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2014

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Xi CHen
School of Management, Zhejiang University, Hangzhou, chen_xi@zju.edu.cn

Shanshan Liu
School of Management, Zhejiang University, Hangzhou, zijinhuakai1031@163.com

Indranil Bose
India Institute of Management, bose@iimcal.ac.in

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Xi Chen, School of Management, Zhejiang University, Hangzhou, China, chen_xi@zju.edu.cn

Shanshan Liu, School of Management, Zhejiang University, Hangzhou, China, zijinhuakai1031@163.com

Indranil Bose, India Institute of Management, Calcutta, Indian, bose@iimcal.ac.in

Abstract

With the growing scale of RFID investment, the relationship between RFID and firm value has attracted the attention of a lot of researchers. Prior research had employed the event study method to examine the short term market reaction to RFID adoption and found significant negative abnormal return. In this paper, we extend previous research by investigating the long term impact of RFID investment on firm market value using the CPA (Calendar Portfolio Analysis), 108 announcements related to 74 publicly traded companies were analysed. Our results indicate an overall significant negative impact on long term abnormal return of market value after adoption of RFID. It is also discovered that non-US based firms, late adopters, manufacturers, highly diversified firms, high financially unhealthy firms and low growth potential firms suffered more negative impact in the long term. The results signify that the market is impacted by the risks associated with the use of a new and disruptive technology like RFID and may not yet be ready to accept it as a standard technology that is adopted by firms. Put together, our results provide new insights into how RFID and other contextual factors interact to affect the financial performance of firms in the long run.

Keywords: Abnormal return, calendar portfolio analysis, firm characteristics, market value, RFID.

1 INTRODUCTION

In the era of Internet of things, the Radio Frequency Identification (RFID) industry has witnessed a steady growth over the past few years. The overall growth in RFID is projected to take over other automatic identification technologies such as barcode. The Global RFID market is expected to grow at a very high rate of 26% till 2014. According to the IDTech Ex's report (2013), in 2012 the value of the entire RFID market will be US$ 7.67 billion, up from US$ 6.51 billion in 2011. This includes tags, readers and software/services for RFID cards, labels, fobs and all other form factors. It includes passive as well as active RFID. The total RFID market projections in US$ billions is shown in Figure 1.

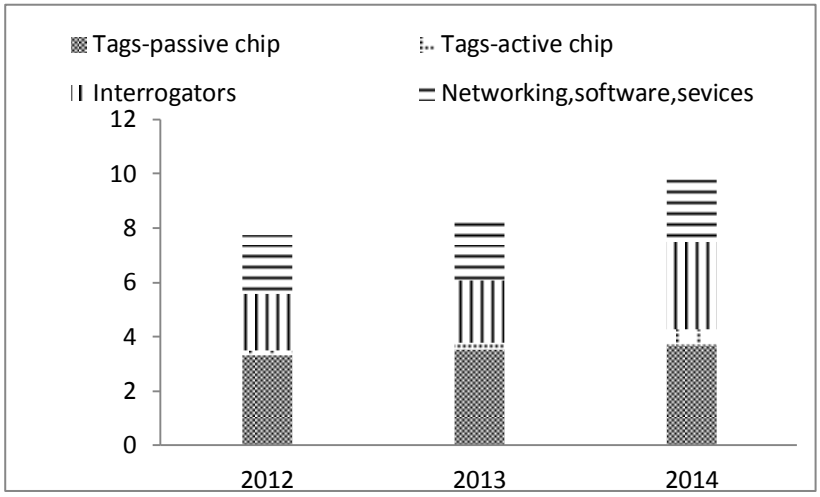

Figure 1. The total RFID market projections in US$ billions (Adopted from Peter and Raghu, 2013）

In light of the growing scale of RFID investment, a key question faced by individual firms is whether RFID is contributing to competitive advantage and profitability of the firm. If so, can this competitive sustain and how long can it last for?

Although several researches used various approaches to examine the short term impact of RFID investment on firm performance, there was no consensus. For example, Jeong and Lu (2007) used the event study method to estimate the short term impact of RFID on firms' market value and discovered a positive impact. However, by using the same method Bose et al. (2009) observed an opposite result with a sample of 108 public RFID announcements. Moreover, there is a lack of clear evidence with respect to the long term effect of RFID. Since it will take years of effort, experimentation, and commitment to transform the organization to adapt so as to gain the maximum value of RFID technology, research on short term impact may not reflect the true financial influence of RFID adoption. Thus it motivated us to fill this gap by investigating the long term market reaction by measuring the abnormal returns in firm market value after the announcement on RFID adoption. Our current research is a follow up study of Bose et al. (2009). We aim to address two research questions. First, how will the market react to the adoption of RFID in the long run? Second, will the contextual factors of the RFID adopters like timing of adoption, location, industry, diversification, financial health and growth potential have any influence on the market reaction in the long run?

The remainder of this paper proceeds as follows: In section 2 we briefly review the pertinent literature. Then, we propose our research framework and develop the hypotheses in Section 3. Section 4 describes the CPA method and empirical model. Section 5 and section 6 describe the data and results. Finally, section 7 concludes.

