Information Technology Investment and Adoption: 
A Rational Expectations Perspective

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Abstract

This study examines the potential applications of the Rational Expectations Hypothesis (REH) 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. In this paper, we introduce REH theory together with some of its applications in non-IS/IT areas. 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. We discuss how the theory can potentially be applied in IS/IT cases by presenting several illustrative examples. We then examine issues in the evaluation of adoption and investments of new and emerging ITs. Based on the theory, we argue that managers that are risk-averse are most likely to wait and adopt or invest in new and emerging technologies later than managers that are risk-takers. We suggest that for the earlier adoption or investments, the conventional method for estimating investment value may not be appropriate. We also suggest research directions with regard to the application of REH in the IS field.

Introduction

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 a particular technology.

In the Information Systems (IS) area, researchers have examined, among other issues, 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 et al. [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 most adopters expect that the next technology will 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 and which factors affect the expectation formation have not been fully understood.

In this paper, we discuss the Rational Expectations Hypothesis (REH) as a potential theory 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. Although REH has been widely used in other areas of microeconomics and macroeconomics, and notwithstanding the fact that rationality is commonly assumed in IS/IT economic analyses, we have not yet seen this particular theory used in technology—particularly IT—investment and adoption research. In this paper, we introduce rational expectations theory and how it can potentially be applied in IS/IT cases. Through a number of examples, we characterize the issues in the evaluation of adoption and investments of new and emerging IT from the perspective of this new theory. We also will argue that managers either make early or late technology adoption and investment decisions depending on the level of risks they are willing to take. This is especially true for “unproven” new and emerging technologies.

As depicted in Figure 1, new and emerging technologies typically go through several phases, which Gartner Research [Linden et al., 2001] terms the “Hype Cycle.” The most interesting of the phases is the “peak of inflated expectations,” when over-enthusiasm for and unrealistic projections of a new technology occur due to well-publicized activities by advocates of the technology, potentially sending the wrong signals to decisionmakers. However, in the subsequent phases, the hype rapidly diminishes due to the inability of the technology to live up to its inflated expectations, and decisionmakers will be in a better position to assess the technology’s applicability, risks, and benefits. The recent exuberance, followed by the bursting of the DotCom technology stocks bubble makes the Hype Cycle look all too familiar. It should remind us of the DotCom technology stocks bubble makes the Hype Cycle rapid but unsustainable, followed by a burst due to unrealistic projections and inflated expectations. The REH is applied 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.

Background literature

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.” In this section, we present the contrast between these two ideas to highlight the key assumptions associated with rational expectations. We introduce “adaptive learning,” which is based on the REH but considers economic agents’ bounded rationality.

Adaptive vs. rational expectations: Basic concepts

Expectations are typically related to past information available to economic agents or firms. A classic example is a problem that 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 respect to period $t$, in which the corn price anticipated by a farmer $p_t^a$ is given by:

$$p_t^a = p_{t-1}^a + \eta (p_{t+1}^a - p_{t-1}^a)$$

(1)

where $p_{t-1}^a$ is the anticipated price in period $t-1$ (as of period $t-2$), $p_{t-1}$ 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:

$$p_t^a = \sum_{j=0}^{\infty} (1-\eta)^j p_{t-j-1}$$

(2)

He further maintains that it is essential to put some a priori restrictions on the form of the lag structure. One restriction, as suggested by Muth [1961], is that the distributed lag should be “rational.” This means that if a particular stochastic process generates a sequence of actual prices $\{p_t\}_{t=-\infty}^{\infty}$, then the anticipated price in period $t$ (i.e., $p_t^a$), as of period $t-1$, should be given by

$$p_t^a = E[p_t | p_{t-1}, p_{t-2}, \ldots].$$

Therefore, if the farmer knows the stochastic process, he should be able to determine the expected price for period $t$ based on the conditional expectation of $p_t$ given all past prices. The farmer is considered “rational” because he utilizes all the price information to correctly compute the true conditional expectation.

