arrive at the restaurants in sequence and observe the choices of the people before them
prior to making their own decision. Now, suppose that 99 of the 100 people have been signaled
that Restaurant A is better, but the one whose signal favors Restaurant B arrives and makes a
decision first. Since the initial signal that each person has received is imperfect (as the

\(^2\) The interested reader should see the body of literature in Economics on *information transmission* and
information that each has received is incomplete), the second person may ignore her own preference of Restaurant A and choose B instead. The third person (and so on) may do the same, with the result that everyone may end up going to Restaurant B. Bikchandani and Sharma [2001] use a similar example to illustrate this idea in the financial markets and investment context.

Bikchandani, Hirshleifer and Welch [1992, 1998] call the above clustering activities herd behavior—everyone does what everyone else is doing. He argues that the decision of the second person to ignore her own information and join the herd imposes a negative externality on the rest of the group. If the second person had used her own information, her decision would have encouraged the rest of the group to use their own information as well. This phenomenon is also known as an informational cascade, since the suppression of decisionmakers’ private information will result in the revelation of less and less new information as more and more of them join the flock. This process involves a complex “I know you know he or she knows we know …” quality of interaction, leading to interdependent decisions whose paths may be hard to predict, moving the market towards inefficiency [Lohmann, 2000]. Banerjee [1992] calls it a “herd externality” and distinguishes it from other behaviors that are based on strong complementarities—when some things are more worthwhile when other people are doing related things—such as network externalities. However, despite its potentially inefficient outcomes, herd behavior may be seen to be individually rational in a utility-maximizing sense if other decisionmakers are considered better-informed, or if making a contradictory decision that deviates from the consensus can be costly as in the remuneration of fund managers [Hwang and Salmon, 2001].
Herd Behavior and Network Externalities

Although it may lead to inefficient herd externalities, herd behavior naturally occurs in the presence of network externalities due to the fact that network effects can only be realized when a cluster of adopters is formed. Choi [1997] offers the following example. Suppose there are 100 potential adopters who must choose between Technology A or Technology B. Suppose the first adopter chooses A. The second adopter, knowing that the first’s selection, must decide between A and B. If the second knows for sure that B is superior to A, then she will choose B. Pure network effects alone will not deter her much, since only one adopter has selected A, and presumably the other 98 potential adopters also know that B is better and will select it. However, if it is uncertain whether B will be superior to A, then the scenario will change. The second adopter now worries that if she selects B and later it turns out that B is inferior to A, then everybody else will choose technology A and she will be stranded without any network effects. Therefore, the second adopter will decide to choose A and, based on the same rationale, so will all the remaining adopters. Technology B will never be adopted by anybody, and a bandwagon for Technology A will develop.

Herd behavior in the above example is motivated by the fear of being stranded. In his model, Choi [1997] demonstrates that in the presence of network externalities, once a technology is adopted and its true value revealed, the technology will be in a favorable position relative to another technology whose value is uncertain, in the sense that the “proven” technology can be successively selected by everybody even when it later becomes common knowledge that the unproven one has a much higher expected value. This generates inefficiencies in the economy.

The herd behavior discussed above is based on an obvious intent by decisionmakers to imitate the behavior of other decisionmakers. Bikchandani and Sharma [2001] distinguish this
sort of *intentional herding* from *spurious herding*, where independent decisionmakers who face similar decision problems and information sets take similar decisions, induced by the movement of the fundamentals. An example is the widespread equity selling that happens when interest rates suddenly rise and stocks become less attractive investments because investors prefer the returns available to newly-issues fixed income securities or in the money market. In this case, the investors are not reversing their decisions after observing others, but instead they are reacting to commonly-known public information, which is the rise in interest rates. Unlike intentional herding—which may not be efficient—spurious herding tends to result in market-inefficient outcomes.

Spurious herding is more in line with the conjectures stipulated by the REH and adaptive learning. The perspectives that we offer in this paper are based on the assumptions that potential IT adopters are willing to observe each others’ behaviors that pertain to the potential adoption of the technology and will adjust its own behavior accordingly before making an adoption decision.

The reader should recognize that there are other different views on the clustering behaviors. For example, one could argue that some may adopt a technology because others have adopted it so as to reduce their incompatibility cost. This kind of rational behavior, while similar to herd behavior, is a fully rational response to externalities and may lead to the “bandwagon” equilibrium. The common reason for this to occur is the existence of multiple Nash equilibria and a lack of coordination of choice amongst them. Similar to herd behavior, this may lead to a socially sub-optimal system. Another view is that some players may have an information advantage over others because of investments in information gathering or exogenous endowments. While these players may not be identified, their choices can be revealing. This is the game played in financial markets. No one knows who is and who is not informed.
observe are trading volumes and prices. Others who make their trading decision use information in these trades. There is considerable debate on exactly how this occurs and some even posit a herd type trading behavior that may give rise to bubbles. However, REH and adaptive learning suggest that market bubbles will burst because players or agents will eventually learn the true value of the financial securities.  

**Rational Expectations, Adaptive Learning and IT Adoption**

Although it entails individual rationality, the herd behavior theory assumes no information sharing among the decisionmakers prior to when they make a decision. In addition, it ignores the fact that decisionmakers may actually wait until they collect enough information before making a major investment decision. In fact, the herd behavior theory defies a very basic assumption of economic behavior: that decisionmakers as economic agents do the best they can with what they have. Rational expectations adaptive learning, on the other hand, assume that decisionmakers will utilize all available information efficiently and are able to learn the true values of a prospective investment over time. Indeed, the key difference between the REH and herd behavior theories lies in the amount of information that is used. REH implies that decisionmakers as economic agents form their expectations as if they are fully informed of the process which ultimately generates the real outcome of the variable concerned. In addition, adaptive learning permits the necessary adjustment by allowing learning to take place over time.

