Information Systems Valuation, in Theory, in Practice, and in Litgation Support
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1. Introduction

Information systems are increasingly strategic, increasingly expensive, and increasingly critical to the operation of any enterprise. As IT budgets soar, careful understanding of the potential benefits of information systems investments becomes critical. Likewise, as information systems become increasingly critical to operations, and as outsourcing of software development and facilities management both increase, valuing information systems performance and contract non-performance becomes more critical in litigation and in claims valuation. We undertook three separate but closely related studies:

- **Valuation technique selection:** We examined how the nature of the valuation exercise, the availability of data from the firm, and the availability of data from comparable firms may interact to suggest one or more valuation techniques that might be applied. There will be far more available data when valuing a business interruption claim for a mature business in a mature industry then when valuing an interruption of a startup in a new industry or when valuing a truly innovative and novel application. This suggests that for business interruption claims in mature industries, regression will probably be most appropriate, while for making the initial determination to invest in innovation, alternative modeling techniques will be preferable. Likewise, when valuing a truly innovative application, such as the first attempt at online distribution to bypass a powerful sales channel, regression will probably be inappropriate, and alternative techniques, including detailed simulation of customer, competitor, and distribution channel behavior may be necessary when no form of historical data is relevant.
- **Valuation techniques in the academic literature:** We examined over 15 years of ***Information Systems Research*** and ***MIS Quarterly*** to see what academic researchers considered most interesting in their own research on valuation. We found the greatest interest in conceptual frameworks that could then be checked (and confirmed or not) against stock price history, followed by an interest in mathematically rich and timely subjects like real options valuation.
- **Valuation techniques in the courts:** We also examined the full online history of Federal court decision (which goes back to 1790) of disputes involving information systems valuation. We found very little actual reference to information systems valuation litigation (less than 50 cases in Federal courts) and most of those made reference to techniques only when there was a dispute. We found that litigation tended to rely upon the most data intensive and best-known techniques, such as regression analysis using data from the firm itself or from a similar firm. We found no references to more exploratory (and often highly subjective) models used in venture capital valuations, such as mark to like or mark to model. Moreover, we found at least one instance in which the court explicitly excluded testimony based on the real options analysis and Black-Scholes formulation so popular in the academic literature, since the data did not come from historical pricing of publicly traded instruments.

In this paper we proceed as follows: We first review a range of techniques that could be applied to valuation problems. We next review characteristics of each valuation problem domain and match them with the requirements of each valuation technique to suggest when each might be appropriate. We then present a preliminary review of two academic journals to suggest which techniques academic reviewers have chosen to examine, and we present a preliminary review of the history of online Federal Court decisions to examine which techniques have been employed in litigation over valuation and which have been disallowed after successful Daubert Merrell challenges. Expert witnesses have a large degree of freedom, in part because they are constrained to employ techniques

that are generally accepted in the scientific community. A Daubert challenge a term coined in the US Supreme Court case, Daubert v. Merrell Dow Pharmaceuticals, Inc.is used to question, and perhaps disqualify, an expert and his or her testimony. 509 U.S. 579-590-92[1]. We conclude with a set of observations on which valuation techniques appear to be under-utilized and have untapped promise, and which appear most mature both in the literature and in legal proceedings, and which may be most useful for inclusion in our own community's future teaching. Most of these valuations were not systems valuation litigation, but by expanding to other US courts we hope identify more.

2. Forms of Valuation — Usage of Data and Underlying Philosophy

Information systems valuation has become more complex. Where once systems were used simply to speed processing and increase throughput and market share, or to reduce labor costs and improve margins, information systems are now used for operational applications ranging from direct sales and bypass of traditional distribution to detailed simulation as an alternative to bench testing of jet engine design and for the widest array of data gathering and data analysis. Valuation was once much easier: how many more transactions could you process, how much more business could you capture, and what would you earn on the new business; or how much would you reduce expenses and how much would you earn on your existing business?