Grossman [1981] provides this example to show how Muth’s rational expectations notion differs from Nerlove’s adaptive expectations model. Suppose that the stochastic process generating $\{p_t\}$ is given by:

$$p_t = \begin{cases} 1 & \text{for } t \leq 1 \\ 2 & \text{for } t \geq 2 \end{cases}$$

(3)

Then, following the distributed lag model in (2), under adaptive expectations:

$$p_2^a = 1, \quad p_3^a = 1(1-\eta) + 2\eta, \quad p_4^a = (1+\eta)(1-\eta) + 2\eta, \ldots, \lim_{t \to \infty} p_t^a = 2.$$  

However, under a rational expectations structure,

$$p_2^a = E[p_2 | p_1, p_2, \ldots] = 2 \quad \text{since } p_2 \equiv 2.$$  

The above example illustrates that under adaptive expectations, agents will need some 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 (3) so they know that after $t = 1$, 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. Subjective expectations on average, are equal to the variables’ true values. 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 a hypothesis that assumes that every economic agent optimally utilizes available information in forming expectations. He proposes the minimum mean square error (MSE) 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 the information available to them. In this case, the rational expectations solution is based on the assumption that individuals behave optimally. This is consistent on the whole with traditional economic theory [Fryman, 1982].

**Information requirements and assumptions in REH**

Although the information requirements the REH makes on economic agents are no more than in models with distributed lags, the assumption that economic agents need to know the stochastic process generating the equilibrium condition means they know a great deal about the economy. The application of these ideas came with the development of a formal theory 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? Because it requires that economic agents...
have full knowledge of the structure of the relevant models and their parameter values. It also requires that random shocks that affect agents’ expectations are independent and identically distributed. Empirical economists typically admit they do not know the parameter values and must estimate them econometrically.

A somewhat weaker assumption is more appropriate: that agents act like econometricians when they make forecasts about the future. By this, we mean that they are willing and able to update their expectations about relevant parameter values on the basis of newly-received information. This perspective introduces a specific form of “bounded rationality” which is called adaptive learning [Sargent, 1993; Evans and Honkapohja, 2001]. When bounded rationality is considered, economic actors are assumed to learn to use reasonable model specifications (and choose meaningful model parameters), which are often appropriate in the resulting observed outcomes but misspecified when there is learning. We emphasize that although adaptive learning allows agents to learn the parameters’ actual values in the equilibrium relations, it still assumes that agents know the correct specification of the equilibrium relationships in the economy.

For the applications of REH in IT investment and adoption decisionmaking that we discuss in this paper, we adopted the assumptions of adaptive learning. We did this because we believe they are pragmatic and reflect actual situations that we observe in the real world.

Non-IS/IT applications of REH

We next present several applications of the REH in non-IS/IT areas to build the reader’s intuition about the new theoretical perspective we offer.

Wage-setting in the labor market

The REH has been used to criticize traditional Keynesian views of wage-setting decisions in the labor market. The argument here is that the Keynesian perspective does not adequately take into account the fact that labor can rationally form expectations about future conditions when they set their wage contracts.

Consider an economy that is in a slump. A government that bases its policy on the traditional perspective will try to fuel hiring and production in the private sector by increasing its own spending while maintaining the amount of money it draws from taxes. As a result of the increased spending by the government, product prices increase, creating new profit opportunities for private corporations, which in turn will enable them to expand their businesses and hire more workers.

A big assumption in this scenario of government-created profit opportunities created is that labor will continue to work at about the same wage, allowing businesses to increase their revenues while keeping their costs under control. Workers are assumed to be willing to accept the same wage rates while facing prospectively higher prices and increasing living costs.

In the rational expectations view, however, this kind of policy will hardly work because workers have the ability to think rationally and forecast the future state of the economy based on what they observe. Also, they may have the means (e.g., workers unions, flexible contracts) to enable them to demand and actually obtain higher wages when they see potential increases in product prices.