We now offer an alternative perspective on the issue of new IT adoption and investment based on the REH and adaptive learning views. Suppose there is a “sub-group” of $N$ potential adopting firms having to decide whether to adopt a new technology or wait until another, possibly better technology becomes available. The technology exhibits strong network

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3 Rajiv Dewan offered useful suggestions regarding these perspectives on herd behavior in this passage, specifically the *incompatibility cost* and the *lack of coordination* for adopter choices.
externalities. Due to the expectations about network externalities that the technology will bring, all $N$ firms in the sub-group must adopt at about the same time, i.e., when they have learned that the other $N-1$ adopters are also ready to adopt the same technology. This is to prevent any firm from getting stranded with a technology that no other firm would choose. This portrays their risk aversion to extreme outcomes following adoption.

Initially firms may have different levels of expectations about the value of the technology and, therefore, different levels of willingness-to-pay. A firm’s willingness-to-pay for a technology will determine the maximum price the firm is willing will pay to buy the technology. To achieve contemporaneous adoption decisions, all firms must reach a level of willingness-to-pay above the price set by the technology supplier. So if some firms have a willingness-to-pay below the price set by the technology supplier, then all firms will defer adopting.

We assume the free flow of information among the potential adopting firms. We could argue that the free flow of information would be hard to justify when there are externalities present. Why? Because a firm may find it to be in its interests to overstate the benefit of a technology so that others will adopt it too. The cost of this kind of behavior for followers is called an influence cost. But the REH and adaptive learning theories maintain that this is not going to happen. A firm may overstate a technology’s benefit, but other firms—based on REH and adaptive learning’s assumptions—will not easily buy such overstatement. Instead, they take in all available information and exercise care in learning what it tells them before making a decision.

Adaptive learning allows us to construct a scenario in which potential adopting firms are allowed to learn—to look for common signals as well as benchmark against each other—and adjust their expectations about the benefit of the technology. In this case, we consider a multi-period situation, where each firm will collect new information—including the willingness-to-pay
of each of the other firms—at the end of every period and adjust its own willingness-to-pay for
the technology based on the new information it receives. The learning process will take place
until all $N$ potential adopting firms agree to purchase the technology at a certain price, which
should be the same or below the level of willingness-to-pay of each of the firms. (We assume
that the indifference level is sufficient to motivate the purchase and adoption of the technology.)
This is a state of rational expectations equilibrium—an REE—where all acts of learning are
complete. Thus, there will be no incentive on the part of the potential adopting firms to further
adjust the beliefs they hold about the potential benefits. All firms are now ready to invest. The
REE is not always achieved though. This occurs when some potential adopting firms never
come to an agreement about the potential value of the technology. When the REE is not
achieved, no adoption takes place and the potential adopter may wait for the next technology.

This scenario is different from the “penguin analogy” offered by Farrell and Saloner [1986]
and Choi [1997]. In their examples, decisionmakers decide to choose simultaneously—just like
penguins decide to plunge into the water at the same time when no one is willing to test the water
—because of collective ignorance. However, this contradicts the assumptions of REH and
economic behavior. We assume that each potential adopting firm is fully informed and does not
want to sacrifice the option to wait to adopt due to the belief that new information will arrive
over time and the information will improve the quality of its decision.

Propositions

To complete the introduction of the new theoretical ideas in this section, we offer a number
of propositions to summarize the thrust of our thinking. These propositions are intended to
exemplify the multiple ways that the theory characterizes the expectations development process
leading up to decisionmaking about IT adoption and the observed outcomes in the marketplace.
□ **Proposition 1 (The IT Value Expectations Alignment Proposition).** IT adoption decisionmakers observe the environment and try to align their expectations with those of the other decisionmakers before making an IT adoption decision. This alignment is necessary to confirm each decisionmaker’s own expectations about the value of the IT being considered. ⁴ We also call this the “Whad’Ya Know? Proposition.”

□ **Proposition 2 (The Adaptive Learning Proposition).** Decisionmakers utilize all available information efficiently to establish an initial basis for expected value and willingness-to-pay, and then continue to obtain new information over time to learn about the “true” value of a prospective investment before making an IT adoption decision.

□ **Proposition 3. (The Network Externalities Construction Proposition).** Decisionmakers continue to share information with each other about their perception of the expected value of the technology prior to making an IT adoption decision. This assures them that all others will adopt the same technology to realize the benefits from network externalities. ⁵

□ **Proposition 4. (The Spurious Herd Behavior Proposition).** Decisionmakers base their IT adoption decisions on commonly known public information and business fundamentals, instead of simply following the adoption behavior of others. ⁶

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⁴ Alignment of expectations in Proposition 1 means decisionmakers benchmark against each other and adjust their expectations accordingly. This signifies the “Whad’dYa know?” notion where they learn from each other (through conversation, cheap talk, etc.), in addition to getting information from other sources in order to find out about the true equilibrium state of the economy. Over time, we expect that all the decisionmakers will be able to form a consensus about their expectations. This consensus may be different from any of the expectations the decisionmakers had initially.

⁵ This proposition is based on REH and adaptive learning. In the real world, contradicting theories are likely to hold in different situations.

