The Effect of Information Technology Investments on the Market Value of Supply Chain Firms: An Improved Event Study Approach

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Abstract

Information technology (IT) plays a critical role in obtaining the competitive advantage and sustainable development in managing supply chain activities. Evaluating the effect of IT investments on business value has always been a great concern of information systems researchers as well as enterprises. Financial theory suggests that the market value of firms will be reflected on the stock price in response to IT investment announcements. Therefore, this study employs an event study method typically used by financial researchers to estimate the effect of a specific event. In the conventional event study, subjectively setting an event window would probably lead to measurement biases. To overcome this shortcoming, instead of being set subjectively the event window in our study is measured by using the iterated cumulative sum of squares algorithm for detecting sudden changes in the variance of returns and how long the shift lasts. The sensitive analysis of cumulative average abnormal returns (CAAR) under different levels of information missing risks demonstrates that the measure of an event window will influence the CAAR on the significant level and positive/negative direction.

Keywords: Information technology investments, event study, iterated cumulative sums of squares, supply chains

1. Introduction

In response to the intense competition of globalization, collaboration is inevitable and essential especially for enterprises in supply chains. Many researchers consider information technology (IT) the backbone and essential enabler of the supply chain, and their results demonstrate that IT-enabled supply chain integration capability results in significant and sustained firm performance gains (Lewis and Talalayevsky, 1997; Sanders and Premus, 2002; Kent and Mentzer, 2003; Subramani, 2004; Rai et al., 2006). Along with the advancement and development of IT, enterprises continuously increase IT investments to maintain the long-term competitive advantage, raise the organizational performance, and so the business value. Therefore, “how to evaluate the effect of IT investments?” and “how to link IT investments to business value?” have become inevitable and intense issues. Many researchers have made a lot of efforts to address these issues (Dos Santos et al., 1993; Subramani and Walden 2001; Hayes et al., 2001; Im et al., 2001; Dehning et al., 2003; Oh et al., 2006). Nevertheless, the potential benefit of IT investments

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is considerably difficult to measure. As such the impact of IT investments on business value is either misestimated (Davern and Kauffman, 2000) or measured inconsistently.

Financial theory suggests that the change of the market value of firms will be reflected on the stock price in response to IT investment announcements. When firms make IT investments, these investments will result in some direct benefits that contribute to future cash flows. Besides, IT investments may also bring indirect benefits in the form of new investment opportunities for the firms (Dos Santos, 1991). The effect of an IT investment can be measured by the discounted value of future cash flows that are expected to be generated by assets already in place, plus the discounted value of investment opportunities that are expected to be available to the firm in the future (Dos Santos et al., 1993). If the market expects that an IT investment will have a positive effect on the firm value, it will be reflected on the market price of firm’s common stock.

An event study method is a commonly used approach for estimating the market reaction to IT investment announcements. It is a standard method used in the accounting and financial literature and is also supported by many information systems (IS) studies to estimate how IT investments affect the firm value (Dos Santos et al., 1993; Subramani and Walden 2001; Hayes et al., 2001; Im et al., 2001; Dehning et al., 2003; Oh et al., 2006). In the conventional event study method, previous researchers almost subjectively assign a fixed-day period as the size of an event window. As a result, it may lead to measurement biases. To overcome this potential shortcoming, this study uses the iterated cumulated sum of squares (ICSS) algorithm developed by Inclan and Tiao (1994) to detect sudden changes in the variance of returns and how long the shift lasts. The ICSS algorithm is commonly used in studies of measuring volatility of stock markets and foreign exchange markets (Aggarwal et al., 1999; Huang and Yang, 2001; Malik, 2003). Therefore, the algorithm is suited to improve the original randomness of setting event windows and to reach an effective estimation of the window size.

2. Prior studies

IT is considered the essential enabler for collaboration of firms in supply chains. Lewis and Talalayevsky (1997) concluded that effective coordination of logistics activities in supply chains was essential to organizational performance, and IT would support effective logistics processes such as just-in-time delivery. Sanders and Premus (2002) found that use of IT provided a significant competitive advantage for firms and the linkage between competitive priorities and organizational benefits. Kent and Mentzer (2003) concluded that a significant and direct link had been established between perceived supplier investment in IT, relationship commitment, and improvements in logistics efficiency. Subramani (2004) highlighted the role of relationship-specific assets in the dynamics of value creation and value retention in contexts of IT-mediated buyer-supplier interactions. Rai et al. (2006) suggested that process improvements resulting from lean/just-in-time (JIT) practices were important contributors to the success of IT integration.

