QUANTIFYING IT VALUE LATENCY:  
THE CASE OF THE FINANCIAL SERVICES INDUSTRY 

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Abstract  
Both the academia and practice recognize that information technology (IT) investments may not yield immediate benefits. Nevertheless, there has been a lack of methodological developments to effectively measure IT value in the presence of value latency. We consider the sources of value latency and develop a time-series measurement methodology based on intervention analysis to measure the temporal value flows from IT investments. We apply the quantitative measurement methodology to six publicly-listed financial institutions that invest in customer relationship management (CRM) technologies to illustrate how it works. Within the bounds of our sample, we show that IT value latency exists and that firms demonstrate different patterns for the accrual of lagged value from IT investments. Our results offer new managerial thinking for IT benefits management.

Keywords: Banking industry, business value of IS, econometrics, financial services, IT value, measurement methods, value latency, value trajectory.

1. INTRODUCTION  
The financial services industry faces unprecedented challenges in the 21st century. These challenges include declining mortgage revenue, flat credit card usage, credit quality concerns as well as changing customer demographics. Gartner reported that the top concern for bank CEOs in 2007 is to maintain competitive advantage through expanding and safeguarding their customer base [23]. The use of technologies such as customer relationship management (CRM), internet banking and business intelligence tools to serve and expand the customer base are well established practices among financial institutions; but what is less understood is the temporal value trajectory that banks can yield from such investments.

Prior literature has established that the returns from IT investments are not instantaneous [1, 3, 5,12,13]. IT value latency is the lag in business value after the implementation of a new IT investment. Despite the growing body of research that identifies the presence of this phenomenon, little is known about the structure of value latency across the time horizon for IT investment impacts, and the appropriate theoretical explanations for this latency. The practitioner literature has also recognized the significance of this phenomenon and suggested that methodologi-
in the value flows over time will provide a basis for benchmarks for IT project performance. This will have the collateral benefit of helping managers to “right size” their IT payoff expectations and focus attention on ways to unlock more value sooner from their investments in competitive environments.

§2 reviews the literature relevant to the value latency problem in IT investment. §3 presents an IT value flow moderators matrix to define factors that impact value latency and discuss the sources of value latency. §4 lays out assumptions and conditions for our modeling. It develops the measurement methodology to treat four different conditions for IT investments. §5 applies this measurement methodology by computing the lagged value flows of CRM investments for financial services firm. §6 concludes with contributions and limitations.

2. THEORETICAL FOUNDATIONS

Observed lags in ROI suggest why IT value latency calls for research [10] to enhance our knowledge of IT benefits management.

2.1 IT Value Latency

Bharadwaj et al. [3] used firm market value to measure IT ROI and contribution to long-term performance. They stated: “[I]nvestments in IT systems may take years to add value to a firm and are ... likely to be reflected in future profit streams” [p. 1011]. Similarly, Brynjolfsson and Hitt’s [6] analysis of firm-level IT benefits reveals that long-term ROI is two to eight times greater than short-term returns. The magnitude of lagged effects of IT investments is contingent on the business context [9]. Brynjolfsson and Hitt [5] noted that returns to IT investments are inconsistent over time, with a lag between initial investment and final payoff. Hitt et al. [19] concluded that value accrual for IT benefits lags in years of time.

IT value latency has not been analyzed in the depth needed to reveal its causes. A large number of possible factors can create friction for the flow of IT value. Choosing among them seems challenging. According to Churchman [7], the key to this lies in proper standardization of measurement variables through the application of a set of well-specified definitions and rules. Our approach to standardizing the measurement variables involves first defining an IT value flow moderator matrix (or moderator matrix, for short) to characterize the factors that impact IT value latency. We will assign these factors as elements in the matrix. Our method will be built to handle the elements of the matrix.

2.2. Sources of IT Value Latency

IT value creation is impacted by technological, competition, organizational and environmental factors [24]. This classification provides us with a theoretical lens to view the source of the moderating factors behind the creation of IT value and differential lagged values of IT investments. Technology-related factors such as system compatibility, standards, system integration, and obsolescence impacts the flow of value. A review of the literature suggests that the role of complementary technology investments and existing technology resources affects value payoffs [8].

Impacts of competition and competitive strategy adopted by the firm also affect the value latency of its investments [19]. Existing competition, threats of new entrants and actions undertaken by competitors are known to skew the distribution IT value among actors within the economy.

Factors within the organization also affect the value trajectory of IT benefits. Friction in IT value creation originates from non-IT-related business processes. IT investments that rely on complementary operational activities face potential inertia from these processes when sub-optimal implementation strategies are applied [24]. This view of how these business process considerations impact IT value creation is echoed by Dedrick, et al. [8], who survey empirical research on IT value. They state that IT value flows are impacted by the structure and business practices of the firms. Weill [30] and Franalanci and Galal [12] and others conclude that different organizational routines seem to be crucial in the creation of limits to value for IT investments. Finally, resistance from users and learning complexities are known to affect users of IT [25,29].