Valuation is now far more difficult, because the range of strategic systems usage is far more complex. Systems are no longer simply modifying the cost of individual transactions or the number of individual transactions that can be processed; information systems are now being proposed for applications that have not previously been possible. What would it have been worth to put online securities trading in at Merrill Lynch three years earlier than the firm actually deployed it? This is actually a problem that Merrill Lynch studied, and their conclusion was that the value of early implementation would have been spectacularly negative. They knew that online insurance brokerage at Prudential Direct had been a disaster, provoking rebellion among agents. Merrill's expectation was that their best Account Executives would have believed that online trading was being undertaken by Merrill in order to bypass them, and the best Account Execs would have deserted the firm, bringing their customers with them. Merrill waited, and was ridiculed for waiting when the market capitalization of online brokers like Schwab exceeded their own; only when Merrill's Account Execs demanded online trading to complete with Schwab's brokers could Merrill safely proceed with their own implementation. Without prior experience with bypass in distribution, there was no relevant historical data for the valuation of systems to disintermediate channel partners, and without any relevant data, econometric analysis and statistical extrapolation would have been impossible, and capital markets techniques like mark to market or mark to like would have been suspect. This was initially true at financial services firms, travel firms, and consumer packaged goods producers.

We consider several forms of valuation, which differ profoundly in their data requirements and in their usage of the data. Each of these valuation techniques is appropriate under different conditions. At one extreme we use history of the firm itself to create projections going forward. At the other extreme, when we have no data either on the firm or on comparable firms (called *comparables*), we may need some form of simulation using parameters to create estimates of the detailed behavior of the firm, its competitors, and their customers.

The principal determinants of which technique to use are availability of historical data and the stationarity of the process being modeled. Historical performance data may be available for the firm

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[1] The methodology of an expert must follow published and generally accepted scientific standards and must apply to the facts of the case. *Id.* at 593-94. A methodology can generally survive a Daubert challenge if it has been published in reviewed journals, but it may not survive if it has failed a Daubert challenge or has been ruled inadmissible in a prior court decision. A Daubert motion will typically seek to show that the proffered evidence lacks scientific validity and reliability by addressing (1) the ability to test the theory; (2) peer review and publication; (3) known or potential rate of error; and (4) extent of acceptance.

or business unit being valued; or in the absence of data on the unit being studied there may be historical valuation data available for directly comparable organizations; or failing that there may be sufficient data to estimate parameter values for critical trends. Additionally, we may have reason to assume that the processes distributions and parameter values are comparable to those of the recent past, or we may have reason to believe that a discontinuous change has occurred, causing us to use existing data with caution.

Based on available data we will recommend one of five strategies, each of which can be implemented with different techniques. These strategies for valuations can be based on projections or on actual data, using data for the firm itself, for comparable units, or parametric estimators.

- **Projection, Based on Actual Data (Projected Future):** The most direct form of valuation can be used when we have historical data on the unit being valued and we believe that our historical processes are continuing largely unchanged. In this case projection going forward, using econometric analysis or regression analysis, is most appropriate. Again, this is appropriate when valuing business interruption claims or other forms of service interruption claims. It can also be used to value investments intended to extend the capability of the firm or to leverage existing assets in new ways; in that case the regression needs to be modified to reflect future capabilities, increased sales, reduced costs, or other changes.
- **Projection Based on Comparable Data (Projected Comparable Future):** This involves synthesizing a comparable future from projections on a comparable firm. It is most appropriate when comparable firms exist, there is little relevant data on the firm itself, and there is historical data on the comparable firms. Instead of performing regression on the data of the firm, since such data are not available, we start instead with the performance of a comparable unit for which we do have a previous history and perform regression on that, then modify as appropriate, based on differences between the unit for which we have data and the unit for which we want to create a valuation. This is sometimes called ***mark to like*** in the financial services community. It is used when valuing investments that seek to replicate the capability of existing firms.
- **Projections Based on Parametric Estimators (Projected Hypothetical Future):** This involves synthesizing a suggested future. Without belief in stationarity of distributions, or if we believe that the market has sustained a shock that renders historical data no longer suggestive, we need an alternative to regression from historical data. Likewise, if the innovation is sufficiently innovative to ensure that historical data are no longer useful, we need an alternative to regression. Without direct data on the unit being studied we may develop a suggestive history. Starting with parameter values we can use techniques to develop a suggested range of futures. This is most useful when attempting to value something truly innovative. The financial services community would call this mark to model. It may involve detailed simulations, Monte Carlo simulations, and decision analysis, perhaps combined with some form of options valuation.
- **Modification of Historical Data for the Firm (Modification of Actuals, not Projections):** This is most useful when we want to value services that would have altered a previous history of the firm, but when some historical data does exist. If some systems failed, but not others, for example, and the firm continued to operate but with less than full efficiency, it may be possible to take the actual history of the firm and modify it to compensate for the loss of capability. Alternatively, when valuing a future investment that would have added capability, one can also start with data from the immediate past, modify it as appropriate for future market conditions, and then modify it again for the capabilities to be added. These are both forms of what the financial community calls ***mark to like***.
- **Modification of Historical Data for Comparables (Modification of Comparables, Not**