Quite a few studies have been conducted to measure the impact of various IT investment announcements on market value of firms using the event study method. Hayes et al. (2000, 2001) examined market reactions to information systems outsourcing announcements and ERP implementation announcements, and their findings indicated positive market value gains within event windows (0, 1) and ((0, 1), (-1, 1), (-1, 3)), respectively. Subramani and Walden (2001) obtained the results that e-commerce initiatives lead to significant positive cumulative abnormal returns (CARs) for firm’s shareholder by setting event windows (-5, 5) and (-10, 10). Chatterjee et al. (2002) found the significant evidence that positive abnormal returns and increased trading volume are associated with IT infrastructure investment announcements while setting event windows (-2, 2). Oh et al. (2006) examined the moderating effects of firm
and IT characteristics on the market reaction to IT investment announcements by setting event windows to (-2, -1), (0, 1), (2, 3), and they found significant changes in firm value around the event date as well as a positive average abnormal return. Recently, Sabherwal and Sabherwal (2007) evaluated the stock market’s reaction to a firm’s public announcement of the knowledge management (KM) effort in 2-day window (0,1) and 5-day window (-2,2). Their results indicate that the alignment between the KM effort and business strategy is positively associated with the impact on firm value.

Nevertheless, the window size of an event study for IT investment needs more consideration. When the window size is set too long, it may be affected by confounding events, thus reducing the reliability. On the contrary, if the window size is set too short, then it may miss critical information and cause the problem of conditional heteroscedasticity. However, existing studies almost subjectively set a fixed-time window by trial-and-error, and do not use an objective approach for identifying the range of the event window. Table 1 shows the comparison of event windows as well as the direction of abnormal returns between this study and existing ones.

Table 1. Comparison of event windows and direction of abnormal returns

<table>
<thead>
<tr>
<th>Study</th>
<th>Direction of AR</th>
<th>Event window</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study</td>
<td>+</td>
<td>objectively identified</td>
</tr>
<tr>
<td>Sabherwal and Sabherwal</td>
<td>+</td>
<td>(0, 1)</td>
</tr>
<tr>
<td>(2007)</td>
<td></td>
<td>(-2, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0, 1)</td>
</tr>
<tr>
<td>Oh et al. (2006)</td>
<td>+</td>
<td>(2, 3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-2, -1)</td>
</tr>
<tr>
<td>Chatterjee et al. (2002)</td>
<td>+</td>
<td>(-2, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-5, 5)</td>
</tr>
<tr>
<td>Subramani and Walden (2001)</td>
<td>+</td>
<td>(-10, 10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0, 1)</td>
</tr>
<tr>
<td>Hayes et al. (2001)</td>
<td>+</td>
<td>(-1, 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-1, 3)</td>
</tr>
<tr>
<td>Hayes et al. (2000)</td>
<td>+</td>
<td>(0, 1)</td>
</tr>
</tbody>
</table>

Many studies on time deformation suggest that high frequency data, such as exchange rate and security price, arrive in irregular time intervals so that an analysis of such data cannot rely on standard econometric techniques which are based on a fixed time interval analysis (Müller et al., 1990; Goodhart et al., 1993; Ap Gwilym and Sutcliffe, 2001; Cook, 2001). One study of forecasting stock indices where the fuzzy time series model is employed also points out that during the fuzzification process, different lengths of intervals will result in various forecasting results, and the forecasting results based on the effective lengths of intervals are found to outperform those based on arbitrary ones (Huarng, 2001).

The ICSS algorithm can be used to detect all structural change points and their duration in the time series (Inclan and Tiao, 1994). Aggarwal et al. (1999) modeled volatility of emerging stock markets by the ICSS algorithm. Huang and Yang (2001) also applied the ICSS algorithm to measure the impact of settlement time changes on the volatility change in the Shanghai and Shenzhen Stock Exchange. Malik (2003) examined sudden changes and volatility persistence in foreign exchange markets by using the ICSS algorithm. Therefore, the ICSS algorithm is used in this study to measure and then form effective estimation of time intervals and as event windows.

To examine the stock price reaction to IT investment announcements, possible relevant
factors are discussed in previous studies. Dos Santos et al. (1993) considered two explanatory variables, industry and innovation. Their results indicated no significant effects for industry variable, but they found that innovative IT investments are related to positive, abnormal stock price returns. Fama and French (1995) presented a three-factor model to explain industry returns. Im et al. (2001) included three variables: industry, size, and time period, and their analysis showed that abnormal returns to IT investment announcements are related to all three variables. Hayes et al. (2001) investigated the market reaction to a specific IT investment (ERP systems) and examined two variables (firm size and health). They found that the market reacts most positively to announcements by small/healthy firms and negatively to announcements by small/unhealthy firms; the reactions to announcements by large/healthy and large/unhealthy firms are positive.