IT value latency can be caused by external environmental conditions that make IT benefits management harder. Environmental IT value flow moderators such as legal barriers and constraints from stakeholders, including the high bargaining power of sellers or customers, often have adverse effects on the firm’s ability to create payoffs from IT investments.

Factors that impact value latency may occur in the course of firm operations or be unexpected ones that are not usually faced in this context. Existing conditions that impact the value flow of investment can fall into one of the four sources of IT value latency discussed earlier. We define these conditions as IT value flow moderators: the set of operating conditions that the firm faced during IT implementation.

We also consider shocks, unexpected changes that occur in the firm operations, and their impacts on our ability to manage IT benefits flows. Economists often refer to shocks as changes in an exogenous variable that causes some disturbance in the system. Shocks reflect stochasticity in the factors that underlie some outcome, although shocks can be forecasted
with some degree of precision. Shocks can have positive effects (e.g., positive technology shocks in production) or negative effects (e.g., supply shocks, oil shocks, etc.) [20]. Like the prevailing circumstances of an IT investment, shocks can impact the resulting value flows and should be considered in the development of the measurement methodology. Shocks can occur cyclically, either as periodic shocks, or singularly, as sporadic shocks. Periodic shocks include economic and business cycles or seasonality, and tend to recur and so are more predictable. Sporadic shocks involve organizational and environmental changes that do not recur.

Shocks involve changes that play a significant role in determining the value latency of an IT investment. Exclusion of these factors in the measurement methodology leads to misspecification and may cause biased estimation of the value latency parameters. We consider both periodic and sporadic shocks. Periodic shocks are cyclical and can occur in the form of business or seasonal cycles. The economics literature recognizes cyclical movement in the economy and business, explained by the theory of real business cycles, attributable to Lucas [21] and others. The theory asserts that cyclical movement in the economy is consistent with the principles of Pareto efficiency and the assumptions of an efficient market economy. Economic cycles are formed by productivity shocks due to inter-temporal optimization, when agents in the economy purposely delay production until a later time. At the aggregate economy level, this behavior leads to voluntary unemployment, resulting in diminishing economic activity. Similarly, seasonal cycles, such as increased retail sales and holiday travel, are known to be associated with the business cycles and the fluctuation of total output [31].

Sporadic shocks are different from periodic shocks. They are less likely to recur and do not follow a cyclical pattern. Sporadic shocks can occur due to changes in technology, competition, business environment or within the organization. Examples include changes in technology standards, increased competition from new entrants, changes in governmental regulation or even internal organization re-structuring and shifts in corporate strategy.

Although both sporadic and periodic shocks involve changes that occur without much relation to the IT investment, they play a key role in the associated payoffs. The temporal nature of a shock makes it a key variable for measuring the IT value latency.

In Table 1, we lay out the factors that impact value latency, and use the matrix format to classify the moderating factors and shocks to be considered in the measurement of IT value latency. The examples listed in this matrix are for illustration; they are not meant to be exhaustive.

### Table 1. IT Value Flow Moderators and Shocks

<table>
<thead>
<tr>
<th>SOURCES</th>
<th>IT VALUE FLOW MODERATORS</th>
<th>PERIODIC SHOCKS</th>
<th>SPORADIC SHOCKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Compatibility</td>
<td>Tech. planning</td>
<td>Tech. changes</td>
</tr>
<tr>
<td></td>
<td>Tech. obsolescence</td>
<td>Emerging innov.</td>
<td>Emerging innov.</td>
</tr>
<tr>
<td></td>
<td>Tech. integration</td>
<td>IT strategy changes</td>
<td>IT strategy changes</td>
</tr>
<tr>
<td>Competition</td>
<td>Competitive env.</td>
<td>Seasonal competition</td>
<td>Digital convergence</td>
</tr>
<tr>
<td></td>
<td>Bargaining power</td>
<td>Foreign competition</td>
<td>Comp. from substitutes</td>
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<tr>
<td></td>
<td>Comp. strategy</td>
<td></td>
<td>Entry of new competitors</td>
</tr>
<tr>
<td></td>
<td>Market position</td>
<td></td>
<td></td>
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<tr>
<td>Organization</td>
<td>Absorptive capacity</td>
<td>Production, mfg. cycles</td>
<td>Mgmt. changes</td>
</tr>
<tr>
<td></td>
<td>Routine rigidity</td>
<td></td>
<td>Firm structuring</td>
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<tr>
<td></td>
<td>Culture</td>
<td></td>
<td>Strategy changes</td>
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<tr>
<td></td>
<td>Learning capability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Legal barriers</td>
<td>Business cycles</td>
<td>Regulations</td>
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<tr>
<td></td>
<td>Stakeholders</td>
<td>Seasonal cycles</td>
<td>Market structure</td>
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<td></td>
<td>Economy</td>
<td></td>
<td>Sale</td>
</tr>
<tr>
<td></td>
<td>Interest rates</td>
<td></td>
<td>Supply shocks</td>
</tr>
</tbody>
</table>

### 3. MODELING IT VALUE LATENCY

We create the measurement models for this research using the value flow moderator matrix shown in Table 1. The matrix provides a summary of the factors that one should be mindful of in measuring value latency across time, as well as relative to the social and economic agents within and beyond the firm. The IT value flow moderators reflect a common baseline state for all of our models and measurements of IT investments. Periodic and sporadic shocks may occur with respect to all IT investments, but they can occur alone or together. See Figure 1.

