1. Introduction

Decades of research on the economic impact of computer information systems used by businesses provide the basis for assessing claims arising in litigation over such systems. It is possible to estimate the impacts of systems on costs of business operations, on market share, on margins, on flexibility of product design, and on market entry strategies. It is possible to estimate economic impacts, even for systems that were never completed, never delivered, never deployed, and for which no historical data are available.

The original information systems developed in the 1960s and 1970s typically involved the automation of routine, labor-intensive tasks (e.g., filing, cost accounting, inventory management) where the principal value could be represented in terms of labor savings. Delays or other difficulties in systems implementation resulted in lost savings or excess cost of systems implementation – the next best alternative to a new system was to continue business as before. Estimation of economic impacts of systems problems was relatively straightforward, even if determination of liability for those problems was not.

Today, firms are increasingly dependent upon information systems for all of their operations, from market forecasts and strategic planning, through product design and the management of their portfolio of product and service offerings, to the daily operations of their sales, production,
logistics, and distribution systems. Some systems are thus strategic necessities, and without systems the operations of firms are adversely affected[1]. A bank that offered ATM services in the mid 1980s would show no specific revenues attributable to its ATM operations, but a bank that could not provide ATM services to its customers would be hampered in the marketplace. Moreover, systems that may have operated in isolation in individual functional areas (operations, marketing, human resources and accounting) are becoming integrated, so that the performance of a single system or technology project can have firm-wide effects. Technologies for integrating systems between buyers and suppliers have extended the potential scope of influence from a system to an entire firm, from a firm to its entire industry, or to the value chains of the firm’s customers and suppliers. To the extent that systems enable new types of products to be designed, produced and sold, the presence of a system can often affect the behavior of consumers as well and alter the competitive position of firms within a marketplace.

It follows quite naturally that as the economic impacts associated with disputes involving information systems have become more complex, the resolution of those disputes has become more complex as well, whether the disputes entail domestic contracting for software delivery, international contracts for business process outsourcing, or the valuation of patent infringement claims. In particular, economic value or economic damage from incomplete or poorly functioning information systems cannot be assessed by examining the cost of the system and what percentage of its intended functionality was actually delivered. Rather, these cases now involve both technological issues for the determination of performance or non-performance of contract terms, and economic issues for determination of claims amounts recognizing the firm-wide or industry-wide impact of a single system or technology project. Likewise, it follows
naturally that the skill sets useful when investigating disputes involving the economic impact of information systems include technology, technology development, knowledge of the specific business or specific industry, and business strategy.

2. Types of Economic Impacts from Systems Innovations

Due to uncertainties inherent in projecting the impact of a system, and limitations in available data that prevent a perfect characterization of current conditions, it is often difficult to get precise estimates of a system’s value. However, the economic value of systems can usually be assessed with a high degree of accuracy if the appropriate nature of the economic impact can be properly determined. To this end, we therefore start by characterizing and listing the forms of impacts that strategic systems innovations can provide:

- Traditional **cost reduction** that results from exploiting new technologies to improve operational performance, such as inventory management or supply chain integration systems. For instance, the combination of information systems and supplier management practices employed at Dell is believed to yield a 10% cost advantage, principally through inventory reductions.

- Capturing market share through faster time to market or **faster introduction of new products or services**. Continuing the Dell example, the same supply chain systems that provide cost advantages also enable them to incorporate new microprocessor technologies into their products in less than two weeks, compared to six weeks or more for their competitors. This creates a considerable advantage in an industry where new product introduction is frequent. In some cases, the “new product” is a service bundled with another product such as the introduction of frequent flier programs by American
Airlines or package tracking services at Federal Express. Also, systems innovations may not lead to the creation of entirely new products, but may enable a greater variety of similar products to be offered that better fit the needs of individual consumers.