Therefore, in order to include critical factors to establish a more explanatory model for predicting stock returns, we consider a five-factor model by integrating the Fama-French three-factor model (market, SMB, and HML) with momentum (Jegadeesh and Titman 1993, Chan et al., 1996) and trading volume (Brennan et al., 1998). SMB (small minus big) is the return on a portfolio of small stocks minus the return on a portfolio of large stocks. HML (high minus low) is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio of stocks with low book-to-market ratios.

These five factors are expected to serve as proxies of previous variables in relation to the firm level and the market level. For instance, SMB is used to represent the firm size, and HML, the firm health. The other three factors are associated with the market expectations. In addition to objective estimations of the window size, we have made an approximately complete investigation for the effect of IT investment announcements on the market value of firms.

3. Research methodology

3.1 Estimation of window size

The event study method is adopted in this study. In general, the period for estimating normal returns typically ranges from 100 to 300 days for daily studies before or after the event window (Peterson, 1989). In order to obtain an appropriate size of the event window, the ICSS algorithm is used to estimate the event windows objectively. The ICSS algorithm can be used to detect all structural change points in the time series and then form event windows in pairs.

As such we choose the period between the change period of this event and the change period of preceding events as the length of an estimation period. Then we observe the actual announcement day, and match a suitable change period as an event window. In addition, for maintaining the uniform estimate, this study uses the period with more occurrences by various sample companies (earlier period or later period) as the estimation period in order to avoid the inaccurate estimate of abnormal returns. The length of the estimation period is given as

\[
\max \left\{ \begin{array}{l}
\min \left( \text{the number of days between left margin of the event window and right margin of preceding event window (earlier period)} \right) \\
\text{preceding 300 days of the event window}
\end{array} \right\}
\]

\[
\min \left\{ \begin{array}{l}
\text{the number of days between right margin of the event window and left margin of succeeding event window (later period)} \\
\text{succeeding 300 days of the event window}
\end{array} \right\}
\]

\[
\min \left( \text{the number of days between left margin of the event window and right margin of preceding event window (earlier period)} \right)
\]

\[
\text{preceding 300 days of the event window}
\]

\[
\min \left( \text{the number of days between right margin of the event window and left margin of succeeding event window (later period)} \right)
\]

\[
\text{succeeding 300 days of the event window}
\]

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3.1.1 Detecting points of sudden changes in variance

The methodology used in this study for detecting changes in the variance of an observed time series is based on the ICSS algorithm developed by Inclan and Tiao (1994). The algorithm assumes that the time series of interest displays a stationary variance over an initial period until a sudden change in variance occurs, perhaps driven by news affecting the stock markets. The variance is then stationary again for a time until the next sudden change. The process is repeated through time, yielding a time series of observations with an unknown number of changes in the variance. Accordingly, let \{a_t\} denote a series of independent observations from a normal distribution with zero mean and with unconditional variance \(\sigma_0^2\). The variance within each interval is denoted by \(\sigma_j^2\) \((j = 0, 1, 2, \ldots, N_T)\) where \(N_T\) is the total number of variance changes in \(T\) observations, and \(1 < \kappa_1 < \kappa_2 < \ldots < \kappa_{N_T} < T\) are the set of change points.

\[
\sigma_t^2 = \begin{cases} 
\tau_0^2, & 1 < t < \kappa_1 \\
\tau_1^2, & \kappa_1 < t < \kappa_2 \\
& \quad \vdots \\
\tau_{N_T}^2, & \kappa_{N_T} < t < T 
\end{cases}
\]

(1)

To estimate the number of changes in variance and the point in time of each variance shift, a cumulative sum of squares is used. Let \(C_k = \sum_{i=1}^{k} a_i^2\) \((k = 1, \ldots, T)\) be the cumulative sums of squares (mean-centered) observations from the start of the series to the \(k\)th point in time. Then define the statistic \(D_k\) as

\[
D_k = C_k - \frac{k}{T} C_t, \text{ for } k = 1, 2, \ldots, T \quad \text{with } D_0 = D_T = 0
\]

(2)

If there are no changes in variance over the sample period, the \(D_k\) statistic oscillates around zero (a horizontal line when the \(D_k\) values are plotted against \(k\)). In contrast, if there are one or more sudden variance changes in the series, the \(D_k\) values drift either up or down from zero. Critical values based on the distribution of \(D_k\) under the null hypothesis of homogeneous variance provide upper and lower boundaries to detect a significant change in variance with a known level of probability. When the maximum of the absolute value of \(D_k\) is greater than the critical value, the null hypothesis of no changes is rejected. Let \(k^*\) be the value of \(k\) at which \(\max_k |D_k|\) is attained. If \(\max_k \sqrt{(T/2)}|D_k|\) exceeds the predetermined boundary, \(k^*\) is taken as an estimate of the change point. The factor \(\sqrt{(T/2)}\) is needed to standardize the distribution. This allows us to identify the change points.