### Figure 1. Periodic and Sporadic Shock Models

![Figure 1. Periodic and Sporadic Shock Models](image)

The locus or location dimension of the matrix serves as a guide to identify the value flow moderators and shocks, and is important for the specification of the model. This dimension serves as a guide and template for the user to identify the factors that impact value latency amidst the set of possible factors.

The next step in the development of the measurement methodology is the specification of the underlying empirical model. We use time-series regression as the empirical foundation for our measurement methodology. Specifically, we model the introduction of an IT investment as an intervention under an autoregressive process using a technique that is similar to the conventional intervention model discussed by Box and Tiao [4]. Intervention models are commonly used to analyze the temporal impacts of an independent variable on a dependent variable and have
been widely applied to study the lagged impacts of project initiatives. Some prior work that utilized this technique includes: the study of the value of advertising [19,16,27]; the impact of governmental policies [28]; and the benefits of airport security [11]. The phenomenon of IT value latency is temporal, and involves a mix of organizational, technological, competitive and environmental factors which are interrelated. The dynamic, sequential and stochastic nature of the delayed payoffs makes time-series regression an appropriate statistical tool.

4. MEASUREMENT: THE Baseline MODEL

We discuss a baseline model (BM), and illustrate value trajectory and value appropriation functions.

4.1. Model Development

Our baseline model represents situations where the IT investment is being made with typical value flow moderators and no shocks in the analysis. The empirical model is:

\[ y_t = a + b y_{t-1} + c I_t + \epsilon_t \]  

**Baseline Model** (109)

where \( y_t \) is firm profit at time \( t \) and the firm’s profit follows an AR(1) time-series process, with \( b \) the degree to which profits in a prior period impact profits in the current period. The parameter \( b \) also is an indicator of the consistency of firm performance over time [11]. The immediate effect on firm profits due to the presence of the IT investment is measured by \( c \) [11]. \( \epsilon \) is an error term.

The intervention variable \( I_t \) can range between 0 to 1 depending on the percentage of IT investment spending that has been accomplished. Assuming that an IT investment is both made and implemented in a single phase, we represent \( I_t \) as, 

\[ I_t = \begin{cases} 
0, & t < 0 \\
1, & t \geq 0 
\end{cases} \]

where \( t \) represents time and \( t = 0 \) is the time when the model begins measuring the flow of IT value. In this case, full implementation implies that the IT investment is completed. Prior to \( t = 0 \), the IT project will not have been not fully implemented or completed, and so we code the investment variable in all of those times in that period with 0. An investment timeline is shown in Figure 2.

Some IT investments are implemented in stages, so the application is utilized prior to the implementation of the subsequent stage. Imagine that a firm implements the Financial Accounting Module of SAP R/3, and after a year of using it, also implements the Materials Management Module. This stage-based implementation calls for a different empirical model.

**Figure 2. Timeline for Single Phase IT Investment**

\[ I_t = 0 \quad I_t = w_t \quad I_t = 1 \]

4.2. Value Trajectory Functions

We next create a set of value latency measures based on the empirical model with value trajectory analysis. For this, we chart the path of value flows over time after implementation. Taking the expectation of Eq. 1, the immediate impact of the IT investment on firm profits is \( c \). The long-term impact of IT investment on firm profits can be represented by \( c/(1-b) \) [11]. This ratio shows us that when there is a disparity for long and short-term effects of IT investment, with \( 0 \leq b < 1 \), the short-term effects of IT investment will always be smaller, suggesting that there is a lag of the related IT payoffs.

Recall that the variable \( I_t \) in the baseline model of Eq. 1 indicates the presence and occurrence of IT investment, but it does not provide information about the associated value flows. To provide additional information on the intermediate effects the IT investment, we specify the value trajectory function for the IT investment. We will show that the value flows of the IT investment for each time period can be characterized as a convergent sequence, which we call the value trajectory. This is given by 

\[ V_t = c \cdot \sum_{i=0}^{t} b^i \]

where \( V_t \) is the value of the IT investment at time \( t \) after the investment has been made, and \( t \) represents some point in time after the IT implementation at which a value assessment is made. The value trajectory function is instrumental in measuring the value flow of the IT investment for successive time periods and the parameters in this model are derived from the estimates in a time-series regression.

4.3. Value Appropriation Functions

Being able to map out the value trajectories for an IT investment is one key step in understanding the value flows of these investments. This leads us to yet another question. Given a particular point in time after the implementation of an IT investment, what is
the proportion of total long-term value being appropriated? We will answer this question by establishing functional forms that measure the extent which the IT investment is achieving the total value. We call these value appropriation functions.