⁶ The other theories involve incompatibility cost reduction and asymmetric information. They suggest that decisionmakers can follow others. However, simply following others is not consistent with the REH and adaptive learning theories. In fact, this is where these theories differ from the others.
Proposition 5. (The Sub-Group Benchmarking Proposition). Decisionmakers benchmark against each other to align their expectations and share information within a targeted sub-group. Members of the sub-group will typically share similar characteristics and objectives (e.g., competing firms in a market segment). 7

Taken together, the five propositions maintain that decisionmakers utilize all available information, share information among themselves, align their expectations with each other within a particular sub-group, rely on commonly know public information and fundamentals, and are willing to gather new information and learn before making their IT adoption decisions.

AN EVALUATIVE FRAMEWORK FOR RATIONAL EXPECTATIONS IT ADOPTION

In deciding whether and when to adopt a new IT, a firm should consider the “I know you know he or she knows” interdependencies among multiple parties with regard to the IT, in addition to its characteristics. The firm must gather information about the IT and its potential value, and also about other parties’ perceptions. We next present an evaluative framework that captures the critical elements of adoption settings that permit us to assess the applicability of the REH and adaptive learning theory in real contexts for IT adoption, and what can be learned.

Evaluative Framework

An evaluative framework will help us to assess the mechanics related to the various settings in which REH and adaptive learning theory provide useful managerial insights. We note the following four evaluative dimensions in terms of the typical kinds of IT adoption problems that the theory seems to address fairly well, and for which it goes beyond the explanations that are offered by other theoretical perspectives in the existing literature:

7 With Proposition 5, we would like to emphasize that the alignment of expectations (as suggested in Proposition 1) may occur within sub-groups of firms. There may be some alignments among sub-groups of firms but these do not always occur.
IT adoption in the presence of network externalities. Network externalities sometimes present a unique challenge to firms that engage in IT adoption decisionmaking process.

Emerging IT adoption. Organizational adoption of emerging ITs often requires decisions to be made amid great uncertainties about their potential and future in the marketplace. One of the shortcomings of the contributions in the existing literature is that only one new IT is typically considered in many of the analyses (e.g., Jensen [1982]; Stenbacka and Tombak [1994]). In reality firms must deal with the possibility of seeing newer, and probably better technologies in the future. Prior to making a decision to fully adopt an emerging IT, firms often conduct pilot projects in order to obtain first-hand learning experiences about the accompanying payoffs.

Time-constrained IT adoption. Time-constrained IT adoption presents a greater challenge to decisionmakers since they have to make a decision in a short enough time so that they may not have the ability to collect all of the relevant information necessary for making a comfortable decision. Unfortunately, the current literature has little discussion about this issue, as previously noted by Benaroch and Kauffman [2000]. The REH and adaptive learning assume that technology investment decisionmakers reach a reasonable level of comfort (based on the concordance of their own assessment with the assessments of others) about the value of the technology before making a decision. Time-constrained IT adoption decisions will require a greater capability on the part of the decisionmaker to gather and process as much relevant information as possible—even if it is incomplete relative to the fuller information that may be developed over a longer period of time.

Complex firm relationship-driven IT adoption. IT adoption that involves more than two different kinds of parties (e.g., a bank, a customer, a brokerage firm, and an
insurance firm) represents a much more difficult situation. Why? Because decisionmakers must understand the expectations of all parties involved. REH and adaptive learning assume that decisionmakers consider all relevant information that pertains to all parties involved in the adoption decisionmaking process, since each of the parties’ adoption decisions is likely to impact the others. Therefore, it will be appropriate to use the theory to analyze the issues that relate to multi-partite technology adoption, so that useful managerial insights can be obtained.

The identification of the key adoption elements that we have mentioned above allows us to develop an assessment framework, whose contents consist of a number of evaluative questions that test the efficacy of the theory in various settings—for applications of the REH and adaptive learning theory in IT adoption. The framework is presented in Table 1.

### Table 1. Evaluation Framework for Application of Rational Expectation Theory in IT

<table>
<thead>
<tr>
<th>Adoption Setting</th>
<th>Evaluative Questions</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT adoption in the presence of network externalities</td>
<td>Do REH and adaptive learning adequately explain the adoption of ITs that exhibit network externalities?</td>
<td>REH and adaptive learning can be used to explain how decisionmakers make adoption decisions at about the same time, thus making sure that network effects will be realized.</td>
</tr>
<tr>
<td>Adoption of emerging ITs</td>
<td>Do REH and adaptive learning adequately explain the adoption of emerging technologies?</td>
<td>Emerging technologies require decisionmakers to assess the value of IT amid uncertainties that are sometimes very large. This requires a clear understanding of the impact of the IT on the future state of the marketplace (or the economy, as stipulated by the assumptions of REH).</td>
</tr>
<tr>
<td>Time-constrained adoption of IT</td>
<td>Do the REH and adaptive learning provide a basis for analyzing time-constrained technology adoption?</td>
<td>REH and adaptive learning assume that IT adoption decisions are made only after decisionmakers feel comfortable with their assessment about the projections of value. Time-constrained adoption decisions require a greater capability on the part of the decisionmakers to gather and process information.</td>
</tr>
<tr>
<td>Complex firm relationship-driven IT adoption</td>
<td>Do REH and adaptive learning adequately characterize IT adoption that involves more than two different kinds of firms?</td>
<td>REH and adaptive learning assume that decisionmakers consider all relevant information thatpertains to all parties involved in the adoption decisionmaking process. It also provides a basis for representing the complexity of the information sharing and the feedback loops that exist in multi-partite adoption settings.</td>
</tr>
</tbody>
</table>
APPLICATION AND ASSESSMENT OF RATIONAL EXPECTATIONS IN IT ADOPTION

We next present three mini-cases that discuss and analyze the adoption of new ITs, and show how we can use the assessment framework to evaluate the extent of the managerial insights that REH and adaptive learning theory can provide.