2 LITERATURE REVIEW

We mainly summary two distinct stream of the IS literature: (i) IT investment and firm value; (ii) RFID investment and firm value.

2.1 IT investment and firm value

There is definitive evidence that IT can create value by raising the efficiency and improve the productivity at both the process (Barua et al. 1995) and firm (Brynjolfsson & Hitt 1996) levels. However, there are mixed results upon whether IT investment would lead to profitability and a clear difference between the short term and the long term of IT investment's impact on firm performance was observed.

Weill (1992) collected six years of historical data on IT investment and performance for 33 valve manufacturing firms and observed that the market did not react to strategic IT investment while reacted poorly in the short term but turned positively in the long term for transactional IT investment. Another similar example is Wang's (2008) finding which revealed that firms experienced bad firm-level profitability one year after taking the IT outsourcing initiatives but improved operational efficiency 2 and 3 years later. However, other studies argued that IT advantage is short-lived and would disappear over time (Stratopoulos & Dehning 2000). Flori (2005) observed that IT/IS outsourcing was positively correlated with short-term abnormal return but negatively with long-term abnormal return. Yet, no prior research has been able to reveal the reason why this impact change could happen. Zhu (2004) gave one possible explanation that the main factor may shift from money spending to organizational capabilities in later stage of IT adoption. Melville et al. (2004) remarked that industry characteristics limited the acquisition and successful application of IT. Business growth opportunities, uncertainties, interactions between uncertainty and strategic role of IT investments, and interactions between uncertainty and asset specificity might also have a significant impact on the abnormal return of firms (Oh et al. 2006).

2.2 RFID investment and its impact

The successful adoption of RFID is also heavily influenced by various factors. Based on a review of the extant literature, we classified those factors into three dimensions: firm factors, industrial factors, and environmental factors.

The first dimension is made up of the firm factors. The most important firm factors include top management support, organizational readiness, IT capability, IT infrastructure, and IT related financial resources. Top management support can greatly enhance investors' confidence about commitment and importance of RFID adoption initiatives (Sharma et al. 2007; Alqahtani & Wamba, 2012; Brown & Russell, 2007). With the support from top management, the necessary resources can be allocated with ease. Moreover, financial and technological resources (people, technology, expertise) of a firm, or referred to organizational readiness, is a key drivers of RFID adoption (Brown & Russell, 2007; Lin 2010; Wu & Subramaniam 2009). The presence of these resources allows an innovative technology like RFID to better comply with the current infrastructure, habits, practices and needs (Rogers 1995). Technological resources can also help to reduce the time and cost required for supply chain partners to share, collect, and analyze information. More technological resources means firms possessing appropriate IT infrastructure capability, technological competence or IT deployment to support RFID implementation (Whitaker et al. 2007; Sharma et al. 2007; Alqahtani & Wamba 2012)

Industry characteristics are considered as an essential factor for the development of RFID. Some researchers discovered a difference between the manufacturing and non-manufacturing industry for adoption of RFID (Bose et al. 2011). Additionally, another important factor which cannot be ignored is the industrial competitive pressure (Wang et al. 2010; Chang et al. 2006). Research showed that when firms faced more partner pressure, especially mandated by powerful partners, they were more

likely to adopt RFID technology. Moreover, companies were usually very concerned about their competitors. If any of their competitor adopt RFID, they may take the same initiatives in case of lagging behind and lose the competitive advantage.

Thirdly, environmental factors such as partner pressure, country factors, and social issues were all identified as important influencing factors as well. Sharma et al. (2007) confirmed that common standards of RFID may significantly affect RFID adoption. Consistency of governmental standards and regulations made it easier to integrate RFID with the data exchange system within and outside the firms. As for the country factor, technical or culture obstacles might hinder the evolution of RFID implementation (Alqahtani & Wamba, 2012). Developed countries might have better economic conditions, sophisticated IT infrastructure, and friendly business environment to adopt an innovative and disruptive technology.

3 RESEARCH FRAMWORK AND HYPOTHESIS

3.1 Research framework

Whether a given RFID initiative will be successful may depend on the firms' capability to appropriately utilize and manage the technical and social risks associated with RFID investment. According to Piccoli and Ives (2005), there are four barriers to the sustainability of competitive advantage: IT resources barrier, complementary resources barrier, IT project barrier, and preemption. In the case of RFID, IT resources barriers refer to organizational readiness, which was a significant indicator of whether the firm have had enough financial and technological resources (Brown & Russell, 2007; Lin 2010; Wu & Subramaniam 2009). Complementary resources comprise of top management. RFID project barriers including RFID compatibility problems, security and customer privacy issues made it hard to implement RFID (Cannon et al. 2008). We present our research framework as follows.