Projections): When we lack data on the firm itself, but we have actual data for competitors for the period in question (such as a business interruption claim) we can start with the data on the competitor, modify it as appropriate based on differences between the firm, and use this to create a valuation. The financial services community terms this ***mark to like***. This is most useful when environmental conditions have changed significantly and extrapolation from the prior history of the firm itself is likely to be unreliable or misleading.

Frequently more than one form of analysis will be appropriate for a specific valuation problem. Sometimes historical data can be used for projections, sometimes data from a different firm can be modified, and sometimes a simulation can be constructed. Most importantly, regression must of course start with the right assumed model. While linear models are least ambiguous, there are situations that simply are not linear; while S-curves are most controversial (having explicitly been excluded from consideration by the 10th Circuit Court (see *LifeWise Master Funding v. Telebank*, 374 F.3d 917 (10th Cir. 2004)), they may under rare conditions be most appropriate.

3. Hedging Strategies and Ad Hoc Valuation Techniques

Finally, valuation may not be based on either projection or modification of existing data. Sometimes no data will be available and simulations or Monte Carlo estimation techniques may be required, if there is sufficient information to generate reliable models. Additionally, hedging strategies such as sequential decision making and options valuation can be used, perhaps while combining other valuation techniques. Sequential decision making in essence suggests making partial investments in strategic prepositioning, waiting to see how events unfold, and then proceeding accordingly; as long as distributions on outcomes and their valuations are understood, this can be pursued, which often means combining other valuation techniques. In rare instances, where accurate market data and its history over time are known, Black Scholes valuation can be used in place of other, less precise techniques. While this has become extremely popular with academics, in most instances, the absence of historical data on value, either for the instrument or for surrogates, simply does not permit traditional Black-Scholes valuation. The requirements for using Black-Scholes valuation require a history of volatility in valuation, easily obtained for publicly traded firms, but meaningless when attempting to value the first investment in online trading systems or in bypass of traditional agency-based distribution systems. Other assumptions, like perfect divisibility and no restrictions on shorting, are even more extreme; what does it mean to build half an online distribution system for insurance, and what does it mean to short an online distribution system? Monte Carlo sampling and other simulation techniques have been used to generate the volatility needed for the application of Black-Scholes valuation in academic studies of real options, but the ability to use this in litigation remains uncertain.

4. Classes of Valuation Problems and their Key Characteristics

The sections above examined techniques that can be used to value investment decisions, examining how data availability affects the selection of a data analysis technique. This section explore the types of investment decisions that might require analysis

Innovation (new product or service): In these cases, historical data does not exist. It may sometimes be possible to find a firm in a different industry with relevant experience. For example, the experience of early insurance companies that added direct distribution (online sales) as a form of bypass of their agent-based distribution system might be suggestive for a traditional retail brokerage firm that was considering adding online trading. It might then be possible to observe change in market valuation in the innovator, and this may provide a basis for beginning to employ **Modification of Comparables.** Alternatively, if there is no directly comparable history or the history does not appear suggestive of the innovator's own industry, then a model must be constructed and **Projected Hypothetical Future** will be the most reasonable way to proceed. This may require a detailed simulation of customer behavior, competitor behavior, and channel partner behavior, in order

to predict future performance after the innovation. Even if we do not have data on customer performance in this precise setting, it may be possible to construct simulations in which customers make choices based on how aware they are of the new service, how attractive it seems, how competitors respond, and how channel participants respond. For example, few customers were immediately interested in online grocery sales, more were interested in online air travel, and still more were interested in online brokerage; WalMart could have responded to punish early consumer packaged goods participants who attempted their own online grocery sales, travel agencies were unable to do so for a variety of reasons explored in other papers (Clemons and Gu, 2004), and traditional securities firms were unable to act until their own brokers were willing to allow online trading.