Complex Firm Relationships in IT Adoption: The Case of Electronic Bill Payment

A key element of many ITs is the network externalities on their users. Network externalities capture the idea that the value of a technology will increase with the number of users. An example of current interest is electronic bill presentment and payment (EBPP) systems, one of a number of payment technologies identified by a recent Federal Reserve Bank of Chicago study as an “emerging payment technology” (also including person-to-person payments, stored value cards, Internet currencies, electronic checks and online debiting of accounts) [Dove Consulting, 2001]. EBPP allows consumers to view and pay bills electronically, merchants and banks to share billing-related documentation in automated fashion, supporting customer transactions. EBPP exhibits network externalities since the more billers that offer the service, the more consumers are willing to sign up. The feedback loop works in reverse as well, since the more consumers that adopt the system, the greater will be the value that is conferred upon all of the kinds of players that participate. In a word, the installed base of users is critical.

There are several major groups that have been trying to entice billers and consumers into using EBPP services. The first group consists of bill consolidators. They act as third-party aggregators of data from multiple billers. They prepare bills for presentment—the act of sending out bills to consumers—through arrangements with banks or popular Internet portals, such as Yahoo and America Online. The second group involves commercial banks, which are central to
the exchange and settlement of value in billing transactions. They can provide both bill payment services, as well as consumer payment services, as shown in Figure 1, although heretofore specialty firms usually have played that role. (See Figure 1.) The third group is the billers or vendors themselves (e.g., electricity and telephone companies, and department stores, etc.).

**Figure 1. The Multiple Parties Associated with the EBPP Business Process**

Note: Figure excerpted from materials on Metavante Corporation’s home pages ([www.metavante.com](http://www.metavante.com)), depicting end-to-end processing capabilities in EBPP, and illustrating the necessity for multi-partite adoption.

A number of the commercial banks previously organized themselves into a bank EBPP services operations consortium called Spectrum EBP, including J. P. Morgan Chase, Wachovia Corporation, and Wells Fargo. (See Au and Kauffman [2001] and Spectrum EBP [2002] for additional details.) Spectrum EBP is now owned by Metavante Corporation ([www.metavante.com](http://www.metavante.com)), a Milwaukee, Wisconsin-based financial technology provider. It is now recognized as the second leading electronic billing services provider after Checkfree Inc. ([www.checkfree.com](http://www.checkfree.com)). Metavante has spent a lot of money developing online billing services and devising a standard for EBPP services. Its recent acquisitions of Derivion Inc. and Cyberbills Inc. now permit Metavante to claim that it is the only end-to-end operational services provider in this area of financial services [Metavante Corporation, 2002]. This provides the basis for the “perfection” of the EBPP business process through acquisition strategy [Dai, 2003].
Morgan Stanley Dean Witter [2000] reported that it expected the “inflection point” separating slower from more rapid adoption of EBPP to be reached in late 2001. In spite of the interest in EBPP, the *American Banker’s Association Journal* reports that adoption is proceeding at a handful of banks, but that broader penetration of EBPP services in the economy will take additional years to accomplish [Bielski, 2003]. A recent Tower Group report states that:

“Adoption of electronic bill presentment and payment [...] is lagging behind the optimistic projections of recent years. Although there is positive evidence that use of these services is beginning to accelerate, banks, billers, and vendors cannot afford to sit idly by as the market takes its course. The value returns of EBPP [...] cannot be achieved without the participation of all parties. ... Adoption issues are at the core of the sluggish growth, affecting all major stakeholder groups ... [Tower Group, 2002a]

Bill consolidators—including the market leader, CheckFree—seem to be more ready with their own EBPP service offerings than the banks do at this time. However, Metavante’s acquisition of the various EBPP technology services players now positions this firm for growth as more of a neutral non-bank third-party technology provider, in spite of the fact that its owner, Marshall and Ilsley Corporation, also owns several regional banks. Banks are signing up gradually, amounting to about 2,600 adopters as of February 2003 according to Bielski [2003].

Billers will benefit from the adoption of EBPP technology since it helps save them money from the reduced costs of generating and mailing bills. In addition, they can also use the technology to enhance their relationships with consumers. For example, they can offer new services based on dynamic and real-time information exchange, as well as personalized marketing campaigns that target specific groups of consumers. As a result, most industry observers view the adoption of the technology as just a matter of time for every biller. However,
each biller must decide whether it should adopt the technology now, or wait until the competition between CheckFree and Metavante sorts itself out. Billers also will need to decide whether to adopt the current technology soon, or wait until the more complete technology solutions become available in the future. A critical piece of the IT adoption puzzle for them will be whether they anticipate large enough network externalities benefits from adopting the current technology. But as of February 2003, only 2% of 20,000 American commercial and community banks and credit unions have announced EBPP initiatives. Moreover, just 13.7% of households in the U.S. use EBPP, although this is up from 2% as recently as 1988 [Tower Group, 2002b].