- Capturing market share or earning higher margins by obtaining and utilizing better customer information. For instance, the success of Capital One Financial (a large credit card issuer) can be largely attributed to the ability to identify and serve customers who are not currently served or are poorly served by existing firms in the market (Clemons and Thatcher, 2001). Priceline’s patented “name your own price” system enables firms to encourage customers to reveal their willingness to pay, which, in turn, enables them to realize greater margins on airline tickets and other products sold through this approach. Generally the value created by these types of innovation results from a combination of increasing consumer value by better matching consumers with products that fit their needs best (maximizing willingness to pay) and capturing a greater share of value created through more accurate pricing for each individual customer.

- Disintermediation and bypass of traditional distribution systems can become possible through systems investments, especially in industries where intermediaries represent a significant component of overall product or service delivery cost – this has included insurance agents, retail brokers, and mortgage brokers in retail finance; travel agents; real estate agents; wholesalers and other industrial distributors. This is often accomplished by enabling electronic provision of service to customers through the Internet to the exclusion of traditional intermediaries. For instance, improvements in consumer distribution technologies in the airline industry have enabled airlines to sell
significant numbers of tickets without the assistance of travel agents, and to reduce or eliminate the commissions paid to travel agents (even online travel agents) for tickets they do sell [2].

- Providing a pure information good, such as on-demand pay-per-view movies, Bloomberg financial data, or Apple’s iTunes on-line music store.

Systems to support each of these functions will produce value in a different way, and valuation of systems to support each must therefore reflect the unique combination of value production, competitors’ responses, and consumers’ valuation and purchase behaviors. For instance, the value of cost saving information systems depends not only on the amount of cost savings, but also upon the time required for competitors to imitate the innovations and upon other marketplace characteristics that determine the amount of cost savings that can be captured by the firm and the amount that is necessarily passed on to consumers as a result of competition. For new products or services the same cost and imitation concerns are present, but a much greater emphasis must be placed on understanding consumer demand for the innovation: Are there substitutes? Will consumers truly value the innovation more highly than existing alternatives and substitutes? Are there barriers to adoption such as switching costs or compatibility issues that would interfere with consumer adoption? How long will it take for consumers to adopt the product? Do firms that introduce similar products at a later time enjoy advantages (such as consumer learning and increased interest in the category, decreased marketing costs in the presence of this awareness, or technological progress that would reduce their development and production costs) or disadvantages such as network effects in which the value of a product depends on the number of previous adopters or switching costs that would protect the initial
innovator? When systems are competitive in nature, such as those attempting to bypass existing
intermediaries, the competitive position and likely response of intermediaries becomes the
critical issue in understanding the potential value of a system innovation.

These issues are relevant for a wide range of business decisions, not just information systems. However, information systems innovations often have unique characteristics that need to be considered. First, innovations related to information systems or to information more broadly are often subject to rapid imitation. Consequently, it is particularly important to understand consumer demand and pricing patterns at early stages of a product introduction and to properly estimate the speed and nature of imitations to the product, in order to estimate profits from the early stages of product introduction. Likewise, it is necessary to understand the extent to which customers experience switching costs (“stickiness” or “lock-in”) that might reduce the competitive effects of subsequent imitation in order to estimate later profits accurately.

Similarly, the success of any information innovation is related to the speed of consumer adoption relative to the speed of imitation – if competitors can imitate before consumer adoption is widespread, the prospects for realizing significant value are severely diminished and again estimates for longer-term profits must be reduced.

Second, it is generally the case that information systems investments are often heavily influenced by the presence or absence of complementary assets or investments [3]. For instance, better customer information is only valuable if the firm can design a product to exploit that information, and then only if the firm has the operational capabilities needed to deliver the product. Frequently the complementary assets needed to profit from an innovation can be more
Determining the Economic Impact of Information Systems

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page 7

Thus the presence or absence of complementary assets and of supporting investments can greatly influence the value of a systems innovation.