Under the null hypothesis that the variance is homogeneous over the entire series, asymptotically \(D_k\) behaves as a Brownian bridge. The critical value of 1.36 is the 95th percentile of asymptotic distribution of \(\max_k \sqrt{(T/2)}|D_k|\). Therefore, upper and lower boundaries can be set at \(\pm 1.36\) in the \(D_k\) plot. Exceeding these boundaries marks a significant change in variance in the series analyzed. If the series under study has multiple change points, the \(D_k\) function alone is not enough because of masking effects. To avoid that problem, Inclan and Tiao (1994) developed an algorithm the ICSS algorithm that uses the \(D_k\) function to systematically look for change points at different pieces of the series. The algorithm is based on successive evaluation of \(D_k\) at different parts of the series, dividing consecutively after a possible change point is found.
3.2 The prediction model of stock price

Each announcing firm’s share price reaction for each day of event windows is obtained by predicting a normal return for each firm on each event day and then subtracting the predicted return from the actual return. Normal returns are evaluated by estimation of the five-factor model on a firm-specific basis:

\[ R_{i,t} - R_{f,t} = \alpha_i + b_1(R_{m,t} - R_{f,t}) + b_2SMB_t + b_3HML_t + b_4MO_t + b_5TR_t + \epsilon_{i,t} \]  \hspace{1cm} (3)

where \( R_{i,t} \) is the return for firm \( i \) on day \( t \); \( R_{m,t} \) is the return on the daily weighted index on day \( t \); \( R_{f,t} \) is risk free interest rate on day \( t \); \( SMB_t \) is the return to a portfolio of small capitalization stocks less the return to a portfolio of large capitalization stocks on day \( t \); \( HML_t \) is the return to a portfolio of stocks with high ratios of book-to-market values less the return to a portfolio of stocks with low ratios of book-to-market values on day \( t \); \( TR_t \) is the return to a portfolio of stocks with positive excess returns less the return to a portfolio of stocks with negative excess returns on day \( t \); \( \alpha_i \) is the intercept for firm \( i \); \( b_1, b_2, b_3, b_4, \) and \( b_5 \) are proxies for the systematic risk of firm \( i \); \( \epsilon_{i,t} \) is the error term for firm \( i \) on day \( t \).

In the event study, abnormal returns (AR) refer to the actual return in the event period minus the predicted return in the estimation period. It is computed as

\[ AR_{i,t} = (R_{i,t} - R_{f,t}) - [\hat{\alpha}_i + \hat{b}_1(R_{m,t} - R_{f,t}) + \hat{b}_2SMB_t + \hat{b}_3HML_t + \hat{b}_4MO_t + \hat{b}_5TR_t] \]  \hspace{1cm} (4)

where \( AR_{i,t} \) is the abnormal return for firm \( i \) on day \( t \).

The individual return rate possibly receives disturbance of confounding event. For decreasing the disturbance of external event factors, this study computes the average abnormal return (AAR) by regarding the sample companies as a portfolio and averaging the daily abnormal return rate across companies to eliminate the influence. The AAR is computed as

\[ AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{i,t} \]  \hspace{1cm} (5)

where \( N \) is the number of sample companies; \( AAR_t \) is the average abnormal return on day \( t \).

Next, when inspecting market efficiency or measuring the impact of stock return, this study uses cumulative average abnormal returns (CAAR) to measure abnormal returns in the event period. The CAAR can be used to understand the cumulative effect of AAR in the specific period so as to judge whether the announcement events influence on the stock price reward in the event period. The CAAR is computed as

\[ CAAR(a, b) = \sum_{t=a}^{b} AAR_t \cdot \frac{1}{N} \sum_{i=1}^{N} \sum_{t=a}^{b} (AR_{i,t}) \]  \hspace{1cm} (6)

\( CAAR(a, b) \) is the cumulative average abnormal return within event window \((a, b)\).