Recall that \( t \) is a point in time after the IT implementation when a manager wishes to analyze the amount of business value that has been obtained from the investment. The difference between the value of the IT investment at \( t \) and the total long-term value of the investment as \( \Delta V_t = c \left( \frac{1}{1 - b} - c \cdot \sum_{i=0}^{\infty} b^i \right) \), which can be reduced to \( \alpha = 1 - b^{-1} \). This implies \( t = \frac{\ln(1 - \alpha)}{\ln b} - 1 \), where \( \alpha \) is the proportion of total value attained by time \( t \).

Since the natural logarithm is a monotonic function, from \( t = \frac{\ln(1 - \alpha)}{\ln b} - 1 \) we see that the duration of the value lag is inversely related to \( b \), the autoregressive coefficient of \( y_{t-1} \). A higher coefficient, thus, will lead to longer value lags, and vice versa. The autoregressive coefficient represents the extent to which the profit that accrues in the preceding time period is correlated with profits in the current time period. This parameter measures the perpetuity of firm profits due to both organizational and environmental IT value flow moderators that are impacting the firm. Larger parameter estimates suggest rigidity in organization performance, so that performance in one period bleeds over to, or is sustained in subsequent periods. This may be a result of organizational factors that we described earlier, including the nature of organizational routines, the existence of organizational friction, and learning discontinuities. It may also be the result of external environmental factors, including constraints on IT value flows from customers who are reluctant to adopt new business practices supported by the CRM implementation, or due to uncertainty in the market about the underlying standards for the CRM implementation.

5. MODELING SHOCKS ON Lagged VALUE

We now extend the baseline model to incorporate effects of periodic and sporadic shocks in IT value latency. We look at a case in which only a periodic shock occurs, followed by another case in which only a sporadic shock occurs. After, we will consider the case in which both occur. Inclusion of shock variables ensures we can establish consistent estimations of the parameters in the value trajectory and value appropriation functions, for each of the different models (periodic shocks only, sporadic shocks only, periodic and sporadic shocks together).

5.1. Modeling the Impacts of Periodic Shocks

To analyze the latency of IT investments implemented in an organization that experience periodic shocks (e.g., an airline industry experiencing higher sales during the year-end holiday season), the measurement model must consider the impacts of these shocks to ensure accurate estimation. We will modify our time-series regression model by incorporating a moving average (MA) component to account for the seasonality. The periodic-shock model (PM) considers the IT value flow moderators and periodic shocks that occur:

\[ y_i = a + b_q y_{i-1} + c t + \varepsilon_i + \eta_q \varepsilon_{i-q} \]  

where \( \varepsilon_q \) is the estimated impact of seasonal demand variation, \( \eta_{i-q} \), that occurs every \( q \) time periods in MA(\( q \)). The seasonality component, MA(\( q \)), captures spikes or troughs due to seasonality impacts across the time periods. We prefer to use a moving average component instead of an auto-regressive (AR) component because the former captures the instantaneous impact of seasonality, which may not persist for very long, but also is unlikely to decay across the relevant cycle in time [11]. Since seasonality is cyclical, \( q \) represents the time between seasonal impacts. So to model a retailer’s demand, for which there is a spike in demand in the fourth quarter, we assign \( q = 4 \).

We can show that the value trajectory function of the IT investment at time \( t \) under conditions of seasonality will be \( V_t = c \left( \frac{1}{1 - b_q} - c \cdot \sum_{i=0}^{\infty} b_q^i \right) \). Likewise, the corresponding value appropriation function is \( \alpha_{Periodic Shock} = 1 - b_q^{-1} \) or \( t = \frac{\ln(1 - \alpha)}{\ln b_q} - 1 \), where \( \alpha_{Periodic Shock} \) represents the proportion of total value attained. \( V_t \) is the value for an IT investment subject to periodic shocks, is similar to the expression we use when the firm does not experience shocks. The key difference lies in \( b_q \), the autoregressive coefficient. By controlling for periodic shocks, there will be an impact on the magnitude of \( b_q \) and, we can obtain an unbiased estimate of \( b_q \). The impact on \( b_q \) is affected by the direction of the shock. We know that \( b_q \) determines the duration of the lag, which is affected by the shock experienced by the firm. Controlling for shocks provides a more accurate depiction of the value trajectory of an IT investment.

5.2. Modeling Impacts of Sporadic Shocks

We have developed the measurement model to account for existing IT value flow moderators, and periodic shocks that impact the value trajectory. We have assumed that the IT investment occurred with
no interference of sporadic shocks impacting the firm. At times though, the organization may be impacted by unforeseen and non-repeated organizational, technological, competitive and environmental factors, such as the occurrence of a merger or major changes in top management or changes in governmental regulation or even technological standards. These shocks create persistent impacts on firm value and affect the value flows from the IT investment. So we also propose a sporadic shock (SM) model:

\[ y_t = a + by_{t-1} + cI_t + gS_t + \epsilon_t \]  

**Sporadic Shock Model (SM)** (3)

\( S_t \) is a binary variable for the presence of the sporadic shock, \( S_t = \begin{cases} 0, & t < t_{\text{Sporadic Shock}} \\ 1, & t \geq t_{\text{Sporadic Shock}} \end{cases} \), where \( t_{\text{Sporadic Shock}} \) is the actual time when the sporadic shock occurs. The parameter \( g \) filters the shock that is felt in output or profitability via \( y_t \).

