Editorial

An economic view of information systems

Technological advances in processing and communicating information are causing what may be the largest transformation of the economy since the industrial revolution. This 'information revolution', driven by dramatic improvements in information technology (IT) and information systems (IS), decreases the costs of activities and enables real-time deployment of technology, thus exploding the range of applications.[1] Examining the effect of these advances and forecasting their future impact requires a framework grounded in sound methodology, for which economics is a natural reference discipline. The economics literature occasionally publishes articles where technology plays some role in the analysis, but often the very issues of greatest interest to IS researchers are abstracted away. This special issue presents eight papers exploring a number of questions central to the IS field: What kinds of IT investments provide value to a firm, and how can firms measure the impact of such investments on financial performance? How do network externalities affect adoption and pricing of IS and IT? What are the roles for electronic agents in markets and what effects do they have? What sorts of governmental policies would stimulate competition, and provide incentives for companies to invest in advancements in IT to fuel future growth?

1. IT investments: valuation and performance

A trio of papers in this issue enhances our understanding of issues crucial to how firms should think about investing in new technology: how and how much information systems improve performance. *An Application of the Learning Curve and the Non-Constant-Growth Dividend Model: IT Investment Valuations at the Intel* by Shana Dardan, Doug Busch, and David Sward provides an in-depth analysis of how investment in information systems grows over time and how to incorporate that growth into the initial investment decision. *The Impact of Information Technology on the Financial Performance of Diversified Firms* by Namchul Shin examines how the benefits of information systems investments are closely related to firms' strategic direction, specifically the firms' diversification strategy. Finally, the paper *The Influence of Governance Equilibrium on ERP Project Success* by Eric Wang and Jessica Chen studies the role of governance in deriving value from IT investments in an application area that is perhaps the fastest-growing sector within the software industry-Enterprise Resource Planning (ERP) systems.

To fully capture the benefits of investing in information technology, Dardan, Busch, and Sward employ a learning curve function within a non-constant dividend growth model to measure the marginal productivity benefits both during the learning about the technology and after its adoption. The model first displays a period of nonlinear growth, then approaches a constant level of productivity enhancing performance. The summation of the cash flows from the high-growth period and the constant-growth

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[1] The distinction between IS and IT is subtle and much debated. We take the view that IT is the actual technology—the "building blocks" of IS; IS is the appropriate (and useful) business-level abstraction of the functions/system (including software and hardware) constructed out of these building blocks.

period, appropriately discounted, yield the total benefits associated with the investment, which can then be compared to the initial investment costs. The authors acknowledge that incorporating the option value in the timing of decisions is important, but, given the specific point about properly measuring the benefits of IT investment and the empirical analysis they wish to conduct, they leave this to future research.

One of the significant contributions of the Dardan, Busch, and Sward paper is its use of detailed data from specific investments in the real world (something very difficult to obtain). The technology investment studied is a standard operating system and hardware upgrade. Intel uses a 3–4-year PC replacement cycle, making upgrades a fairly regular occurrence. The authors begin the analysis with a time and motion experiment to study the marginal change in short-term labor productivity. This marginal productivity impact is the input into their non-constant-growth dividend model, enabling them to enumerate both the short-term high-growth productivity impacts and the long-term constant productivity value. Using Intel's standard assumptions for decision making, the authors conclude that the total lifetime discounted benefit from a marginal productivity increase is close to US$600 million. Given that the hardware and software upgrades they study (Microsoft Windows XP and Pentium 4) are standard to most organizations, the investment valuations may have general applicability.

Prior studies of the impact of IT investment on firm-level financial performance have often produced mixed results. Shin attempts to study how the benefits from IT investments may depend on firms' diversification strategies through exploring the relationships among IT investment, diversification, and financial measures such as gross margin, return on equity, and return on assets. The results show that the interaction term of IT and strategic direction contributes to financial performance significantly, particularly as measured by gross margin. The results also indicate that IT improves the financial performance of diversified firms when their strategic direction is oriented more toward related diversification.

Of closely related interest is the paper by Eric Wang and Jessica Chen. Enterprise Resource Planning (ERP) software is one of the fastest growing segments of the IT industry. Nevertheless, ERP implementations

have met with mixed, and widely varying, degrees of success—where success is measured in terms of metrics such as timeliness of project implementation, adherence to cost estimates/budget, and satisfaction of original objectives such as efficiency gains. (The complement of each of these measures of success constitutes a 'project hazard'.) The drivers of success in ERP implementation are little understood. The paper by Wang and Chen addresses this by studying the role of governance structures in driving the success of ERP projects.