Enhancements to existing capabilities, increasing capacity, or leverage of existing resources: Here, of course, the analyst enjoys the greatest range of existing data sources, since the analysis involves modification to existing capabilities of an existing firm; there will certainly be data on the firm, and there will probably be data on competitors as well. The historical value of the firm can be used as a starting point for analysis, modified to account for increased capabilities. The historical value of competitors who have undertaken enhancements can likewise be used, modified to reflect differences between the firms. Regressions can be used, based on previous performance of the business unit or of competitors business units, if business unit data are available, modified to account for the increased capabilities to be provided or modified for differences between the firm and competitors. And simulations can be constructed since the data needed to estimate parameters is generally available, although sensitivity analysis is recommended.

Achieving parity with an existing competitor by replicating a necessary application: Once again, the analyst enjoys the widest array of data sources. **S**ince the analysis involves modification to existing capabilities of an existing firm; there will certainly be data on the firm, and there will probably be data on competitors as well.

Cost reduction, operating expense reduction: Once again, the analyst enjoys the widest array of data sources. **S**ince the analysis involves modification to existing capabilities of an existing firm; there will certainly be data on the firm, and there will probably be data on competitors as well.

Valuation of losses due to system failure, accident, or other source of business interruption: If the business is mature and in a mature industry, historical data should be a good indicator of future performance. In the rare instance of a innovative start-up with a business interruption claim early in its history, like a start-up inter-market electronic trading firm destroyed in the World Trade Center Disaster, alternative valuation techniques may be necessary.

5. Matching Valuation Problem Types to Choice of Methodologies

What we would expect to see is shown in table 1, based on matching data requirements to data availability for each form of valuation. As noted above, we found that the academic community was more interested in exploring the application of the most advanced techniques from finance while the courts seemed more confident using the most traditional methodologies.

6. Directions for Future Research

There will be three important extensions:

- A more detailed study of a wider range of academic publications will provide a larger, and perhaps broader sample.
- A more detailed study of the courts will help assess the techniques actually used. While the online description of the litigations does not always allow us to determine the valuation techniques used or challenged, analysis of court transcripts may provide more information.
- Finally, a more complete examination of the match between data requirements and applied techniques, our own community's writing, and the behavior of the courts will allow us to improve our own community's teaching of valuation and perhaps our contribution to the behavior of the courts in this increasingly important area of litigation.

	Projections of Historical Trends			Modification of Actual Data		Construction of Detailed Model	Hedging Strategies
	(What could last year tell us about the future?)			(How could this year have been different?)		(What can we infer from structure and first principles?)	(How can we deal with uncertainty?)
	Project Actuals	**Project Comparables**	**Project Estimates**	**Modify Firm's Historical Performance**	**Modify Other Firm's Historical Performance**	**Detailed Simulation or Monte Carlo**	**Black Scholes or Sequential Decision Theory**
	(Econometrics and Regressions)	(Mark to Like)	(Mark to Model)	(Mark to Market)	(Mark to Like)	(Mark to Model)	(Real Options Valuation)
Deciding to Undertake Truly Innovative Product or Service					Use data from firms in related industries if they tried similar innovations	Detailed simulation or Monte Carlo valuations	Options valuation or sequential decision making, using historical or simulation data
Enhance Existing Capability, Increase Capacity, or Leverage Existing Resources	How would performance have differed with these capabilities or enhanced capacity?	Using data on competitors or other related firms may help valuation	Using data on competitors or other related firms may help valuation	How would performance have differed with these capabilities or enhanced capacity?	How did competitors' performance improve with these capabilities?	Detailed simulation or Monte Carlo valuations	
Achieve Parity With Competitors	How would performance have differed with these capabilities or enhanced capacity?	Using data on competitors or other related firms may help valuation	Using data on competitors or other related firms may help valuation	How would performance have differed with these capabilities or enhanced capacity?	How did competitors' performance improve with these capabilities?		
Reduce Costs or Operating Expenses	How would performance have differed with these capabilities or enhanced capacity?	Using data on competitors or other related firms may help valuation	Using data on competitors or other related firms may help valuation	How would performance have differed with reduced operating expenses?	How did competitors' performance improve with these capabilities?		
Value a Loss from Interruption of Existing Business	Compare operations with those that would have been expected			See how the loss market reduced valuation if firm is traded	Compare with similar firms that did not suffer loss		

Table 1.—Valuation Techniques and Their Data Requirements.

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