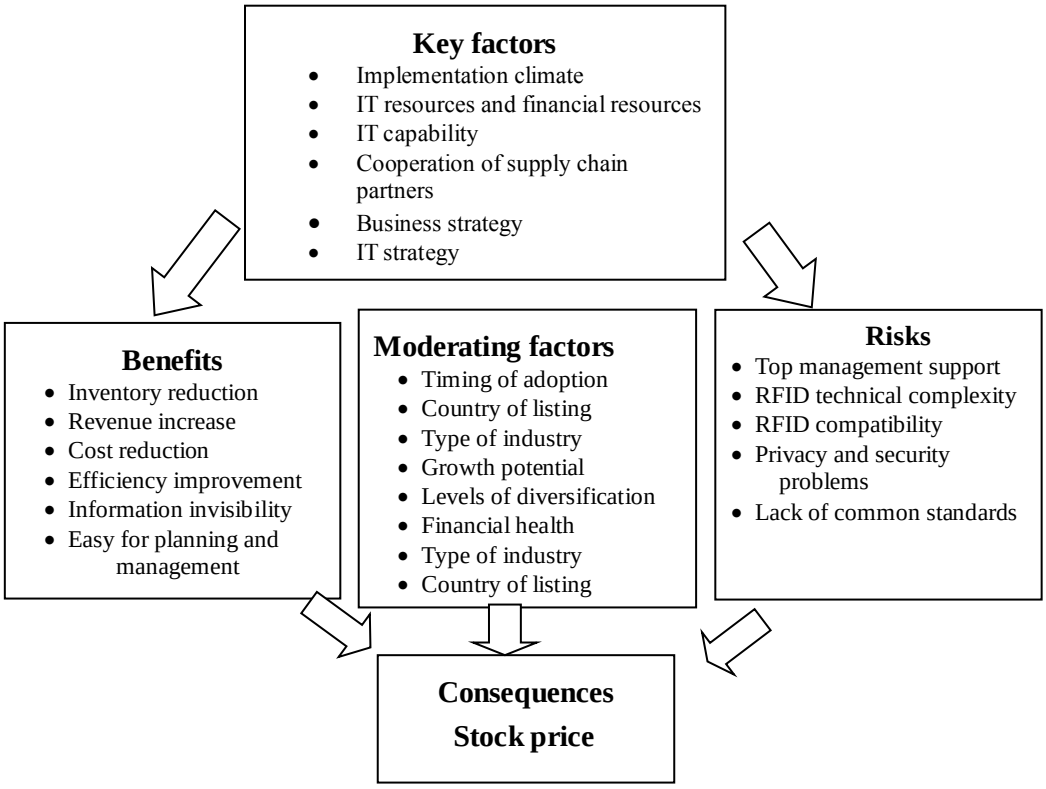

Figure 2. Framework for analyzing the impact of RFID

3.2 Hypothesis

According to Vera and Crossan (2003), firms can only gain an edge by being restructured to align to the organizational context, or called process innovation. If the firm can't learn dynamically and quickly from the mistakes, the risk could dominate the benefit even in the long term. For an disruptive technology like RFID, this transforming process could be quite time consuming since more resources need to be allocated . Furthermore, if the IT becomes a strategic necessity and is widely imitated, the competitive edge may not exist (Hitt & Brynjoffson 1993). In the era of the things of Internet, RFID is more a strategic necessity than a competitive edge. This may partly because RFID adoption is mandated by industry giants like Wal-Mart's, the US Defense Department and Metro. Firms mandated to adopt RFID may have miss-match between their IT strategy and firm strategy, which may influence the firm negatively. Hence, in general we believe that firms adopted RFID may have negative abnormal market return in the long run.

H1: Firms announcing RFID investments generally will experience significant and negative market return over a long term.

The timing of adoption reflects the IT strategy of firms. Like any Information technology, RFID adoption usually goes through four stages of deployment, not deployed, development or testing, limited deployment, and wide deployment (Whitaker et al. 2007). Early adopters are those willing to embrace disruptive technology like RFID despite of the huge risks while the followers may be risk avoiders. They usually wait some time until the technology is much riper and more knowledge is accumulated about RFID. Usually, higher risk is associated with higher payback. Early adopters can have enjoy many benefits such as technological leadership, pre-emption of scarce assets, and imposition of high switching costs on customers(Lieberman & Montgomery 1988), while the followers cannot enjoy the sustained lead time advantage as early adopters. Thus we believe the followers suffer more. We select the year 2006 as the boundary to distinguish between early adopters and later followers because the year 2006 is recognized as the era of RFID as RFID Journal.com claims that "as we enter 2006, RFID can be said to have crossed the Chasm". Accordingly, we propose the following hypothesis:

H2: RFID adoption after 2006 will have more negative long term market reaction than that of RFID adoption before 2006.

Watson et al. (1997) claimed that the national environment like cultural, economic, legal and business markets is crucial for firms to develop sustained competitive advantages. As is well known, the US takes a lead in the development of RFID and is the largest RFID market in the world. In US-listed companies, RFID is more recognized and popularized. Non-US adopters may lack the essential IT capability, enough cash flow and relevant managerial experience to address such a disruptive and complex technology like RFID. Additionally, the regulatory environment in Non-US listed countries may be unfair which is believed to be an important facilitator of RFID adoption (Porter, 1986). For example, political support and standard law is incomplete in developing countries. Hence, we conjecture that US-listed companies have more opportunities to achieve long standing competitive advantage than firms in other countries. The following hypothesis is proposed:

H3: Non-US based RFID adopters will have higher and significant negative abnormal market returns compared with US listed adopters over a long term.