Third, information-based innovations often are not sold directly to customers, but instead create value by increasing the price that customers can be charged for complementary products that are sold to them. For instance, Fedex package tracking does not earn revenue directly, but enhances the value of the Fedex service and thus enables them to compete more effectively with UPS, Airborne and other shipping companies. Apple Computer initially developed their iTunes music service to promote the sale of iPod music players, which have little serious competition and are highly profitable.

Finally, pure information products or the information components of existing products are often subject to network effects, where the value to each incremental user is increased by the number

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1 For instance, the ability to implement differential pricing, and charge customers different prices for their credit cards, was introduced by Signet Bank (now Capital One) in the early 1990s. The code modifications needed to vary interest rates and annual fees are not difficult to implement, but the expertise needed to know how to determine the appropriate price for each customer is complex and took years to acquire. The expertise needed to determine when an attractive account, with a large balance, is in danger of bankruptcy, is critical, and likewise took years to develop. The use of retention specialists, to retain profitable accounts being wooed by competitors, and to do so at rates attractive both for the customer and the bank, likewise enhances the profitability of Capital One. Differential pricing in the software turns out to be only a small portion of the expertise and expense needed to profit from differential pricing in the credit card industry. This is a special case of the role of structural differences in sustaining competitive advantage [1].

2 Switching costs are costs that customers would have to bear if they changed from their initial choice to a competitor’s offerings; for example, switching to Windows from Mac OSX requires learning to use a new system, purchasing new software, and converting some files, like Mac Keynote presentations to PowerPoint presentations. Network externalities and standards are benefits that often accrue to initial market entrants; if everyone on your email mailing list can
of existing users already in the network. Traditional examples of products exhibiting network effects include products designed to facilitate communications, such as the telephone system, word processing packages, or email systems. Non-traditional information services such as online auctions also show network effects. When network effects are large, early introduction of a product or service can lead to the formation of *de facto* standards, which can significantly reduce long-run competition and thus create great value through the establishment of a large base of early adopters.\(^3\) However, not all information goods exhibit these effects and considerable care must be exercised so that these effects are not overestimated or confounded with other more traditional economic issues such as economies of scale in production or distribution (see [4]).

3. Data Collection and Analysis

A critical part of any evaluation of systems value is obtaining appropriate data. While the types of data that are most important are specific to a particular evaluation, there are several general types of data that can inform a systems valuation exercise.

3.1. Technical Evaluation of Systems

A critical question in most systems evaluations is how the system as it exists compares to the "ideal" system as it might have existed. While this is seemingly straightforward, it can be hampered by lack of sufficient documentation of the specification of the desired system (making it hard to identify the "ideal"), or the fact that that a system in dispute may have been modified, read Word files and no one can read WordPerfect, this is an example of a strong network externality.

\(^3\) Perhaps the best known example of an early *de facto* standard leading to long term profitability is DOS, and later Windows, at Microsoft.
upgraded, replaced, or retired since the relevant time period of the dispute (making it hard to identify the actual system to compare to the ideal). Nonetheless, it is often possible to understand the nature of a system and the process by which it was created by analyzing commonly available archival information:

- **Direct observation of the output produced by existing systems.** This is likely to be an important place to start in almost all information systems disputes. When the system is actually operational and available to the investigator, using it or examining the results of real users’ interactions with it is a very good way to determine what it does and what it does not do. In other cases, when the system is no longer available, or when the current version of the system is not the subject of the dispute, the evaluation is preceded by identifying and restoring a prior system to operational condition from sources such as system backups, storage devices on retired hardware, or code escrow systems. From direct observation of systems it is possible to determine functionality and to compare systems to their specifications and thus to identify deviations. Observation can include direct evaluation of the internal operation of the system or the behavior of the system to various inputs or outputs. In some cases, especially with data processing systems, historical input and output data may have been archived and available for analysis.

