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RESEARCH NOTE

ADOPTION OF IDENTITY THEFT COUNTERMEASURES AND ITS SHORT- AND LONG-TERM IMPACT ON FIRM VALUE[1]

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Identity theft has impaired e-commerce. To combat the crime, many identity theft countermeasures (ITC) have been proposed. As investments in ITC are substantial and the benefits of such investments are intangible, companies are often hesitant to adopt such measures. This was the motivation for this study of the impact of 526 ITC adoption announcements on short- and long-term market value. The event study shows that such announcements result in positive market return of about U.S. $583 million around the date of announcement. Calendar-time portfolio analysis (CPA) is used for the long-term impact analysis and shows that the adoption of ITC generates positive and significant average monthly return up to 1.5% with control of market risk factors in two years. Subsampling analysis and interaction analysis show that U.S. listing, early ITC adoption, and two-factor authentication may moderate the market value of ITC adopters differently. A number of robustness checks (e.g., Heckman model, cross-sectional regression on Tobin's Q, firm-specific risk factor analysis, subsampling analysis by ICT development, and analysis of security statements in annual reports) are performed. The research provides quantitative evidence of financial gain resulting from adoption of ITC and aspires to raise ITC awareness among industrial practitioners.

Keywords: Calendar-time portfolio analysis, event study, firm value, identity theft, identity theft countermeasures, long-term impact, short-term impact, stock prices

Introduction

According to the U.S. President's Identity Task Force, identity theft is defined as "misuse of another individual's information to commit fraud."[2] It is a crime to obtain personal data[3] about individuals in order to misrepresent them for fraudulent gain. The first publicized incident of identity theft can be traced back to 1943 in the United States (Biegelman 2009). It is estimated that more than 500,000 cases of identity theft take place in the United States each year.[4] Losses due to

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The appendices for this paper are located in the "Online Supplements" section of *MIS Quarterly*'s website (https://misq.org).

[2]https://www.ftc.gov/sites/default/files/documents/reports/combating-identity-theft-strategic-plan/strategicplan.pdf.

[3]For example, social security number, bank account number, and credit card number.

[4]News of many identity thefts hit the international media. For example, Adobe Systems, eBay, LinkedIn. and FriendFinder all experienced hacking and data breaches from 2012 to 2016 with millions of customer credentials stolen, leading to serious identity theft (https://themerkle.com/10-most-effective-data-breaches-in-the-history-of-the-internet/). Ponemon surveyed 113 global firms and found that on the day data breaches were announced, a firm's stock value decreased by 5% and customers' churn rate increased by

such cases exceeds U.S. $52.6 billion per year, and 90% of the loss is borne by commercial institutions (Mercuri 2006).

Since loss due to identity theft is tremendous, it is imperative for businesses to adopt ITC. We define ITC as technical solutions to prevent and detect identity theft, and mitigate their negative impact on firms.[5] However, many industrial practitioners are hesitant about investing in ITC due to high cost.[6] To recover the high setup costs of ITC, some companies planned to levy the financial burden on customers. However, a recent survey by McKinsey shows that customers are unwilling to pay extra costs for the security they desire.[7] Another reason deterring the use of ITC is the unknown level of acceptance of these measures by customers.[8] The decision to adopt ITC is justifiable if there is evidence that such an adoption can increase the market value of firms.

To combat identity theft, researchers have analyzed features of online identity theft and developed a number of innovative measures (e.g., email authentication and identification systems (Wang et al. 2009), and the Web 2.0 emergency reporting system (Oh et al. 2013)). Although many ITCs have been introduced, unless it is evident that the potential gain outweighs the high cost, there is not much incentive for corporations to invest in them (Mercuri 2006).

Investment in information security is substantial.[9] Studies on the impact of information security investments are limited although this line of research resembles studies related to the impact of investment in IT on firm value.[10] Chai et al. (2011) investigated the market impact when firms adopt information security technologies and found that such adoption generates a short-term cumulative abnormal return (CAR) of 1.36%. However, the sample data used in the research were not specific to ITC but included all types of security measures.[11] In addition, most of the previous studies only consider short-term market reaction to IT investment in the United States rather than its long-term impact on a global scale. This has motivated us to study the impact of ITC adoption using 526 announcements from 312 unique firms in to 39 countries.[12] We propose theoretical arguments using the concept of cue utilization theory to explain the positive impact of ITC adoption on firm value. We also identify moderating factors such as country of listing, time of adoption, and government advocacy that affect this impact. Unlike most of the prior studies on IT investment that use the standard capital asset pricing model (CAPM), which suffers from the influence of macroeconomic factors (Dewan and Ren 2007), we combine the Fama-French three factor model and the Fama-French international model to better explain the risks in the cross-sectional abnormal return for global firms. To determine the long-term impact of ITC adoption, we use the CPA to analyze the long-term impact one to two years after such adoption.