Financial markets

The REH is the foundation of the efficient market view. In the financial markets, a decision to buy or sell a company’s stock is based on expectations about the company’s future financial performance. The price of the shares of a company, therefore, will reflect the expected bottom line of the company. The equilibrium price is determined by some market clearing mechanism. Under rational expectations, the market is considered to be efficient since the stock price at any point in time is based on some expectations formed by taking into account all possible information about the company. If markets were not efficient, then there would be arbitrage opportunities that rational traders could exploit. In an efficient market, all traders are rational and changes in asset prices are completely random, solely driven by unexpected “news” about changes in economic fundamentals, such as interest rates, inflation, exchange rates, unemployment figures, and growth rates.

Interest rates

Consider again a situation with an economy that is experiencing inflation. To ease the situation, the Fed will increase the money supply growth rate by a series of purchases in the stock markets. This action ends up with the economy having an inflow of new cash, subsequently resulting in banks obtaining new reserves that allow them to increase lending to businesses. We can then expect to see interest rates go down, not only because the buying actions of the Fed have boosted securities prices—lowering interest rates on those securities—but also because banks now have to compete with each other in aggressively disbursing loans, resulting in a relative decrease in cost of capital for other firms.

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1 Simon [1957] argues that “bounded rationality” exists because agents have limited cognitive resources and capabilities, and it is often impossible for them to obtain the solution algorithms required to deal with all available information in a manner that would allow optimization by the time a decision is to be made.
As businesses see chances to use cheaper funding to make new investments, they will start building new plants and hiring new workers, causing outputs to increase. Some investment ideas that were not considered profitable previously suddenly seem lucrative due to the fact that expected revenues have not changed, but instead because expected costs have declined. This is due to the reduced cost of capital. The next thing we expect to see is that the newly-hired workers will drive additional new spending themselves, resulting in more production by businesses. As a result, we will see some real effects on the economy through the inducement for initial investments that reflect small changes in monetary policy.

From the rational expectations point of view, however, the above scenario is not very realistic. Why? The scenario does not adequately accommodate people’s ability to form their expectations. The decrease in interest rates as a result of the Fed’s security buying actions will be temporary and short-lived at best. Rational lenders and investors who have the ability to look far enough into the future will see that any effort on the part of the Fed to increase growth rates for money will eventually increase the general price level. Consequently, lenders will not commit their funds in long-term loans at the lower interest rates of interest due not to the fact that expected revenues have not changed, but instead because expected costs have declined. This is due to the reduced cost of capital. The next thing we expect to see is that the newly-hired workers will drive additional new spending themselves, resulting in more production by businesses. As a result, we will see some real effects on the economy through the inducement for initial investments that reflect small changes in monetary policy.

Micro-level decisionmaking

The REH is appropriate in situations where economic agents have to make predictions of future variables when making current decisions [Sheffrin, 1996]. For example, Rust [1987] examined the monthly observations on bus mileage, repairs, and engine replacements from the maintenance records of the Madison Metropolitan Bus Company. The bus engine is treated as a “portfolio of parts,” each having a stochastic failure rate as a function of use. An engine component that fails at a relatively low mileage might get repaired or replaced, as it is considered the optimal option. However, if the part fails at a high mileage, it might be best to simply replace the entire engine since it is reasonable to assume the other parts will also fail soon. This engine-replacement strategy is an optimal-stopping model. The maintenance superintendent decides when it is optimal to replace the engine, weighing a trade-off between minimizing maintenance costs and minimizing unexpected engine failures.

The purpose of the study is to construct a model to predict the time and mileage at which engine replacement occurs. Factors considered are accumulated mileage since the last replacement, expected costs of bus maintenance, and an estimate of lost ridership and goodwill of customers due to a breakdown. The superintendent’s decision is assumed to be based on the current value and all past values of the state variables, as well as the past history of engine replacement. So, the superintendent makes a decision based on available information and all past decisions, suggesting that REH holds.

Potential applications of REH to IS/IT

There are numerous IS/IT investment and adoption cases where REH theory can offer insights.