- **Direct observation of the code of existing systems.** Sometimes the direct observation of the code is sufficient to resolve one or more of the claims of the dispute. Sometimes

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4 It is increasingly common that firms purchasing software require “source code escrow” in which a third party is provided with complete information on a system that can be released to the purchaser under some circumstances (e.g., a certain period of time, the bankruptcy of the systems provider). It is also common for historical versions of systems to be present on the hard disks of old machines which are no longer in service but retained by the firm.
the code simply cannot have produced the effects claimed by one party or the other, either because the code has no way of producing information that the party claims was improperly distributed or because the code has no way to delete or withhold information that the party claims was omitted or filtered. This can guide the investigator in a search to determine what actually was produced. Once it is clear through analysis that the code could not have produced the results alleged by the plaintiff, the defendant is in a better position to determine where to look for an explanation; did the plaintiff simply lose some of the data, or was some other aspect of the plaintiff’s analysis faulty. Sometimes the output of two systems appears to be very similar, but each is created by internal processes that are so different that claims of patent infringement or trade secret violations are difficult to sustain. Additionally, sometimes the code itself is so poorly structured and so poorly documented internally that this provides insight into disputes over the quality of the system and problems with maintenance or operational performance.

• **Observation or evaluation of systems design documentation.** Most commercial information systems are developed based, at least in part, from a formal specification. This specification document may make it possible to assess functionality, although performance levels or even feasibility of implementation cannot be established solely from specifications. While systems are rarely built exactly to their specification, and specifications can evolve over time, the information provided by specifications and contracts is often the only way to describe systems or parts of systems that were not completed.
• **Observation of project management documents.** Most commercial systems developers and internal corporate systems departments follow a formal project management approach. While there is some variation in the nature of these approaches is quite common to have project specifications, timelines, resource plans (especially staffing), test results, “bug” tracking databases, minutes from project team meetings (including developers and clients), and formal progress reports. These may also be supplemented by traditional accounting information such as time cards, salary reports and invoices. The frequency and detail of such documentation can vary considerably, but this can be an invaluable source of information about how a system was developed. This may be especially important in cases involving failure of systems implementations (e.g., cost overruns, delays, reduced or non-existent functionality) since these notes can provide insights on the relative contribution of the systems developer, the client, and external uncertainty on the outcome of a project. They can document what was and was not available, what was known about functionality by both parties, and when. These documents, along with the specification, can often be useful in determining whether a system project was a “failure” or “success” or, more frequently, whether individual modules, requests for functionality, or requests for modification can be considered a failure or a success. In many cases, the assessment of outcomes is difficult because it is very common for clients and developers to mutually negotiate changes in cost, time or functionality during the course of a project and consequently systems projects are rarely completed entirely in accordance with their original specifications. Moreover, developers and their clients often disagree in their assessment of systems functionality or the causes
of systems or project deficiencies, so that even the historical record of communications may be ambiguous. In the case of such disagreements, the historical record of bugs and outages, both at client and vendor, and at their network providers, can be indispensable. For example, if one client reports that its online customers repeatedly suffer from outages or slow service when no other clients report similar difficulties supporting their customers, this strongly suggests that the investigator look at the performance of the network service providers used by the different clients. The network design or performance histories of the various network service providers and their histories of downtime or transmission delays may enable the investigator to determine that a third party service provide was the source of the performance difficulties encountered by the client.

3.2. Observation of Users and their Adoption when Economic Data are Available

In addition to understanding systems’ capabilities, it is also important to understand the effect of the system on its users, whether they are individuals or corporate entities. Depending on the nature of the dispute and the nature of the system, there are several potential information sources:

- **Historical data and comparables:** When systems are delivered and then fail, historical data on sales and profits before delivery, after adoption, and then after failure can enable the cost of the failure to be determined, provided the calculations can be corrected for changes in the firm or business environment that might influence sales or profits for reasons unrelated to the systems failure. When such data are not available, data from
similar systems implemented at similar companies or even in similar industries may form the basis for reasonable estimates.