Consider one of our evaluation framework questions here: “Do REH and adaptive learning adequately explain the adoption of ITs that exhibit network externalities?” As Proposition 3 (The Network Externalities Construction Proposition) suggests, we believe that these theoretical perspectives offer useful interpretative insights into how various kinds of firms share information and form their expectations about the network externalities and other benefits. This occurs when each player (including consumers, banks, billers, bill consolidators, etc.) in this complex multipartite IT adoption setting observes other players’ demeanors and expectations that pertain to the potential adoption of EBPP technology. When players acquire relevant new information, they will adjust their own expectations accordingly, possibly resulting at some point in a positive adoption decision. If a convergence of expectations occurs (e.g., billers develop similar attitudes toward adopting the current technology as banks and consumers), then widespread adoption will take place in a relatively short period of time. Otherwise, some form of subsidies to those parties to adoption that have the least well-formed expectations about the potential payoffs will be required to get market adoption going. A recent case in point is Bank of America, which made EBPP services free in 2002, after their efforts to generate market interest seemed to stall. This
pricing policy change led to a 112% growth in service usage, and an additional installed base of 200-plus billers [Emtec Inc., 2002]. Prior to this time, their success in achieving widespread interest and adoption lagged senior managers’ and external observers’ expectation.

This case points to the ability of REH and adaptive learning theory to characterize the underlying process of IT technology adoption that involves a number of different kinds of firms. In other words, we can apply another of our evaluation framework questions: “Do REH and adaptive learning adequately characterize IT adoption that involves more than two different kinds of firms?” An equity research report in 2000 by Morgan Stanley Dean Witter captures the essence of the “Should we wait?” problem with complex multi-partite IT adoption, and which REH and adaptive learning theory are able to interpret:

“Clearly, adoption [of EBPP services] has been very slow [up to April 2000] ... again, the result of the chicken-and-egg problem. The billers have been waiting for customer adoption before they enable their bills, while customers have been waiting, and continue to wait, for a number of their personal billers to be enabled before they use the Internet to receive and pay their bills.” [Morgan Stanley Dean Witter, 2000, p. 33].

We should emphasize that it is not necessary that the whole universe of consumers and different kinds of firms converges in their expectations before EBPP adoption can take place. This is unrealistic. Our interpretation of the theory recognizes the extent to which appropriate “sub-groups” of adopters define the boundaries of the market adoption, including appropriate groups of consumers, banks, billers and so on. We see this elsewhere, for example, with asymmetric “price-tier” competition in retailing [Blattberg and Wiesniewski, 1989]. This makes the new theoretical perspective all the more
powerful, since it permits an analyst to assess how adoption is progressing with the idea of “adopter tiers” in mind. Indeed, one expects willingness-to-pay levels to be different across different kinds of firms over time, but somehow, so far as we know, firms in the marketplace are always able to establish a fairly good sense of the other firms that they need to be tracking.

**Emerging ITs That Will Be Strategic: The Case of Wireless Fidelity (Wi-Fi)**

*Wireless Fidelity (Wi-Fi)* is used to refer to networks that use radio technologies to provide wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, as well as to wired networks. Although the term “Wi-Fi” was initially referred only to the IEEE 802.11b standard, the Wi-Fi Alliance has expanded the generic use of the term to also include the IEEE 802.11a and, possibly in the near future, the IEEE 802.11g standards. The Wi-Fi Alliance was formed in 1999 to certify interoperability of wireless local area network products based on the IEEE 802.11 specification. Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, with an 11 Mbps (802.11b) or 54 Mbps (802.11a) data rate. They also work with products that contain both bands, the so-called “dual band” capability, creating the basis for near-universality and connectivity, as we have seen with Cirrus and PLUS shared network “duality” for automated teller machine interoperability [Kauffman and Wang, 2002]. Products that have been tested and approved as "Wi-Fi Certified" by the Wi-Fi Alliance are certified as interoperable with each other, regardless of manufacturers or brands. The growth in Wi-Fi Certified products since early 2001 has been dramatic, pointing towards the impetus for future expansion in installed base, as well as across different kinds of products. (See Figures 2 and 3.)
Figure 2. Measured Growth in Wi-Fi Products By Year (2000-2002), as of October 2002

Source: Adapted from Wi-Fi Alliance [2003]. In April 2003, the Wi-Fi Alliance has 193 member companies globally, and 611 products were compliance-certified. Data as of October 31, 2002.

Figure 3. Breakdown of Types of Wi-Fi-Compliant Product Diversity (2003)

Source: Adapted from Wi-Fi Alliance [2003]. Data as of April 2003.

Wi-Fi networks in public places known as “hot spots” are being built by commercial service providers such as AT&T Wireless Services and T-Mobile Inc., the largest providers in the United States, and by thousands of community do-it-yourself hobbyists worldwide. Many of these
community hot spots allow the public to access e-mail and the Web for free. In fact, BusinessWeek reports that some 5,000 free hot spots have emerged with more than 18 million people worldwide have logged on, and the numbers continue to grow every day [Green et al., 2003]. T-Mobile already has wired up many airports in the United States, as well as Borders Bookstores and Starbucks, and it recently announced that it would create 1,000 more hotspots at Kinko’s locations [T-Mobile USA Inc., 2003]. Clearly, Wi-Fi is moving into the mainstream.

The current major challenge is to make Wi-Fi an industrial-strength solution. This includes making sure that hotspots are reliable and have airtight security systems [Green et al., 2003]. It also means bringing adoption of Wi-Fi across international operating regions of the largest corporate investors. However, interest in Europe (with only 8% of all adopting Wi-Fi-compliant device producers) pales in comparison to the commitments that are observed in the United States and Asia (each with 46% of all adopting Wi-Fi-compliant producers) [Wi-Fi Alliance, 2003].