IT with network externalities: The EBPP case

A key element of many ITs is network externalities, which indicate that the value of a technology will increase with the number of users. An example of this kind of technology is electronic bill presentment and payment (EBPP) systems, a technology that allows consumers to view and pay their bills electronically. EBPP exhibits network externalities since the more billers offer the service, the more consumers are willing to sign up. Thus, the value of each biller’s EBPP system will increase with the number of billers offering the same service.

There are two major groups that will compete to entice both billers and consumers into using each service. The first group consists of bill consolidators, a third-party aggregator of data from multiple billers. They prepare bills for presentment through arrangements with banks or popular Internet portals, such as Yahoo and America Online. The second group, called Spectrum EBPP, was founded by a consortium of major banks, including J.P. Morgan Chase, Wachovia Corp., and Wells Fargo and Co. Spectrum, now owned by Metavante Inc., has spent a lot of money developing online billing services and devising a standard but has not yet experienced widespread adoption. Bill consolidators (e.g., CheckFree) seem to be more ready with their service offerings of EBPP than the consortium of banks does. However, the Metavante Inc. acquisition now positions Spectrum as more of a neutral non-bank third-party technology provider. (See Au and Kaufman [2001] and Spectrum EBPP [2002] for additional details.)

Without a doubt, billers will benefit from the technology since it will help them save money from the reduced costs of generating bills. In addition, they can also use the technology to enhance 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. Therefore, the adoption of the technology is just a matter of time for every biller. However, each biller must decide whether it should adopt the technology now (i.e., go with CheckFree’s) or wait until Spectrum/Metavante’s technology is ready and see which one is better. Billers will decide to adopt the
current technology sooner, instead of waiting until the next technology is ready, if they anticipate large enough network externalities benefits from the current technology.

The REH can explain how billers form expectations about the network externalities benefits by showing that each biller will observe other billers’ behaviors that pertain to the potential adoption of the technology and will adjust its own behavior accordingly. If convergence of behaviors occurs (i.e., billers have similar attitudes toward adopting the current technology), then adoption will take place. We should emphasize that it is not necessary that the whole universe of billers converges in their expectations before the adoption takes place. It may be just a subset of billers that serves the same groups of customers.

Wireless technology: GPRS strategy at Motorola

Today’s digital cellular networks are based on the second generation (2G) of wireless technology, which has limited capabilities in delivering high-speed digital applications (e.g., interactive gaming, video conferencing). The third generation (3G) of wireless technology, while widely anticipated, is not fully developed yet. The more recently developed 2.5G technology—primarily embodied in the General Packet Radio Service (GPRS)—is expected to bridge the gap between 2G and 3G, providing a solution for consumers who demand for a better technology now. GPRS is an upgrade to current Global System for Mobile (GSM) Communications systems. GSM—implemented in the majority of 2G wireless networks worldwide—is based on traditional circuit-switched technology, which is optimal for voice but not for data applications.

Motorola—a major manufacturer of semiconductors and mobile communications devices—is the leader of GPRS. In July 2001, the company announced that it planned to offer its 2.5G semiconductor and software technology to other mobile phone makers. This is an important move by Motorola and it has come as a surprise to many observers. The complexity of the 2.5G technology has been a significant barrier to other mobile phone makers eager to enter the market. By offering its expertise, Motorola basically opens up the 2.5G market.

The questions now are: First, why would Motorola be willing to offer its technology to other mobile phone makers, who are essentially its competitors? Second, will the competitors accept Motorola’s technology? The rational expectations hypothesis (REH) offers answers to these questions. From Motorola’s point of view, supplying other phone makers is an obvious opportunity to increase its business in the embedded wireless market. Furthermore, industry participation is essential in rolling out a major new technology. More importantly, Motorola sees that the other phone makers do not have any competing technology on hand amidst the growing interest in such technology among consumers.

Real and de facto standards for XML web services

The Extensible Markup Language (XML) has attracted attention from the Internet community. It involves standards developed by the Internet Engineering Task Force (IETF) and World Wide Web Consortium (W3C). They specify formats for structured documents and data, allowing easy data sharing and access. XML-based protocols—UDDI, SOAP and WSDL—have been promoted by IBM and Microsoft as a foundation for Web services. However, none has received official approval.