The presence of the shock has an impact on the profits of the firm via the value flows from the IT investment. The value trajectory function from the IT investment at time, \( t \), affected from time \( t_{\text{Sporadic Shock}} \) when a sporadic shock through the period when the IT value flow is affected is:

\[ V_t^{\text{Sporadic Shock}} = c \sum_{i=0}^t b_i + g \sum_{i=0}^t b_i^t \]  

This reflects the modified value for the IT project subject to a sporadic shock, which is equal to the original value flow plus the impact on value due to the sporadic shocks. Eq. 4 establishes the idea that the sporadic shocks that firms face have sustained impacts and will affect the payoff of an IT investment over time. We now extend our analysis to obtain the related value appropriation function.

We represent the difference between the value of the IT investment at time \( t \) and the long-term value of the investment, under conditions of shock, by \( \Delta V_t^{\text{Sporadic Shock}} \), as follows:

\[ \Delta V_t^{\text{Sporadic Shock}} = \frac{c + g}{1 - b} - \left( c \sum_{i=0}^t b_i^t + g \sum_{i=0}^t b_i^t \right) \]  

\( \forall t > t_{\text{Sporadic Shock}}, t > 0 \)

This model only considers times after the occurrence of both the IT investment and a shock. For times after the IT investment but before a shock occurs, the measurement model reduces to the value appropriation function of the baseline case. We can show that Eq. 5 simplifies to the value appropriation function:

\[ \alpha^{\text{Sporadic Shock}} = 1 - b^{t_{\text{Sporadic Shock}}} \cdot \Theta \]  

where \( \Theta = \frac{c + g \cdot b^{t_{\text{Sporadic Shock}}}}{c + g} \)  

Here, \( \alpha^{\text{Sporadic Shock}} \) is the proportion of long-term value obtained at time \( t \) after the shock occurs. This proportion is impacted by \( \Theta \), the shock latency coefficient. The magnitude of \( \Theta \) affects the extent to which the IT investment attains its long-term value in a given time period. Eq. 6 suggests that the size, direction (positive vs. negative) and timing of the shock impacts the magnitude of \( \Theta \), which affects the latency of value flows. Eq. 6 is a general expression for the value appropriation function of the baseline case; when there is no shock (i.e., \( g = 0 \)), Eq. 6 simplifies to the baseline case.

5.3. Modeling Joint Periodic and Sporadic Shocks

We finally consider the case where the firm experiences both periodic and sporadic shocks during IT implementation after investment. Imagine an airline company that is affected by seasonal travel during year-end, but experiences an oil price shock while it is investing in and implementing some new CRM technologies. The joint periodic and sporadic shock model that represents this condition will be:

\[ y_t = a + b_y y_{t-1} + cI_t + gS_t + \epsilon_t + \eta_t \epsilon_{t-q} \]  

**Joint Shock Model (7)**

\( S_t \) measures the sporadic shock and \( \epsilon_{t-q} \) measures the periodic shock. Similar to what we have done for the analysis of the two kinds of shocks in isolation, we can show that the value trajectory function follows a convergent series and is represented by:

\[ V_t^{\text{Joint Shock}} = c \sum_{i=0}^t b_i^q + g \sum_{i=0}^t b_i^q \]  

where \( b_q \) is the autoregressive coefficient controlled for seasonality. As in the other three modeling conditions, we let the difference between the value of IT investment at time \( t \) and the long-term value be \( \Delta V_t^{\text{Joint Shock}} \). The corresponding value appropriation function is:

\[ \alpha^{\text{Joint Shock}} = 1 - b_q^{t_{\text{Join Shock}}} \cdot \Theta^{\text{Joint Shock}} \]  

where \( \Theta^{\text{Joint Shock}} = \frac{c + g \cdot b_{t_{\text{Joint Shock}}}}{c + g} \)  

6. FINANCIAL SERVICES VALUE LATENCY

To demonstrate the application of this measurement methodology, we assess value latency for CRM investments in financial services, based on conditions that a firm experiences when implementation occurs.

6.1. Methodology

We apply our proposed measurement methodology to six publicly-listed firms (labeled A to F) that invested in CRM technologies from the first quarter of 1990 to the third quarter of 2005. We downloaded articles pertaining to these firms’ CRM investments from Lexis-Nexis (www.lexisnexis.com) and Factiva.
We ascertained when the implementations occurred. We scanned other news related to the firms to identify major shocks that occurred three years before and after the investments. We used the value flow moderators matrix to identify these shocks. We chose a six-year window or 24 periods of quarterly data around the IT investments. This is sufficient for the effects of all relevant shocks to accrue. Shocks outside this time frame are unlikely to create impact the payoffs of CRM investments.