Despite these and other outstanding issues, many large corporations have recognized the potential of Wi-Fi and have started to invest in the technology. General Motors Corporation, for example, has partially deployed Wi-Fi in ninety manufacturing plants. However, GM apparently is still holding off on the technology at its headquarters for security reasons [Green et al., 2003]. Figure 4 suggests the current expectations of several aspects of the Wi-Fi standard and its applications that will be developing in parallel over time. Note the entries for upgrades to the security capabilities of Wi-Fi, since they are a major consideration in corporate adoption. But even with these planned upgrades, industry observers still are cautious about the level of market
acceptance that lies ahead, in view of competing technologies and standards.  

**Figure 4. Wi-Fi Alliance’s Planned Enhancements to Wi-Fi That Create Adoption Inertia**

<table>
<thead>
<tr>
<th>Planned Enhancement</th>
<th>Estimated Task Group Completion</th>
<th>Product Availability</th>
<th>Earliest Wi-Fi Alliance Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Multimedia Support</td>
<td>Q3 2003</td>
<td>Q4 2003</td>
<td>Q1 2004</td>
</tr>
<tr>
<td>802.11a for Europe</td>
<td>Q2 2003</td>
<td>Q3 2003</td>
<td>Q4 2003</td>
</tr>
<tr>
<td>Enhanced Security</td>
<td>Q4 2002</td>
<td>Q4 2002</td>
<td>Q1 2003</td>
</tr>
<tr>
<td>AES Enhanced Security</td>
<td>Q4 2003</td>
<td>Q4 2003</td>
<td>Q1 2004</td>
</tr>
<tr>
<td>802.11g</td>
<td>Q2 2003</td>
<td>Q4 2002</td>
<td>Q2 2003</td>
</tr>
</tbody>
</table>

**Source:** Adapted from Wi-Fi Alliance [2003]. All availability dates are estimates.

Another evaluation framework question makes sense to ask in this context: “Do REH and adaptive learning adequately explain the adoption of emerging technologies?” In other words, do they offer insights about what we are observing with the adoption and diffusion of Wi-Fi?

Nicholas Negroponte, Director of MIT’s Media Lab, comments:

“Wi-Fi is like the Internet itself, reenacting the bottoms-up process that surprised people so much. ... The benefit this time is a little different, however. The value of fixed wireless—call it nomadic computing—is very much something unto its own. It changes the way people meet, where they work, and how they stay connected.” [Quoted from BusinessWeek, 2003].

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8 A recent news item on MobileInfo.com makes this point. “In spite of short-term confusion ... [about embedding Wi-Fi chips in handheld computers], ... embedded chips in handheld devices ... will reduce costs and introduce standardization. However, the picture is not quite clear with smart phones. Bluetooth might be a more appropriate standard because of cost and handset manufacturers’ reluctance to adopt Wi-Fi that quickly. Convergence can be and should be handled at the workplace access point level in our view of the local wireless connectivity architecture. Remember, we still need to worry about the wide area wireless networks—GPRS, 1xRTT and eventually 3G. That will make the workplace access point a more sophisticated box with WLan and wide-area wireless connectivity” (MobileInfo.com, 2002).
Negroponte’s comments suggest that “fixed wireless” (in contrast to the roaming connectivity that cellular cell phone services provide) will be gradually better understood by corporations that consider investing in it relative to the value that it can provide in the consumer marketplace. REH and adaptive learning-based thinking suggest that there will be a progression from issue to issue, and value driver to value driver that will be necessary for information about Wi-Fi’s value to effectively diffuse to decisionmakers in the economy.

It is natural that firms that invest early in Wi-Fi will want to do so with the creation of “real options” in mind, choosing to wait (to some extent), and obtain a first-hand learning experience prior to making a full commitment. This is in line with Proposition 2 (The Adaptive Learning Proposition). So the REH and adaptive learning perspectives permit us to predict the process through which some of the “wait and see” issues will be worked out, as the capabilities of the new technology expand. Indeed, we expect corporate Wi-Fi technology investors to be rational expectations investors, taking advantage of new information as it comes from the variety of players that have entered the market with hopes to profit from it. It is important to note that just as Proposition 4 (The Spurious Herd Behavior Proposition) suggests, we believe that firms will continue to follow the development of Wi-Fi and only make a full commitment to adopt when the time is right.

**The Adoption of New Technology Standards: The Case of XML Web Services**

The Extensible Markup Language (XML) has attracted widespread attention from the Internet community. XML involves standards developed by the Internet Engineering Task Force and World Wide Web Consortium. They specify formats for structured documents and data, allowing easy data sharing and access. XML-based protocols—e.g., Universal Description, Discovery, and Integration (UDDI); Simple Object Access Protocol (SOAP); Web Services
Description Language (WSDL)—have been promoted by IBM and Microsoft as a foundation for Web services. They are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. They perform functions that range from simple requests to complicated business processes. Once a Web service is deployed and made available, other applications, as well as other Web services, can discover and invoke the deployed service. They allow sharing of multiple applications among multiple developers around the world to be run on multiple different platforms. The UDDI, SOAP, and WSDL allow the Web services to perform those tasks.