To test the significance of AR, generally there are two approaches, parametric and nonparametric. The main premise of the parametric approach is that AR belongs to the independently identical normal distribution. However, the nonparametric approach does not need to make any hypothesis for the AR distribution. Besides, this study uses the traditional statistic \( t \) value to test its hypothesis as follows:
\[ H_0 : CAAR(a,b) = 0 \]
\[ H_1 : CAAR(a,b) \neq 0 \]

\[ t(CAAR(a,b)) = \frac{CAAR(a,b)}{\hat{S}(\text{AAR}) \sqrt{b-a+1}} \] (7)

where \( \hat{S}(\text{AAR}) \) is the standard deviation of the average error in the event period and \((b-a+1)\) is the number of days of the event period.

4. Results

4.1 Data

The sources of data collection in this study include the following:

1. The daily stock return, market return, market value of the firm, book value of the firm, and turnover are retrieved from the Taiwan Economic Journal (TEJ) database.
2. The risk free interest rate is obtained from looking up financial statistical databank of AREMOS database and converting the First Bank three-month time deposit interest rate divided by 90-day into daily rate.
3. In regard to the announcement day, it is retrieved from Extemporary Newspaper Headline & Index Database which covers major Taiwan newspapers such as United Daily News, China Times, Central Daily News, Economic Daily News, and Commercial Times.

The aim of this study is to investigate the stock price behavior of public offering companies disclosing their IT investment plans in relation to supply chain management. At first, we search the Extemporary Newspaper Headline & Index Database for news articles on announcements of IT investments associated with Taiwan public offering companies over the period between 1971 to 2006 by using keywords such as supply chain management systems along with action verbs (such as purchase, install, and develop). Besides, other sampling criteria are: only IT investment announcements by firms with complete market transaction data during the study period as well as sufficient information about the event announcement day. If the announcement day happens to be a non-business day, then the first trade date after non-business day is taken as the announcement day.

These sampling criteria yield a total of 159 candidates with IT investment announcements. After eliminating those candidates with incomplete data during the study period, the sample size is 147 companies. Moreover, in order to compare our results with existing studies on the uniform basis, those candidates involving other announcement days except the first announcement day within the event window are eliminated. As a result, there are 51 candidates left for analysis.

4.2 The sensitive analysis for event windows

In order to emphasize the difference between this study and existing ones on estimation of the event window and to examine the importance of the window size, different sizes of fixed-time windows commonly used by prior studies are included to implement the sensitive analysis of CAAR within event windows under different levels of information missing risks. The results indicate that the CAAR within event windows reverse from positive to negative under all levels of missing risk but 0 and 0.3864. Furthermore, the CAAR of event windows fluctuates significantly under a missing risk of 0.9053. Table 2 shows the details.
Table 2. Sensitive analysis of event window

<table>
<thead>
<tr>
<th>Event window</th>
<th>CAAR</th>
<th>t value</th>
<th>Samples at event day</th>
<th>Missing risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-17, 35)</td>
<td>1.2235</td>
<td>0.9757</td>
<td>898</td>
<td>0</td>
</tr>
<tr>
<td>(0, 1)</td>
<td>-0.5258</td>
<td>-2.4946</td>
<td>88</td>
<td>0.9020</td>
</tr>
<tr>
<td>(-1, 0)</td>
<td>-0.4798</td>
<td>-2.9309*</td>
<td>85</td>
<td>0.9053</td>
</tr>
<tr>
<td>(-1, 3)</td>
<td>-0.9146</td>
<td>-1.6733</td>
<td>209</td>
<td>0.7673</td>
</tr>
<tr>
<td>(-2, 2)</td>
<td>-0.5327</td>
<td>-0.9252</td>
<td>215</td>
<td>0.7606</td>
</tr>
<tr>
<td>(-5, 5)</td>
<td>-0.6058</td>
<td>-0.8218</td>
<td>379</td>
<td>0.5780</td>
</tr>
<tr>
<td>(-10, 10)</td>
<td>0.3972</td>
<td>0.4063</td>
<td>551</td>
<td>0.3864</td>
</tr>
</tbody>
</table>

Notes: * denote significance at the 0.10 levels. Missing risk = the number of samples at event day / total numbers of samples at event day

5. Conclusion

In this study, we have examined the effect of the window size on the extent and direction of cumulated average abnormal returns (CAARs) by including different sizes of fixed-time windows to implement the sensitive analysis of CAAR within windows under different levels of information missing risks. According to the sensitive analysis result shown in Table 2, the empirical results indicate that the selection of event windows will influence the CAAR on the significant level and positive/negative direction. Hence, the fixed-time window assumed by existing studies may result in measurement biases of abnormal returns. To overcome this shortcoming, we have used the iterated cumulative sum of squares algorithm to ensure the effectiveness of the event windows measurement. Our result is consistent with existing studies that IT investments provide a positive effect to the market value of firms, thus enabling firms to obtain the competitive advantage and sustainable development in managing supply chain activities.

References