Web services are a new type of Web application. 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. Their potential is huge since they will allow the 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.

Considering the big potential that Web services offer, many companies have begun looking into the possibilities of utilizing the technology. However, should the fact that the protocols have not been officially approved by the standards-setting bodies delay a company in adopting the technology? From the rational expectations perspective, given the joint strength of IBM and Microsoft, they should be able to transform the technology and its protocols into de facto standards. If every company thinks this way, the tasks for IBM and Microsoft will become even easier. If that is the case, the next question is: Should IBM and Microsoft make the technology available for free or should they charge the Web developers and users for using the protocols?

Assessing REH for IT adoption and value

In many cases, firms must make intertemporal decisions in spite of uncertainty about the future. Most intertemporal decisionmaking processes require managers to form expectations about the future values of economic variables such as income and prices.

Formation of Expectations

There has been much debate over how managers actually form their expectations. Some argue that

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2 UDDI stands for Universal Description, Discovery, and Integration; SOAP stands for Simple Object Access Protocol; WSDL stands for Web Services Description Language.
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 expectations about the future based on their previous errors in forecasting. The more sophisticated mechanism—as we have seen—is rational expectations, which specifies that agents make efficient use of all available information and their understanding of the economic model governing the economy in order to formulate their expectations [Schwartz, 1998].

Information Processing and Bounded Rationality

The ability of each agent to access and process information plays an extremely important role in the agent’s decision about when to adopt or invest in a technology. This is because from the REH perspective, expectations are rational only if people fully utilize all relevant available past information in forming their expectations. However, in many situations, information access and/or processing abilities may be limited, a phenomenon called “bounded rationality.”

Though Simon [1957] attributes bounded rationality more to the limited information processing and computational capabilities, Williamson [1975] in his introduction of transaction cost economics claims that bounded rationality is more about limited access to information. Bounded rationality for Simon implies the availability of more information than can be processed by economic agents as decisionmakers, whereas for Williamson bounded rationality means the lack of information, creating a constraint in optimization procedures.

Information processing and market intelligence capabilities of firms are likely to affect adoption timing and investment willingness. For example, a firm that has strong capabilities in this area should be able to narrow the perceived variance and understand the related risks faster, within an acceptable range of error, thus potentially accelerating its decisionmaking process.

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 IS/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, as we have seen in the Hype Cycle, the trend for most new and emerging technologies is to go through the phase of “peak of inflated expectations,” when over-enthusiasm and unrealistic projections occur. Estimates of cost and value will be affected by aggregate uncertainty in the market. This makes it hard for decisionmakers to predict how the new and emerging technology 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 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 been available and processed properly.

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 a competitive threat, 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, and even if they are uncertain about some of the parameters of those relationships initially, under the
adaptive learning framework assumption they will be able to learn the actual values of the parameters eventually, facilitating the 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., EBPP, HD-TV, CORBA, 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.

**Research directions**

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. 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.

As we have seen, during the “Peak of Inflated Expectations” in the Hype Cycle, 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.

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.

We need to make sure that the IT under consideration has reached the maturity phase in its lifecycle. By that time, the potential adopters already will have a good idea about how the IT is likely to benefit them. When this happens, we can imagine that there will be a group of potential adopters that will be willing to adopt the technology at a certain price due to the network externalities benefits the IT can potentially deliver. We assume that this group will make the adoption decision at about the same time to make sure that each of them will actually realize the network benefits. The adoption decisions themselves are based on observations over some period of time. What economic factors these companies have observed becomes an important question to study.

Another potential research direction involves surveying a group of firms involved in emerging technology adoption in a longitudinal study spanning several time periods (e.g., quarters). In each period, company managers will fill out a questionnaire that asks them about their expectations about the values (expressed in terms of specific measures and units) of the IT they have adopted or are about to adopt. These responses can later be compared with the actual values. The main research question will be: Are managers “rational” in making their forecast about the values of the IT they adopted? The REH implies that a forecast is “rational” if its forecast error is unpredictable, given what the forecaster knew when making the forecast. The findings will be important in that they will provide some indications of the consistency that managers have in their forecasts and decisionmaking processes before deciding to adopt a particular IT.