We also obtained quarterly profits up to the third quarter of 2005 from Compustat. The data permit the application of our measurement methodology based on the business conditions experienced by the financial institutions. Fig. 4 shows the time-series of profits by quarter for the selected financial institutions. The profit figures fluctuated over time. By applying our measurement methodology, we will isolate the impact of the CRM investments on the changes in profits, yielding evidence on the business value of the CRM investments.

![Fig. 4. Financial Inst. Profit, 1990-2005 ($ millions)](chart)

### 6.2. CRM Investments under Baseline Model

Unlike firms in the retail or transportation industry, financial services firms do not experience significant year-to-year seasonality. So we will not incorporate periodic shocks in our evaluative models. Based on relevant news articles, five of the six financial institutions did not experience any major shocks during the period for analysis. We use the baseline model to examine the lagged value of the CRM investments in these firms. We apply data to the baseline model time-series regression in Eq. 1 to obtain estimates for the parameters of the value latency model. See Table 2.

### 6.3. Short-Term Value vs. Long-Term Value

Using our model estimates, we compute the immediate payoff in one quarter, and the long-term payoff of the CRM investment. See Table 3.

### Table 2. Baseline/Sporadic Shock Model Results

<table>
<thead>
<tr>
<th>NAME</th>
<th>COEFFICIENT (STD. ERR.)</th>
<th>COEFFICIENT</th>
<th>STD. ERR.</th>
<th>COEFFICIENT</th>
<th>STD. ERR.</th>
<th>COEFFICIENT</th>
<th>STD. ERR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>286.87*** (56.44)</td>
<td>0.4565** (0.1383)</td>
<td>179.94*** (70.66)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>382.81*** (87.08)</td>
<td>0.3489** (0.0756)</td>
<td>573.28*** (169.32)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>84.50*** (28.80)</td>
<td>0.4438** (0.0667)</td>
<td>156.48*** (28.15)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>D</td>
<td>327.50*** (192.55)</td>
<td>0.7339*** (0.1019)</td>
<td>286.93*** (171.98)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>E</td>
<td>406.57*** (156.59)</td>
<td>0.3553*** (0.0862)</td>
<td>0.3553*** (0.0862)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>388.86*** (181.66)</td>
<td>0.4332*** (0.1173)</td>
<td>948.0*** (215.13)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Notes.** Data: Six financial services firms, including: Bank of Montreal, A; Merrill Lynch, B; State Street Corporation, C; American Express, D; GE Capital, E; Bank One, F. Baseline model estimated for A to E; sporadic shock model estimated for F. ** p < 0.05; *** p < 0.01.

### Table 3. Short/Long-Term CRM Investment Value

<table>
<thead>
<tr>
<th>NAME</th>
<th>SHORT-TERM VALUE (US$ '000)</th>
<th>LONG-TERM VALUE (US$ '000)</th>
<th>LONG-TERM TO SHORT-TERM VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$179,944</td>
<td>$331,077</td>
<td>1.840</td>
</tr>
<tr>
<td>B</td>
<td>$573,282</td>
<td>$880,444</td>
<td>1.536</td>
</tr>
<tr>
<td>C</td>
<td>$156,480</td>
<td>$281,333</td>
<td>1.798</td>
</tr>
<tr>
<td>D</td>
<td>$286,933</td>
<td>$1,078,373</td>
<td>3.758</td>
</tr>
<tr>
<td>E</td>
<td>$760,319</td>
<td>$1,179,253</td>
<td>1.551</td>
</tr>
<tr>
<td>Mean</td>
<td>$391,392</td>
<td>$750,096</td>
<td>2.210</td>
</tr>
</tbody>
</table>

Comparing short and long-term value allows us to gauge the value lags for CRM investments. Our results suggest that the long-term value of CRM investments is stronger for our financial institutions than the short-term value. All firms have long-term payoffs higher than their short-term payoffs. The ratio of the long-term to short-term value for CRM investments in the five financial institutions ranges from 1.536 to 3.758, with an overall mean of 2.097.

### 6.4. Value Trajectories for the CRM Investments

Fig. 5 shows value trajectories for the CRM investments in the six financial institutions. The disparity between short-term and long-term value suggests that value flows of the CRM investments exhibit some lags. To predict these lags, we computed the value trajectories of the CRM investments over time so as to reflect the expected payoffs of the CRM investments for a number of periods after implementation. We then substituted the estimated coefficient estimates from the appropriate regression model into the value trajectory function to obtain CRM value during the period after implementation.
Financial institutions vary. Calendar dates associated with Table 4. Time Required for Long-Term Value

6.5. Instantiating Value Appropriation Functions

We next compute the percentages of value appropriation for our sample using the value appropriation function. Table 4 shows the time taken by each financial institution to achieve the corresponding percentage of the long-term payoff.