Wang and Chen point out that ERP aims at breaking 'functional silos' in an organization and is a complex collaborative effort among client firms, ERP software vendors, and implementation consultants. Governance in these cases is an inter-firm (rather than merely an intra-firm) problem. Hence, it is plausible that governance is an important driver of successful implementation. Further, they identify four specific kinds of governance structures—*explicit contracts*, *implicit contracts*, *reputation* and *trust*. The distinctions are important. *Explicit contracts* are formal, written contracts between vendors, consultants, and clients. *Implicit contracts* are expectations shared by all parties in the relationship, for example, implicit agreements on behavioral norms. *Reputation* reflects the credibility of the firm, and finally, *trust* involves positive expectations about the other party's motives when one is in a position of risk. Reputation and trust are built up over time. The paper makes the interesting point that studies of the effect of any one governance structure, in isolation, on ERP project success are too 'reductionistic', and specifically, ignore complementarities among the different governance structures. For example, in complex environments, incompleteness of explicit contracts is inevitable, and 'gaps' or deficiencies in the formal contracts are covered by one or more of the other governance structures. Hence, the paper postulates that a 'governance equilibrium' built up of a combination of multiple governance structures working together (and complementing each other) is the right measure of governance. ERP success is measured on a vector of attributes, as discussed above.

Wang and Chen use data from 122 ERP implementation projects in their empirical study. Their model of ERP governance analyzes the complementary contributions of different governance mecha-

nisms on ERP project success. They demonstrate, among other results, that a project's governance equilibrium is significantly correlated with its success. Thus, they posit that the governance equilibrium plays a mediating role between ERP project hazards and ERP project success. Their study is of relevance to management practitioners, systems professionals, and customized application software developers in general, and ERP vendors, implementation consultants, and ERP clients in particular.

To extend these studies in the future, it is our hope that broad and long standardized panel data on IT spending by firms, preferably broken down by its application areas, will eventually become widely accessible to IS researchers. Combining this with the vast available financial data would provide enormous opportunity for extending our knowledge of technology's impact on firms' financial performance. It could also help sort out the simultaneity/endogenity issues which potentially exist in many papers in this area.

2. Network externalities: impacts on adoption and pricing

Network effects have become increasingly important as advances in technology enable information systems to dramatically decrease the costs of communications. This makes new types of networks possible and existing networks cheaper—from both the user and providers' point of view. *Adoption of Electronic Trading at the International Securities Exchange* by Bruce Weber focuses on how network effects and advances in information systems are transforming one segment of the largest class of exchange markets: financial markets. *A Hedonic Study of Network Effects in the Market for Word Processing Software* by Sujoy Chakravarty, Kutsal Dogan, and Nels Tomlinson studies the role of network effects in pricing in the word processing market.

In the US, options traditionally traded primarily on the floors of exchanges in Chicago, New York, Philadelphia, and San Francisco. This changed with the formation of the International Securities Exchange (ISE) in May 2000. The ISE is an all-electronic options trading platform that allows for human intermediation in a virtual environment. This approach can ease user acceptance and adoption.

Weber provides an excellent quote summarizing the difficulty confronting a new electronic market facing existing entrenched competitors: "It's a bit of a chicken-and-egg situation for the ISE. To get order flow, they need liquidity—willing buyers and sellers—but to get liquidity they need order flow. Better, cheaper, faster won't mean much if they don't get the critical mass of order flow they need to keep their market makers and the brokerages happy." Network effects arise in financial markets when traders are able to come together either physically or virtually in space and time, reducing trading/search costs and enhancing price discovery. This in turn attracts more traders, further reducing trading costs and improving price discovery. Without traders initially, new electronic markets have often been unable to attract enough traders to survive, e.g., Optimark, Tradepoint, Jiway, BondConnect, and others.

Using Securities and Exchange Commission's Rule 11Ac1-6 quarterly data on brokers' order routing choices from the ISE's launch through the 1st quarter of 2004, the paper examines how past adoption decisions, in this case the choice about where to route orders, affect subsequent choices. Given that traders want to trade in the same market as other traders, traders' past choices impact the future choices of others. Weber finds that 40% of the ISE growth is accounted for by the network effects of growing market liquidity. Firm-specific factors such as whether the firm is an online discount broker and the firm's membership role in the ISE explain the remaining 60% of ISE adoption. Further study of IT adoption in other electronic markets, both financial and otherwise, is a promising area of research.

In the case of software, a market exhibits network externalities when the value of owning a unit increases with the number of other users already using the product. Much of the value arises from the ability to share documents with other users. Chakravarty, Dogan, and Tomlinson follow the classic hedonic approach of decomposing the price into components attributable to the different features of each product. A similar approach has been taken in examining the spreadsheet market. Contrasting the word processing and spreadsheet markets provides excellent opportunities to confirm and sharpen our knowledge in these two closely related markets. Just as Weber's study of network effects in the adoptions

of trading systems increases our understanding of entry and competition in financial markets, Chakravarty, Dogan, and Tomlinson further our understanding in software markets, something of great recent interest to antitrust regulators.

Chakravarty, Dogan, and Tomlinson find positive effects of network externalities and strong brand effects on word processing prices similar to those for spreadsheets. In contrast to the evidence from spreadsheets, word processing software prices (adjusted for quality) trend upward over time and quality attributes do not significantly affect price. Further study of the pricing impact of network effects for information goods can help facilitate our understanding of how the virtual economy may depart from the physical one.