The role of industry type in determining the payoff of IT investment has been well examined in IS researches. Jeong and Lu (2007) found different results between the manufacturing industry and the service industry. Similar results are observed between manufacturing and trade and logistics industry (Whitaker et al. 2007). This is because the manufacturing industry and non-manufacturing industry have drastic different IT resources and competitive pressure. We followed Bose et al. (2011) and classified our samples into manufacturing and non-manufacturing samples. Non-manufacturing firms are more automatic and capital intensive, the managers tend to seek new efficient tools like IT to raise efficiency. They usually have better IT infrastructure foundation and higher IT management capability

than manufacturing firms. While manufacturing firms are labor-oriented and the IT drive is not as strong as non-manufacturing firms. RFID implementation is quite time-consuming and costly, it will be quite risker for manufacturing firms to undertake such complex technology. Hence, we may anticipate that manufacturing firms will suffer more compared with nonmanufacturing firms.

H4: Manufactures who adopted RFID will have higher and significant negative abnormal market return compared with non-manufacture adopters.

The growth opportunity of firms refers to the capability of turning capital investments into positive net present values. However, upon whether it is highly correlated with the impacts of IT investment, the views are controversial. Eberhart (2004) did not observe great variance in firm performance between firms with high MB sore (high growth potential) and low MB score (low growth potential) in his long term track of R&D spending. While Dewan et al. (1998) argued that firms with high growth potential may reinforce the confidence of investors since these firms may use IT more aggressively and innovatively than firms having limited growth opportunities. As to RFID, firms with high growth prospects are more willing to undertake this technology and have more ability to cope with the RFID adoption barriers. As a result, shareholders may react favourably to RFID investment made by firms with high growth prospects. This suggests our fifth hypothesis:

H5: RFID adopters with low growth potential will have significant and higher negative abnormal market return in the long run.

The level of the firm's diversification refers to the number of business lines of firms. There is no consensus upon the relationship between diversification and IT investment's impact on firm value. Some of the studies found that diversification was highly positively related to market reaction (Bharadwaj et al. 1999; Chari et al. 2008; Clemons & Row 1991; Ren & Dewan 2006), while others observed an insignificant negative relationship (Chatterjee et al. 2002; Barclay & Litzenberger 1988). It is commonly believed that more diversified firms need more internal coordination (Eisenhardt 1985) and higher demand for IT (Dewan et al. 1998; Szulanski 1996). Besides, for more diversified firms, the decision and coordination could be more difficult since more control is needed to address the agency conflicts. Additionally, internal communication could be more difficult, which could become a hidden danger in the long term. Thus, we believe that the more business lines firms have, the more risky RFID adoption is.

H6: RFID adopters with higher level of diversification will have significant and higher negative abnormal market return in the long run.

Additional resources can help firms acquire the necessary managerial and technical talent to facilitate the implementation of an innovation (Chau & Tam 1997). In the context of RFID adoption, more financial resources mean more opportunities to pursue riskier strategies, for these resources provided the buffering against failures (Kim & Garrisonb 2010).To be specific, financial health of firms is an indicator whether firms have enough IT related budget to cover associated IT costs of recruiting specialized personnel and building any needed infrastructure. This is especially the case in the long term, because more cash is needed to ensure the transformation process of RFID. Moreover, allocating more money in building IT infrastructure may imply that less money can be invested in the core business of firms. By doing so, the growth potential of firms would be greatly impaired. For an emerging technology like RFID, losing growth potential even means the losing of position in the market, and hence the market value would be negatively affected. Based on the above studies, we hypothesize that the market will react more negatively toward financially unhealthy firms over a long term. Thus, we propose the following hypothesis.

H7: Financial unhealthy RFID adopters will have significant and higher negative abnormal return compared with financial healthy RFID adopters.

4 METHODOLODGE

The data procedure and research model is presented as follows.

4.1 Data Preprocessing

The RFID investment announcements were collected using a thorough search of database Factiva using 'RFID' or 'radio frequency identification' as key search words over 13 year period beginning January 1, 1997 to September 31, 2009. The database yielded thousands of announcements initially, so a systematic screening mechanism was conducted following Bose et al. (2011). In the end, we got a total of 108 announcements by 76 firms, of which the majority is US listed firms. Some of the announcements are listed in Table 1:

Company	Date	Headline	Country
Sainsburys	16-Sep-97	U.K. Grocery Giant Enlists SCS Corp. To Automate Grocery Tracking and Distribution; Sainsbury's Supermarkets Undertakes Unprecedented Passive RF/ID Pilot Program	United Kingdom
Sumitomo Realty & Development	25-Feb-04	Innovative New Packaging in Japan: Sony Broadband Solutions card to offer condo entry, other functions.	Japan
Bharat Aluminium Company	31-Dec-08	BALCO: IN GROWTH MODE (to install radio frequency identification technology at Korba plant)	India
Ringnes	24-Mar-09	Journal of Commerce Online	Denmark
Wal-Mart	1-Aug-08	Made in Canada; Wal-Mart Canada's RFID project is a sign the firm has not given up hope on the technology despite its spotty US track record	United States
Nabors	9-Jun-09	Nabors Canada Selects Trig Point For Assets and Operations Management	United States

Table 1. Partial listing of announcements

The moderating factors such as adoption time, country, and industry type, levels of diversification, financial health, and growth potential was also collected and will be discussed later.