XML-based Web services enable multiple businesses to easily interact and exchange data between disparate systems, creating the ability to automate a multiple-step business process within the same value chain using open standards. Web services offer a more flexible and less expensive solution than older electronic data interchange (EDI) networks, which can only handle the exchange of specific transaction data. Platform independence and a simpler implementation mean that the technology is readily available to every organization—even the smallest one—opening up new opportunities to those firms that previously could not afford to implement EDI to conduct business with large corporations that demanded the use of EDI as a prerequisite for procurement and financial management partnerships.

In a 2002 survey of 200-plus IT executives in financial services, Wall Street and Technology magazine and ILOG, a Paris, France-based software company, found that 81% of respondents considered XML to be critical to overall business strategy, with 78% already adopting the standards or planning to implement an XML strategy during the year 2002 [Malik, 2002]. According to the survey, the reason that companies adopt is to support systems-integration strategies. Financial institutions specifically need the ability to access multiple systems in real
time to allow them to offer specific services to customers, business partners and suppliers on the Web—such as verifying credit, placing orders, or performing a trade. XML and Web services offer an economical solution for integrated business services to be delivered via the Web.

Although this survey was done with a particular sample (i.e., executives in the financial services industry), the findings are encouraging considering that the XML standards are still new. It is interesting to note that the executives seem to be able to give a favorable view of the technologies in a relatively short period of time. What insights do REH and adaptive learning theory offer? Another evaluation framework question asks: “Do REH and adaptive learning provide a basis for analyzing time-constrained technology adoption?” With these theories, we can attribute the positive developments to the common knowledge and understanding about the importance of integrated systems that has developed among the decisionmakers from years of experience working on the issues, including their involvement with EDI-related technologies, enabling them to understand the critical aspects of the technologies in a short time.

This is confirmed by the findings from another recent survey by Accenture [2003]: 89% of executives were either very or somewhat familiar with the concept of Web services, and 76% ranked Web services as either a high or medium priority. In addition, the executives surveyed seem to have reached a significant alignment in their expectations as 57% of them agreed that Web services would mature in one to two years, and 93% said that the technologies would mature within three to five years. We believe that the alignment of expectations, as stipulated in Proposition 1 (The IT Value Expectations Alignment Proposition), will prove to be significant in accelerating the adoption of the technologies. Furthermore, the alignment will likely be done by benchmarking against firms within the same value chain, an example of “sub-group” as specified in Proposition 5 (The Sub-Group Benchmarking Proposition). However, the surveys were based
on executives’ understanding that the technologies are open. Any new developments such as the introduction of XML-based proprietary products (e.g., Apple’s Rendezvous and Sun’s JINI) may alter the dynamics of expectations alignment and slow down the adoption process since decisionmakers will need some additional time to learn about the developments.

Discussion

Our illustrative cases demonstrate that learning is an essential aspect in IT adoption decisionmaking processes. They indicate that adoption will not normally occur before decisionmakers feel comfortable with their knowledge about the technology and their expectations about its potential benefits. This means that decisionmakers will invest a reasonable amount of time to gather all relevant information from all possible sources and process the information optimally. Furthermore, the cases suggest that decisionmakers do not simply follow what others have done, although they may learn from the experience of others.

The insights that we have discussed in the cases, however, represent the IT adoption in the large, as collective phenomena. Of course there are variances observed among the behaviors of individual potential and actual adopters. This is consistent with Muth’s REH theory since what he claims is that the average of subjective expectations is equal to the true economic value. Consequently, it is important to identify how decisionmakers can differ in their expectations.

Formation of Expectations. There has been much debate over how managers actually form their expectations. Some argue that managers rely on simple "rules of thumb." Others maintain that they use complex decisionmaking processes. The most straightforward rule of thumb is to assume that next year will be like this year, a rule called “static expectations.” However, managers may also employ adaptive expectations to update their views about the future based on their previous errors in forecasting. The more sophisticated mechanism is rational expectations,
which specifies that agents make efficient use of all available information and their understanding of the model governing the market to formulate expectations [Schwartz, 1998].

**Value Variance, Payoff Horizon and Firm Resources.** Rapid technological change puts significant pressure on decisionmakers, who must either optimize using an inadequate amount of information or process only a subset of available information due to the constraints of time. The variance in potential payoffs or costs of the new technology under consideration, the time it takes to materialize the expected benefits from the technology, and the availability of resources of each firm are all likely to impact decisionmaking. High initial costs will most likely slow down the adoption or investment decisionmaking process, and vice versa. Soon-to-materialize versus longer-to-materialize benefits will certainly affect the adoption or investment timing. Cash-rich adopters or investors that have greater access to resources will be able to adopt or invest earlier, simply because they have the funds available, while cash-poor firms will tend to adopt later.

**Understanding the Underlying Economy.** This discussion raises a question about whether REH is actually realistic in the IT adoption and investment decisionmaking contexts. The ability of decisionmaking adopters and investors to identify the “true” equilibrium relations of the economy is essential in any REH-based model. However, the trend for most new and emerging technologies is to go through the phase of inflated expectations, when unrealistic projections occur. Estimates of cost and value will be affected by aggregate market uncertainty. This makes it hard for decisionmakers to predict how new technologies will fare and affect the economy in the future. Any estimates involve high levels of variance, both in terms of costs and benefits. This is because most new and emerging technologies do not have long-enough “track record,” and over-enthusiasm and unrealistic projections will most likely create “noise” in any forecast.