However, unless the underlying model is correct, statistics and measurements that arise out of econometric analysis such as confidence intervals and degree of prediction error are meaningless. There is also an important distinction between having a correct model and having a model that exhibits a good fit to available data. One setting in which this problem arises is predictions about the diffusion of a new technology. Most technologies tend to exhibit a classic “S” shaped diffusion process (slow early sales, rapid market penetration, and then saturation with slow growth into the future). A line will typically fit the pattern of early stage adoption quite well, but lead to vast underestimates of future product sales. If one only observes the middle phase of rapid diffusion, it will appear to rapid or accelerating growth, leading to an overestimate of future sales. Each model, when matched to the comparable data will show very low “in sample” error, creating an illusion of accuracy, impartiality and reliability, yet show tremendous “out of sample” errors because the calculations are based on invalid assumptions. While this is true for any econometric analysis, it can result in particularly egregious errors for the analysis of information systems adoptions due to their rapid rate of adoption once a critical mass of early adopters is achieved.\footnote{Information systems innovations generally follow patterns similar to those observed in the introductions of other novel technologies, but often at faster rates. The widespread adoption of flexible manufacturing in the automobile industry took over a decade; in contrast, the nearly universal adoption of order routing and order management systems in large securities trading firms occurred within two years of their introduction.}
• **Observation and inference from behavioral drivers:** One can observe how systems are used, and make inferences about how they would have been used if they had been more complete or more completely in accordance with specifications. However, these inferences rely on an understanding of the business context. A system that is delivered with incomplete functionality may result in significant losses if the missing functionality is critical and no losses if the functionality is not salient to potential users. The use of online securities trading systems differs from instrument to instrument and from country to country, so functionality considered critical in one market may be irrelevant in another. A delayed system or missing functionality that decreases a firm’s service quality may be critical in a highly competitive industry; the same systems problems may have substantially less impact when customers have few alternative suppliers or when their service expectations are not high. The fact that systems benefits are closely related to user behavior and industry context means that it can be important to not only the what capabilities of a system were (or were not) available but also the state of the marketplace, the current behaviors of consumers, and the possible behaviors of consumers had the omitted features been available.

3.3. Observation of Users and their Adoption when Economic Data are Not Available

When systems were never delivered and no economic history is available for analysis it may still be possible to use simulation and other techniques, based upon observation of the parameters that would have driven use if the completed system had been available for use.

• **Observation and estimation of behavioral parameters:** Mathematical simulations and econometric analysis can be utilized to infer what customers might have done if a system
had been available or if it had performed differently. This process begins by using current data to construct a model of how consumers behave, with parameters calibrated to reproduce actual behavior under current conditions. Using this model, behavior under different conditions can then be estimated. In some cases the model can be obtained directly from economic theory or practice (e.g., there are well known methods for estimating the relationship between price and demand). In other cases, the structure of the model will have to be adapted from a combination of economic modeling and behavioral investigation. However, a well designed model may provide little insight if the available data is not sufficient to support analysis using the model. Thus, the development of behavioral model inherently involves tradeoffs between the ability to capture the dynamics of the setting and the challenge of making the best use of the available data. However, regardless of data constraints, it is critical that the model be correctly specified. Without a correct model, simulation results have no meaning.

4. In Conclusion

Systems are increasingly strategic, and their economic impacts are increasingly significant. Systems failures can lead to bankruptcy, as evidenced by the litigation involving FoxMeyer, SAP, and Accenture [5]. More commonly, delay in the delivery of systems, or incomplete adherence to specifications and resulting flawed system performance, can have significant economic impacts on the intended users of these systems. While providing estimates of the economic gains that would have been provided “but for” the systems failures in dispute requires using data that, by definition, are not available, a range of techniques can be applied to assess the economic value of these systems. It is possible to reason systematically from paradigms and
prior experience when evaluating the economic impact of these systems, to determine what data to obtain, and to determine what economic valuation is implied by the data that become available. The appropriate specific methodology used for the valuation of the selected paradigm will be determined by the amount and type of data available, by the time period that must be analyzed, and by the sources of uncertainty.