4.2 Research model

4.2.1 Calendar Portfolio Analysis

Event study is inappropriate for measuring long-term abnormal returns because events may be clustered in time (Lyon 1997; Kothari & Warner 2006). To overcome this deficiency, we use the Calendar Portfolio Analysis (CPA) method which can account for cross-sectional correlation of returns (Lyon et al. 1999; Mitchell & Stafford 2000). This can be explained by two reasons. First, in CPA we use monthly returns rather than daily returns. They are less susceptible to the bad model problem, since they are serially uncorrelated among rational investors (Kothari & Warner 2006). Second, by forming monthly calendar time portfolios, all cross-correlations of event-firm abnormal returns are automatically accounted for in the portfolio variance. Finally, the distribution of this estimator is better approximated by the normal distribution, allowing for classical statistical inference (Mitchell & Stafford 2000). The only drawback of CPA is that it has low power to detect abnormal returns because it averages over hot and cold event periods.

The CPA procedure is illustrated in Figure 2, we present how a 6-month portfolio of the same country is constructed. Firstly, the assumption is that there are only two announcements separately from A and B of the same country. Firm A made the adoption announcement before month 1, we believe that stock A is invested into $1 right at the following the announcement month, namely the

beginning of month 2. Next, the portfolio holds stock A for six months and sold it at month 6. Similarly, announcement of firm B is made between month 1 and month 2, and the corresponding stock B is pursued at the beginning of month 2, hold for 6 months, and sold at month 8. As we can see, we had both stock A of $1 and stock B of $1from month 2 to 6. After month 7, the portfolio became empty.

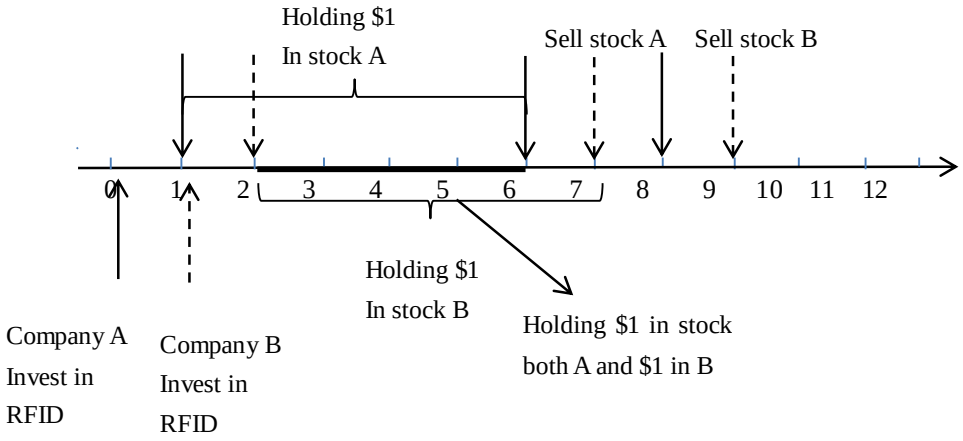

Figure 3. Example of CPA for a 6-month portfolio

In addition, for each portfolio in month t, we formed an equally weighted portfolio for each subset consisting of all announcements. Under the assumption that individual abnormal returns are normally distributed with mean zero, we pooled them together and got a pooled Rpt, SMB, HML are all weighted portfolios. The observing time windows we have chosen are 3 months, 4 months, 5 months and 6 months. Because a time interval of shorter than 3 months is not long enough to capture the long term impact, and the impact may decline or disappear in time longer than 6 months because the market responses fluctuates daftly especially for emerging high technology like RFID. Next, we undertake FFM method to observe the long term excess return.

4.2.2 FFM Method

The FF model was first introduced by Fama French on the basis of the traditional Capital Asset Price Model in which two more factors SMB and HML were added to consider the size effect and the book-to-market ratio effect. SMB was the correction for the difference in the rate of return between small and big firms in a value-weighted portfolio of stocks, while HML was for the difference between the high and low book-to-market ratio stocks in a value-weighted portfolio of stocks. Several scholars have employed the FF model to study the impact of branding (Madden & Fournier 2006), new product announcements (Sorescu et al. 2007) and marketing alliances (Swaminathan 2009) on market value. Since the samples in our paper are both US listed and non-US listed, hence, we adopted the merged model proposed by Bose et al. (2011) in which an international HML was added to the FFM-three factor model ,thus the model could explain the returns generated from global value and global growth portfolios. The monthly IHML data is downloaded from Prof. French's website. The merged FF model (FFM) is shown below.