3. Electronic intermediaries in imperfect markets

An important element of electronic commerce is the use of IT to collect and analyze customer and product data, and also make recommendations on prices and strategies to web-based operators (both sellers and buyers). For instance, sellers can use intelligent agent technologies to evaluate buyers, customize products, and price in real-time. IT has also enabled the use of various kinds of decision support systems (DSS). Two papers: *Intelligent Agents in Electronic Markets for Information Goods: Customization, Preference Revelation and Pricing* by Ravi Aron, Arun Sundararajan, and Siva Viswanathan and *Agent-Intermediated Electronic Markets in International Freight Transportation* by Barrie Nault and Albert Dexter analyze the effect of such electronic intermediaries in different settings.

Aron, Sundararajan, and Viswanathan model a monopolistic seller selling on the web to heterogeneous buyers who vary in their preferences for the good, specifically in their valuation or willingness-to-pay (WTP). The seller can offer different levels of customization, and the buyer picks her preferred level. The electronic intermediary ('Intelligent Agent') analyzes the buyer's choice, in combination with web-site demographics, customer history, and other information in estimating the buyer's valuation. This information is used in setting the price for the customized product sought by the buyer. From the buyer's point of view, the information she

provides can be used for good or evil. On the positive side, she gets a better tailored product that more accurately matches her non-price preferences. On the negative side, the seller can use the information in setting a price close to the buyer's WTP, eroding the buyer's surplus. Thus, the buyer's behavior reflects these tradeoffs; she sets the level of customization sought, by fudging or omitting personal information, in order to control the accuracy of inference achieved by the Intelligent Agent. Aron, Sundararajan, and Viswanathan analyze the pricing, profitability, and welfare implications of Intelligent Agents that enable dynamic pricing based on product preference information revealed by consumers. The implications are of interest to privacy advocacy experts and policy makers, in addition to web-based sellers, buyers, and purveyors of intelligent technologies.

While the paper by Weber in this issue focuses on financial exchange markets, the paper by Nault and Dexter applies to exchanges for complex (non-commodity) products. Like Weber, Nault and Dexter study the use of IT to assist (rather than replace or 'disintermediate') traditional human intermediaries, via an Electronic Market (EM). The electronic market improves market efficiency by facilitating the matching of supply and demand.

While the application that motivates their model is freight transportation (specifically, container-shipment by sea), the model in fact applies more generally to markets characterized by 'whole product' complexity (i.e., wherein either the product or the associated services needed to execute trade, or both, are complex), calling for some degree of specialization by agents. Agents in their setting can generate both supply and demand, and are heterogeneous in their *potential* (ability) to generate supply and demand. One important feature of their model is that each agent can *invest* in generating supply (and demand)—these investments are decision variables in the analysis. Another interesting feature is their very general (nonspecific) modeling of supply and demand as a function of agent valuations, price, and investment levels. The EM trades off agents' investment incentives with participation incentives in setting fees, and hence can limit agent participation. This leads to several interesting results that are a twist on traditional price-theory. For instance, the

electronic market can simultaneously increase agent participation and individual agent investment, possibly leading to a surge in both supply and demand. Because investments in supply and demand generation are endogenized, both prices and quantities (volume of trade) can increase with the use of the EM. Also, because the EM facilitates liquidity and trade, under the EM, individual agents can afford to specialize in their investments (i.e., on the demand or supply side) and focus on their niches. Without the EM, individual agents must focus more on finding supply (demand) for their individually generated demand (supply), leading to less specialization and greater inefficiencies.

4. Patent policies and software innovation

The final paper of this issue addresses the issue of the role of governance in stimulating innovation in the software industry as a whole, specifically through the system of patenting. The paper *Welfare Analysis of Alternative Patent Policies for Software Innovations* by Matt Thatcher, Taeha Kim, and David Pingry presents a game-theoretic study of two firms competing in the dimensions of innovation as well as pricing, under different *patent policies*. A patent policy is defined in the abstract in this analytical model by two characteristics—*patent height* (the minimum level of improvement to existing, previously available know-how needed for an innovator to be successfully awarded a patent) and *patent width* (level of protection of the patent from imitation). Based on the patent height and patent width set by policymakers, the firms compete on innovation modeled by endogenous variables for R&D investments for each firm. Innovations are realized with the exponentially distributed probability distribution, with the exponen-

tial parameter determined by the level of investments. Where one firm wins and develops a product, the other firm (the imitator) can offer a competing product (a *partial* substitute) within the scope permitted by the patent width. Finally, the firms set prices for these vertically differentiated products. Thus, the paper integrates patent policy with firms' choice of R&D investments and customer preferences, enabling the study of the effect of patent policies on incentives for innovation, pricing, consumer surplus, and welfare. They find that an increase in patent width (i.e., protection afforded the patent) increases the profitability to the patent owner, and hence provides incentives to innovate and generate patents to both firms. This leads to an unambiguous increase in R&D spending (for each firm). In contrast, the effect of an increase in patent height on R&D investments is ambiguous, and depends on the cost of converting the patent to a commercial product. The analysis also shows that patents in general may improve or worsen consumer surplus and welfare, and identifies conditions for each. The insights of the paper are of interest to patent policy makers, particularly in the context of the many recent lawsuits and legal wrangling with regard to patenting in the software industry, as well as to firms setting their R&D budgets and priorities.

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