At one level of analysis, we can imagine that there are some firms that are risk-takers and some that are risk-averse. Furthermore, some organizations, both public and private, may be less able to innovate due to their organizational cultures. As a result, they may not be able to change the way they do business easily. These companies can be considered laggards among the risk-averse firms in the context of technology adoption and
in many companies). Also Adobe’s Portable Document proprietary systems (e.g., DEC’s VMS and IBM OS/400 Windows and Unix (and now Linux) that replaced examples include operating systems standards such as issue for which the REH may offer a useful perspective.

**Conclusion**

The familiar S-shaped curve (which characterizes the rate of adoption or the diffusion of innovations) groups adopters into five categories: innovators, early adopters, early majority, late majority, and laggards. The grouping is based on a normal distribution that is partitioned into the five adopter categories by laying off standard deviations from the average time of adoption [Rogers, 1995]. This results in innovators being 2.5% of the population, early adopters 13.5%, early majority 34%, late majority 34%, and laggards 16%. We can further group the early and late majorities as the mainstream adopters. Another research issue presents itself in this context: What are the organizational economic factors that differentiate between the mainstream adopters and the laggards, which signify the “rational” and “non-rational” organizations, respectively, in a particular IT adoption context? These factors may include firm size, market share and market size, firm’s revenue and earnings, and industry sector, among others, for example.

The development of *de facto* standards is another issue for which the REH may offer a useful perspective. Examples include operating systems standards such as Windows and Unix (and now Linux) that replaced proprietary systems (e.g., DEC’s VMS and IBM OS/400 in many companies). Also Adobe’s Portable Document Format (PDF) is a *de facto* standard for final form delivery and display of electronic documents. Clearly, some rational expectations should have developed among market participants about the benefits of each of the technologies that made them decide to adopt the technologies. What’s interesting is that there seems to be no single dominant factor that can explain why these technologies become the *de facto* standards. The research question is therefore: What (economic) factors did the market participants consider when each of them decided to adopt a particular technology that helped to make the technology a near standard?

**Conclusion**

The rational expectations hypothesis can be quite powerful if applied properly in IT investment and adoption decisionmaking situations. It helps decision-makers to put things into perspective by challenging basic assumptions that often seem to be taken for granted. As a result we can expect managers to be able to engage in decision making processes that are endowed with sounder and more useful information.

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 looks more realistic. Nonetheless, the original assumption has enabled 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 decision making 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 to the IT investment and adoption analyses.

Economists today routinely use rational expectations and related ideas as the basis for their theory-building work. In fact, Sheffrin [1996] maintains that not using rational expectations requires specific justification and analysis in a variety of decision making 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 an overall mixed bag of results, there are some findings that strongly support the theory [e.g., see Keane and Runkle, 1998].

Our discussion also suggests that when analyzing an early adoption or investment of a new and emerging technology, we should reconsider the use of the conventional method for estimating the value of investments (including IT investments) via the discounted cash flow (DCF) analysis approach. DCF essentially involves discounting the expected net cash flows (the “risk-adjusted” discount rate) based on the time value of money. In this approach, a forecast must be made about the expected future cash flows. Needless to say, the forecast must be pretty accurate in order for this approach to provide results that are useful in IT adoption and investment decisionmaking. And to make a reliable forecast, economic agents must be “rational” in the REH sense. Consequently, the conventional method for estimating the value of investments—the discounted cash flow (DCF) analysis—cannot provide the correct estimates when used to value an investment or adoption decision that is made early about a new IT.

In closing, we believe that it is now time to explore,
utilize and test the theory in IS research. Although the present effort is only a preliminary attempt, we hope that further exploration of the theory in this new context in our field will help solve some puzzles and shed light on some research questions that will remain difficult to understand without giving serious consideration to the assumption that economic agents make efficient use of all information that is available to them.

References