$$R_{pt} - R_{ft} = \alpha_p + \beta_p\left(R_{mt} - R_{ft}\right) + D_p\left(\gamma_p\, SMB_{pt} + \delta_p HML_{pt}\right) + \left(1 - D_p\right)\epsilon_i IHML_{pt} + \varepsilon_{pt} \quad (1)$$

Where R_{pt} is the rate of return of portfolio announcement on month t, R_{mt} is the rate of return of market index m on month t, the estimate of y-intercept α_p provides a test of the null hypothesis that the mean monthly abnormal return on the calendar-time portfolio is zero. β_p is the slope that measures

the sensitivity of R_{mt} , D_p is a dummy variable that takes the value 1 when the announcement is listed in a US stock exchange and 0 otherwise. $IHML_{pt}$ is the international book-to-market ratio correction factor for month t, and for the country where the announcing firm is listed, and i is the corresponding slope, and ε_{pt} is the error term. M is a dummy variable referring to a list of moderating factors and β the corresponding slope .The error term in this regression may be heteroskedastic, thus we use the weighted least squares estimation, where the weighting factor is based on square root of the number of securities in the portfolio in each calendar month.

The monthly stock price is retrieved from Google finance and Yahoo finance ,they are adjusted before being put into the portfolio , for company i in month t, the stock fluctuation computation is $(R_{it}-R_{i(t-1)})/R_{it}$. The monthly $R_{ft,}$ SMB, HML, and IHML are downloaded from Prof. French's website. To examine the moderating effects, we define the market-to-book value correction factor (IHML) and firm size correction factor (SMB) as control variables and each moderating factor is put into the equation each time. For example, if we want to see whether country factor plays a crucial role in determining the long term impact of RFID adoption on firm value in H3, M takes 1 when it is US-listed and 0 the verse . Other moderating variables are interpreted as follows:

Regarding the time effect in H2, the sample was divided into two subsamples: announcements issued before 2006 and after 2006. The dummy variable M takes 1 when it is an announcement made after 2006. Similarly, M takes 1 when the firm belongs to non-manufacturing industry classified by the SIC codes in H4. By the same logic, M takes 1 when growth potential, financial health, and the diversification score is low in H5, H6, and H7.

The market-to-book (MB) ratio is prevalently used in accounting as the measurement of growth potential of a firm (Brief and Lawson, 1992). The computing method is dividing the current common stock price of a firm by the book value of the firm per share. Median score 2.28 is used to distinguish low growth potential firms (MB ratio < 2.28) and high growth potential firms (MB ratio > 2.28).

As to the level of diversification of a firm , we firstly count the number of segments generating more than 10% of the total sales of the firm according to Rule 14 of the Financial Accounting Standards Board (as shown in US Form 10-K), three sample firms are eliminated because of unavailable financial data. Then we use the median diversification sore which is 3 to divide the firms into two groups: firms with low diversification (diversification <3) and firms with high diversification (diversification > 3).

The EM score is predicted to be positively correlated with the firms' financial health. An EM score higher than '8' is considered as equivalent to an AAA bond rating. Thus, we use the EM score to distinguish poor financial healthy firms and good financial healthy firms. The computation of EM score is as follows:

$$EM = 6.56(WCAP/TA) + 3.26(RE/TA) + 6.72(EBIT/TA) + 1.05(MV/LT) + 3.25 \quad (2)$$

Where WCAP refers to the working capital, RE the retained earnings, EBIT the earnings before interest and taxes, MV is the market value of equity, LT is the total debt, and TA is the total assets. Since the median EM score of this entire example is 8.63, EM score higher than 8.63 is defined as healthy financial firms and lower than 8.63 unhealthy financial firms. Fifteen sample firms are discarded because of unavailable financial data.

Next , we firstly had the subgroup regression by separating the sample by one moderating variable , when all the moderating variable had the regression one by one ,then we had the overall regression putting all the variable together .

5 RESULTS

As Table 2 shows, abnormal returns of the full sample ranging from 3 months to 6 months show consistent negative results. Besides a gradual decline in the absolute excess return is observed, suggesting it might take quite a long time for RFID to manifest its benefits .Hence, H1 is supported.

Months	3 months	4 months	5 months	6 months
Size	187	229	270	308
AR	-2.11	-1.77	-1.54	-1.33
p-value	0.03	0.04	0.04	0.06

Table 2. The overall abnormal return in the long term

The results of subsample analysis are displayed in Table 3.

The results of subsample analysis are displayed in Table 3. As to the timing effect, an insignificant positive abnormal return is found for pre-2006 adopters while a significant negative abnormal return is found for post-2006 adopters. Thus, H2 is supported.