Table 4. Time Required for Long-Term Value

<table>
<thead>
<tr>
<th>Percentage</th>
<th>FI-A</th>
<th>FI-B</th>
<th>FI-C</th>
<th>FI-D</th>
<th>FI-E</th>
<th>Mean</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>75%</td>
<td>0.77</td>
<td>0.32</td>
<td>0.71</td>
<td>3.46</td>
<td>0.34</td>
<td>1.29</td>
<td>1.16</td>
</tr>
<tr>
<td>80%</td>
<td>1.05</td>
<td>0.55</td>
<td>0.98</td>
<td>4.20</td>
<td>0.56</td>
<td>1.66</td>
<td>1.16</td>
</tr>
<tr>
<td>90%</td>
<td>1.94</td>
<td>1.19</td>
<td>1.83</td>
<td>6.44</td>
<td>1.23</td>
<td>2.80</td>
<td>2.09</td>
</tr>
<tr>
<td>95%</td>
<td>2.82</td>
<td>1.85</td>
<td>2.67</td>
<td>8.68</td>
<td>1.90</td>
<td>3.95</td>
<td>2.72</td>
</tr>
<tr>
<td>99%</td>
<td>4.87</td>
<td>3.37</td>
<td>4.67</td>
<td>13.89</td>
<td>3.45</td>
<td>6.60</td>
<td>4.18</td>
</tr>
</tbody>
</table>

This table provides useful information for decision-makers to understand and observe the expected time to achieve the long-term payoff levels for their CRM investments. There is quite a bit of dispersion in how long it takes to achieve full return. According to our estimation for this data set, to achieve 95% of the total long-term payoff for CRM investments, the value latency ranges from 1.85 quarters to more than 8.68 quarters, with a mean of 3.95 quarters and standard deviation of 2.72 quarters. Financial institutions that require longer lag periods to achieve the payoff have a higher autoregressive coefficient. This suggests a reduced absorptive capacity for the technological innovative, leading from higher routine rigidity, organizational friction and learning complexities, diminishing returns to IT investment.

6.6. CRM Investments and Sporadic Shocks

Firm F implemented CRM for its credit card services sometime in the last quarter of 1999. Shortly after the implementation of the CRM system, the firm underwent a massive restructuring. By the end of the first quarter of 2000, the firm installed a new CEO, and would soon replace its CFO. The bank sold off more than US$2 billion of its loan portfolio, and was also looking to sell its Internet banking operations. It also laid off more than 5,000 employees nationwide. This shock came soon after the full implementation of the CRM system. This is a good example of an IT investment that was implemented in the presence of sporadic shock. So our sporadic shock model (SM) is natural for evaluating this firm’s CRM investment.

We used the time-series regression specified in Eq. 3 to estimate the parameters of our value latency functions for the firms. Table 2 presented earlier shows the estimates of the model. We substituted these estimates into the value trajectory function and the value appropriation function to measure the value lags of the investment in light of the sporadic shock.

As shown in Figure 6, the value trajectory (the solid curve) is diminished by the shock that occurs about one period after the CRM investment.

Figure 6. Value Trajectory, Firm A

Note: $t_{FULL}$ represents the time period when CRM is fully implemented. All other times are relative.

Instead of building up to the long-term value represented by the dotted curve, the negative impact results in lower long-term business value for the investment. This causes a dip in the value flows after the shock. To examine the proportion of total value created by the firm’s CRM investment, we substitute the parameters into the value appropriation function. The results are shown in Table 5.

Table 5 indicates that the immediate payoff from the CRM investment is 3.8 times higher than shock-adjusted long-term payoff. The shock experienced by Firm F appears to have had strong negative impact.
on the CRM investment’s payoff, with the effects mostly felt within the three quarters following the shock. The CRM investment reached its shock-adjusted long-term payoff after 1½ years.

Table 5. Time to Achieve Long-Term Value

<table>
<thead>
<tr>
<th>$t$</th>
<th>RATIO OF SHOCK-ADJUSTED LONG-TERM VALUE ATTAINED ($L_t$)</th>
<th>VALUE AT TIME $t$ ($L_t$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.801</td>
<td>$948,070</td>
</tr>
<tr>
<td>1</td>
<td>2.213</td>
<td>$552,100</td>
</tr>
<tr>
<td>2</td>
<td>1.526</td>
<td>$380,560</td>
</tr>
<tr>
<td>3</td>
<td>1.228</td>
<td>$306,250</td>
</tr>
<tr>
<td>4</td>
<td>1.099</td>
<td>$274,060</td>
</tr>
<tr>
<td>5</td>
<td>1.043</td>
<td>$260,110</td>
</tr>
<tr>
<td>6</td>
<td>1.019</td>
<td>$254,070</td>
</tr>
<tr>
<td>7</td>
<td>1.008</td>
<td>$251,450</td>
</tr>
<tr>
<td>8</td>
<td>1.003</td>
<td>$250,320</td>
</tr>
</tbody>
</table>

Notes. Data: Firm A. $t = 0$ represents the time period when CRM is fully implemented. The other times, $t = \{1 \to 8\}$, are all relative to $t = 0$. Due to the sporadic shock occurring after the investment, the short-term value of the investment is 3.8 times higher than the long-term value.