**The Role of Risk Aversion.** Without a well-defined picture of the future economy, it will be
hard to expect that the decisionmakers will figure out the so-called “true” equilibrium relations of the economy as required by the REH. We can argue that in such settings, early IT adoption or investment decisionmaking are based more on risk-taking behavior than rational expectations. Decisionmakers more averse to risk are more likely to make a decision later when enough information has become available and has been processed appropriately. In the case of e-commerce-related technologies, for example, we have witnessed how new entrepreneurial firms, such as Amazon.com and E-Trade, adopted and leveraged on the technologies earlier than the more established brick-and-mortar companies, such as Barnes and Noble and Merrill Lynch. Many of these entrepreneurial firms—arguably more risk-taking—quickly developed into competitive threats, dramatically transforming the marketplace.

The assumptions of REH—that people cannot systematically be fooled and will try to make unbiased forecasts based on the available information—should lead us to believe that risk-averse decisionmakers will be able to learn the true equilibrium relations of the economy. This should occur even if they are uncertain about some of the parameters of those relationships initially. Moreover, under the adaptive learning framework assumption, they will be able to learn the actual values of the parameters eventually, facilitating adoption and investment of a technology.

Mutual Consistency and Consensus Formation. In addition to individual rationality, REH imposes mutual consistency of perceptions among decisionmakers as economic agents. This implies that adoption may occur even later because it may take some time before the economic agents reach a “consensus” among themselves about the economic benefits a new and emerging IT may bring. This is especially true for ITs whose potential benefits mainly come from network externalities (e.g., HD-TV, object request broker technology, data storage technologies, etc.).

The need for potential adopters to reach a consensus creates interesting dynamics in the
adoption and investment decisionmaking process. Firms must now observe each other’s actions and perhaps take their cue from each other before making a technology adoption or investment decision. There are many dimensions that each firm needs to examine to achieve the best decision. Risk profile is one dimension we have discussed. We have argued that risk-averse firms ought to be more reluctant to adopt or invest than risk-neutral firms, all else equal. In market adoption terms, then, it will be important for firms to have rational expectations relative to the different risk tolerances at other firms that influence decisionmaking.

Rational expectations mean knowing about the position of each potential adopting or investing firm with regard to the various dimensions, and then acting accordingly. In a dynamic adoption and investment decisionmaking process, a subset of firms that have better positions in one or more dimensions are likely to adopt earlier and become catalysts in the whole system, facilitating the decisionmaking process of the remaining firms.

CONCLUSIONS

The rational expectations hypothesis (REH) can inspire decisionmakers to carefully consider their policies and decisions by insisting that expectations of economic actors be consistent with the economic models used to explain their behavior.

Contributions

Although the key assumption of the REH—that economic agents know the true structural relations of the economy—is probably too strong, the adaptive learning notion that allows some adjustments of parameter values over a period of time makes the theory look more realistic. Along with the spurious herding theory, the REH and adaptive learning have allowed us to develop arguments that lead to the propositions established in this paper. Expectations of profits
and of relevant economic events are always essential to the analysis of financial and economic processes, and IT adoption and investment decisionmaking are important for senior IS managers. Indeed, managers should not base their investment or production decisions on the results of the past beyond the point where the past information serves as an input for forming expectations about the future. This is why we believe that the REH theory is appropriate.

Economists today routinely use rational expectations and related ideas as the basis for their theory-building work. We have attempted to do something similar in applying rational expectations theory to our interpretation of several IT adoption mini-cases, in order to focus the reader’s attention on the mechanics of business value expectation formation. In fact, Sheffrin [1996] maintains that not using rational expectations requires specific justification and analysis in a variety of decisionmaking settings. Many interesting theoretical constructs in favor of the rational expectations approach have been presented in the Economics literature in order to provide explanations for leading issues in macroeconomics, financial markets, and microeconomics. Some of the most interesting research—such as “noise trading” in finance—combines rational and non-rational actors. In related empirical work, despite mixed results, there are some findings that strongly support the theory [e.g., see Keane and Runkle, 1998].

Final Thoughts

In the recent era of “irrational exuberance” sparked by unrealistic expectations of many e-commerce business models, REH-based thinking might have been a savior for the present down market. When expectations are very high, it is possible that self-fulfilling expectations will develop when a possibly false model is considered by most market participants as the true economy relationship [Pesaran, 1987], creating a “trap” for managers to make the wrong IT decisions. This is despite the fact that the market participants may have shared their information
with each other. In fact, repeated communication could lead to all decisionmakers to agree in their assessments of the true value: they just cannot “agree to disagree” [Geanakoplos and Polemarchakis, 1982]. In the simple example discussed by Geanakoplos [1992], a single round of communications could cause agents to unite in their beliefs but a richer set of outcomes would need additional rounds of communication. These findings suggest that decisionmakers should be careful with their initial assessment and expectations especially when the expectations seem to be unrealistically high. A longer learning process may be necessary.

In addition to requiring agents to have an ability to figure out the true economic model, the REH also assumes that every economic agent makes efficient use of the available information. In many cases, we can investigate if there is evidence to support the assumption. In the case of adoption of ITs that exhibit network externalities, for example, it may be possible to find out what economic factors a company will look into before it will decide to adopt the technology. This will involve the use of adaptive learning to take into consideration that most companies need some time to observe the technology as well as their business environment before making any decision. Although our present effort is only an exploration, we hope that further with the theory in our field will shed light on some research questions that will remain difficult to understand without giving serious consideration to the ways that economic agents make efficient use of information that is available to them in IT adoption.
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AUTHOR BIOGRAPHIES

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