Panel A Impact of adoption time period								
Months	3 months		4 months		5 months		6 months	
Time	Pre-06	Post-06	Pre-06	Post-06	Pre-06	Post-06	Pre-06	Post-06
Sample size	79	108	94	135	112	158	130	178
AR	0.60	-3.24	1.02	-2.93	0.53	-2.32	0.34	-1.93
p-value	0.53	0.04	0.17	0.03	0.49	0.05	0.63	0.07
Panel B Impact of country of firm								
Months	3 months		4 months		5 months		6 months	
Country	Non-US	US	Non-US	US	Non-US	US	Non-US	US
Sample size	121	66	155	74	188	82	220	88
AR	-3.81	-0.19	-2.96	-0.54	-2.06	-0.83	-1.43	-0.97
p-value	0.04	0.87	0.07	0.61	0.15	0.36	0.27	0.24
Panel C Impact of industry of firm								
Months	3 months		4 months		5 months		6 months	
Industry	Non-mau	Manu	Non-manu	Manu	Non-manu	Manu	Non-manu	Manu
Sample size	120	91	151	113	181	130	201	146
AR	-0.75	-3.72	-0.97	-2.78	-1.02	-2.44	-0.95	-1.89
p-value	0.56	0.03	0.38	0.05	0.28	0.05	0.27	0.09
Panel D Impact of MB ratio of firm								
Months	3 months		4 months		5 months		6 months	
MB	Low	High	Low	High	Low	High	Low	High
Sample size	98	114	127	136	148	163	172	184
AR	-2.72	-1.67	-2.15	-1.68	-1.58	-1.68	1.39	-1.10
p-value	0.12	0.15	0.12	0.13	0.25	0.08	0.20	0.23
Panel E Impact of diversification of firm								
Months	3 months		4 months		5 months		6 months	
Diversification	Low	High	Low	High	Low	High	Low	High
Sample size	164	41	191	59	229	67	285	34
AR	-1.61	-4.71	-0.88	-3.66	-0.64	-3.77	-2.01	0.50
p-value	0.10	0.06	0.30	0.03	0.40	0.02	0.01	0.65
Panel F Impact of EM score of firm								
Months	3 months		4 months		5 months		6 months	
EM	Low	High	Low	High	Low	High	Low	High
Sample size	99	91	129	108	154	126	180	139
AR	-0.16	-3.77	-0.62	2.07	-0.37	-2.34	-1.64	-1.98
p-value	0.92	0.00	0.62	0.04	0.73	0.02	0.13	0.03

Table 3. The moderating effects

To examine the country factor effect, the sample was separated into US firms and non-US firms. This choice of country groups can be supported by the widely held belief that RFID investments have a greater effect on firm performance of non-US firms rather than US firms. As shown in table 3, the 58 non-US firms had a statistically insignificant average excess return ,while the 43 US firms even do not pass the F test (at the level of %10). This result confirms our expectation that RFID investments have a greater negative effect on non-US firms. H3 is supported. Regarding the growth potential of firms, results show that firms with high MB score suffer less and insignificant negative excess return. H4 is not supported. In respect of industry effects, manufacturing firms show significant negative reaction while non-manufacturing firms display insignificant slight negative reaction. This indicates that the manufacturing industry is more negatively affected by RFID adoption compared with non-manufacturing industry. H5 is supported.

Similarly, regarding the level of diversification and the degree of financial health, we find that the market react more negatively to firms with high level of diversification and good financial health. H5 is supported but H6 is not supported. The results are summarized in Table 4.

Hypothesis	Description	Results
1	RFID will generate an overall significant long term impact	Supported
2	RFID's long term impact will show first-mover advantage	Supported
3	Non-US listed firms will be more negatively affected than US firms	Supported
4	Manufacturing firms will be more negatively affected than non-manufacturing firms	Supported
5	High growth potential will moderate the long negative impact	Supported
6	High levels of diversification will moderate the long negative impact	Supported
7	Good financial health will moderate the long negative impact	Rejected

Table 4. Hypothesis supported or rejected

6 DISCUSSION

Generally, We discovered a consistent significant long term negative impact for all the time periods of thefull sample. This result is quite different from previous studies on IT investments' short term impact which all revealed a positive effect (Jeong & Lu 2007; Chatterjeeet al. 2002; Oh et al. 2006; Hayers et al. 2001). One explanation is that IT strategy is not a list of one-time decisions but the configuration of integrated and interlocking activites (Rivkin 2000 ; Siggelkow 2001). These money-taking activities may obscure the profitiblity of RFID. Besides, as we have discussed earlier, the adoption of RFID was mandated by controllers in the supplier chain. Mandated adoption of IT technology may lead to miss-match between a firm's strategy and its IT strategy, and the unsuccessful adoption of RFID is resulted. Consistent with McFarlan's (1981) findings, our study is another confirmation of Hitt and Brynjolfsson's (1996) findings that IT creates value in the form of increased efficiency or productivity rather than the value in profits due to the dissipative effects of competition in the product market.