7. CONCLUSION

We answer the call from both the academia and practice for better management and measurement of IT value by proposing a new methodology involving time-series econometrics to estimate the lagged returns to IT investments. The value creation process related to IT investments includes a wide variety of factors. Our measurement approach considers technological, competitive, organizational and environmental determinants for the inter-temporal payoffs of IT investments. We extended the time-series intervention model to obtain a set of IT value trajectory functions and IT value appropriation functions under varying firm production conditions in the presence of periodic shocks and sporadic shocks. We also applied this measurement methodology to examine CRM investments in six financial institutions. We observed that the short-term payoffs of these investments were lower than the long-term payoffs. In addition, there is considerable dispersion in the time it takes for an IT investment to reach its long-term potential value.

Our proposed measurement methodology provides a useful tool for decision makers related to IT investments and the management of their benefits. To the best of our knowledge, this is the first instance that we know of an approach that permits the computation of inter-temporal payoffs of IT investments. The value trajectory and value appropriation functions that we developed act as indicators for IT value and give relevant time-based information on business value. Our approach also contributes by addressing the pressing need to understand IT value latency [10].

In addition, our proposed application of an IT value moderator matrix acts as a guide in determining which modeling conditions need to be considered. It also aids managers in developing a more in-depth understanding of the extent to which different conditions (e.g., typical internal and external IT value flow moderators, as well as periodic and sporadic shocks) impact the latency of investment payoffs.

We foresee two uses of the proposed measurement methodology in IT value management. First, it can be used as an assessment or explanatory tool for IT value lags. Second, it also will be possible for managers to use this methodology as a forecasting instrument for future investments in IT. Using historical IT investment and firm profitability data, our methodology will enable the assessment and explanation of why value lags occur in different instances, providing insights to why some investments outperform others over time. These evaluation results can be used for managerial performance assessment and the determination of managerial compensation. The longitudinal nature of the measurement approach discourages managers from having a myopic vision of their IT investments, and encourages them to optimize longer-term organizational objectives.

In the sporadic shock models, our choices for the length of the window when shocks are factored into the measurement are based on personal judgment. A possible improvement will be to provide some more structure form of guidance for determining the appropriate length of time. In addition, because our empirical models involve time-series regression, a fairly large sample of data (especially profit figures) is necessary to ensure meaningful estimation of the parameters for the value trajectory and value appropriation functions. With this constraint in mind, the reader should recognize that quarterly data will be preferred to annual data. Nevertheless, this modeling approach still can be effectively used when less data are available in support of IT value analysis.

REFERENCES

nitions and Theories, John Wiley and Sons, New York, 83-94.


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**APPENDIX A. MODELING NOTATION**

<table>
<thead>
<tr>
<th>NOTATION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_t$</td>
<td>Profit at time $t$</td>
</tr>
<tr>
<td>$d$</td>
<td>Dummy variable for IT investment at time $t$</td>
</tr>
<tr>
<td>$c$</td>
<td>Coefficient of $I$: Immediate impact of IT investment on firm profit</td>
</tr>
<tr>
<td>$b_{[a]}$</td>
<td>Auto-regressive coefficient of $y_{t-1}$ under periodic shock</td>
</tr>
<tr>
<td>$S_t$</td>
<td>Dummy variable for sporadic shock at time $t$</td>
</tr>
<tr>
<td>$g$</td>
<td>Coefficient of $S$: Immediate impact of sporadic shock on firm profits</td>
</tr>
<tr>
<td>$a_{[condition]}$</td>
<td>Proportion of total value attained at time $t$ under (periodic shock, sporadic shock or joint shock)]</td>
</tr>
<tr>
<td>$V_t$</td>
<td>Value of the IT investment at time $t$ under (periodic shock, sporadic shock or joint shock)]</td>
</tr>
<tr>
<td>$\Delta V_t$</td>
<td>Diff. between IT investment value at $t$ and long-term value under (periodic shock, sporadic shock, or joint shock)]</td>
</tr>
<tr>
<td>$\hat{a}$</td>
<td>Estimated impact of seasonal variation</td>
</tr>
<tr>
<td>$e_{[a]}$</td>
<td>Seasonal component, M$A(q)$</td>
</tr>
<tr>
<td>$q$</td>
<td>Time between seasonal impacts</td>
</tr>
<tr>
<td>$\Theta_{[condition]}$</td>
<td>Shock latency coefficient [under (sporadic shock or joint shock)]; Sporadic shock impact on IT value flows</td>
</tr>
<tr>
<td>$t_{[condition]}$</td>
<td>Time [time when (full investment or sporadic shock) occurs]</td>
</tr>
</tbody>
</table>