With respect to moderating factors, our results suggested that the timing of adoption, location, industry type, and firm characteristics are all important moderators of influence of RFID adoption on market value of firms. Consistent with Powell and Dent-Micallef's theory (1997), RFID did show a first-mover advantage. RFID adoption before 2006 yield a positive abnormal return as expected, but the result is insignificant; RFID adoption after 2006 generate a significant negative adoption. This result may confirm that RFID has become an IT necessity and lose the competitive advantage which is

consistent with Weill (1992)'s conclusion. Contrary to the findings in Brynjolfsson's paper (1994) that non-US firms provided better incentives for exploiting RFID than US firms, we found a significant negative reaction for non-US firms but no significant market reaction for US listed firms. This indicates those US listed firms suffer less compared with other countries. This result might be due to the fact that RFID is mainly used for supply chain management which involves multiple stakeholders. Adoption by single company may not be successful. The prevalence of use of RFID in US provided better environment for RFID adoption. Therefore investors may perceive less uncertainty and lower cost for RFID adoption in US companies, which resulted in insignificant negative market return.

It was also found in our study that manufacturers suffered high negative abnormal market return compared to non-manufacturers. There are two reasons. As RFID is more an infrastructure IT investment rather than an application one. First, it is more directly related to manufacturers. Secondly, infrastructure change may be perceived by investor as having higher risks. As A.T. Kearney's report (2007) claimed, RFID's benefits are not equal to all supply chain members. Technology will bring great benefits to retailers, manufacturers will bear most of the costs and see little return.

The results on the influence of diversification were also in accordance with our expectation. The higher the diversification, the more difficult it is to integrate different resources and collaborate among different business lines, which may be perceived as having high risk in the long run by investors.

A more significant negative abnormal return is discovered for firms with high growth potential. This is probably because high-growth option firms typically reinvest their earnings in positive net present value projects and have low level of cash on hand (Smith & Watts 1992). Jenson (1986) pointed out that the managers of firms with limited growth prospects have incentives to invest in highly asset-specific IT resources, rather than paying dividends to shareholders, because doing so is likely to increase their bargaining power against their principal. Besides, agency theory indicates that low growth firms are more apt to have free cash flow and possess greater incentives to make extensive IT investments (Dewan et al. 1998). He also found that the level of IT investment is negatively related to growth potential which is consistent with our findings. But if looking further, companies with high growth potential will have a better ability to gain revenue from investment of IT resources. In our results, it could be observed that for the time window of 6 months, the abnormal return turned from significant negative to insignificant positive.

Financial healthy firms suffered a more significant negative abnormal market returns. These finding is contradictory to pervious research where financial health is positively related to market reaction. First, previous studies only focus on IT investments short term impact. Second, RFID as a disruptive technology, its implementation may bring bigger changes to companies. Financial healthy companies may be more confident to spend more on RFID while financial unhealthy companies may not. Due to the high risks, investors may perceive that financial healthy companies may suffer bigger loss.

Taken together, these findings can give rise to both managerial and theoretical implications. From the theoretical perspective, this research contributes to the literature on RFID by providing quantitative evidence that project RFID as a disruptive technology and extending the current understanding of RFID's short term impact to long term impact on firms' market value fluctuation. Calendar portfolio analysis was used to complement event study method, case studies, surveys, and other quantitative work in this area. Our results indicate RFID adoption may not be favoured by long term market reaction. More refined examination of the interaction effect between RFID adoption and factors such as industry, country, financial health, growth potential, and diversification helped us better understand what kind of companies may suffer from what kind of influence in the long run.

From the managerial perspective, managers should try to identify the problem and redesign the business process to fit the strategic role of RFID adoption. The technology must play an integral part in the entire business strategy, rather than simply an independent and isolated function (Levy et al. 2008). Besides, a special attention should be addressed on the firm characteristics. When firms decide to adopt RFID, they should keep an eye on the capital chain, cash flow and the coordination of various

business lines .In addition, partner's readiness regarding to the use and adoption of RFID should not be ignored. For the successful implementation of RFD requires the cooperation of all supply chain partners (Blomqvist et al. 2008).

Although negative influence was reported, our results do not suggest the companies should avoid RFID adoption. The fluctuation of market value only reflects the concerns of investors. Investors are usually risk avoiders. On the other hand, IT may not drive return on asset (ROA) directly, but indirectly through global competence and sales (Samuel et al. 2009). Instead, our results should be used to prepare the top management for possible future challenges after the adoption of RFID. For example, top management commitment and complementary resources should be enhanced to facilitate the implementation of an innovation.

7 CONCLUSION

This research extends previous studies by analysing the long term impact of RFID adoption on firms' market value. CPA (calendar portfolio analysis) method combined with FFM method was used in this study in order to discover the relationship between the announcement of RFID adoption and the firms' abnormal market return over time window of 3 months, 4 months, 5 months, and six months. 108 RFID adoption news announcements were analysed together with confounding factors such as timing of adoption, country, financial health, diversification, and growth potential. The results indicated a general significant negative impact. Specifically, subsample regressions revealed that late adopters, Non-US based firms, manufacturing firms, highly diversified firms, and financial healthy firms and firms with low growth potential may suffer more negative impact. Future studies are needed to find out what is the main factor that prevents firms from obtaining revenue. Moreover, interaction analysis between these moderating factors should also be explored.

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