Our results show that an ITC announcement gives rise to an immediate positive cumulative abnormal stock return of 0.58% on and one day after the announcement, on average, and results in a gain of market capitalization of at least U.S. $583 million per announcement. The CPA shows that adoption of ITC gives rise to an average monthly return ranging from 0.44% to 1.50% in 24 months. For U.S. listed firms, the short- and long-term market return in the event study and the CPA are significant and positive. For early adopters of ITC and adopters of two-factor authentication (2FA), mandated by

7% on an average (https://www.cso.com.au/mediareleases/30163/ponemon-australian-research-shows-data-breaches/). Adobe paid U.S. $1 million to settle the data breach of 38 million accounts (https://krebsonsecurity.com/2016/11/adobe-fined-1m-in-multistate-suit-over-2013-breach-no-jail-for-spamhaus-attacker/). Shortly after a data breach in May 2017, eBay lowered its annual sales target by U.S. $200 million (https://www.scmagazineuk.com/ebay-counts-the-cost-after-challenging-data-breach/article/541162/).

[5]Examples of ITC include dynamic password generators, SMS-based one-time passwords, personal digital certification, and electronic signatures (Bose and Leung 2013).

[6]The cost of a dynamic password generator is between U.S. $20 and $100 per device with a lifespan of two to three years (https://www.wikidsystems.com/learn-more/authentication-problems/key-fobs-are-an-expensive-hassle/) and the total cost of ownership of various enterprise authentication solutions may vary from U.S. $135,900 to U.S. $316,075. Enterprise authentication solutions include smart device software, hardware one-time passwords (OTPs), smart tokens, mobile OTP soft tokens, PC OTP soft tokens, and SMS OTPs. More details can be found at https://www.encapsecurity.com/study-companies-can-halve-authentication-costs-by-ditching-hardware-tokens/.

[7]https://www.mckinsey.it/idee/security-in-the-internet-of-things.

[8]HSBC has expressed concern that customers may not be interested in two-factor authentication (2FA) tools because they are burdensome for customers with more than one account (http://www.computerworld.com.au/index.php/id;847801426).

[9]According to Forrester Research, companies spent 14% of their IT budget on information security in 2010 (http://www.informationweek.com/security/management/security-spending-grabs-greater-share-of/229218689). In 2012, despite the economic downturn, the Gartner CIO survey found that 50% of companies maintained the same IT security budget and 45% anticipated that the budget would increase (http://www.eweek.com/c/a/Security/ Security-Infrastructure-Market-to-Top-86-Billion-in-2016-Gartner-591583/).

[10]Appendix A lists these studies and their source of data, tests used, and generated returns.

[11]For example, intrusion detection systems, anti-virus, anti-worms, and fire walls.

[12]Some examples of announcements related to adoption of ITC are shown in Appendix B.

many governments, the market return is significant and positive in the event study but marginal in the CPA. The interaction analysis shows that the two-way interaction of early ITC adoption and U.S. country factor generates positive and significant market return in both the event study and the CPA. However, the interaction effect of 2FA and U.S. country factor is only significant and positive in the event study. The significant U.S. country factor coincides with the fact that there are more U.S. firms with security related statements in their annual reports than firms listed elsewhere. Our study also passes a number of robustness tests (e.g., Heckman model, *Tobin's Q* model, and long-term firm-specific risk model). This study complements the study by Gordon et al. (2010) on voluntary disclosure of information security risks. It shows that apart from corporate disclosure, proactive action taken by companies against identity theft is also rewarded by the equity markets.

Theoretical Background

ITC as a Cue to Online Safety

According to cue utilization theory (Cox 1967), products or services provided by a company may send signaling cues to individuals that "enable them to make indirect judgments using information which is available" (Sullivan and Burger 1987, p. 64). Adoption of ITC is a strong cue that the adopters are willing to deter identity theft. There are several reasons for that. First, ITC can reduce the risks in online transactions. Adoption of ITC may send a positive cue to investors about safeguarding online safety. Previous research shows that security related cues can alleviate their information security concerns about online transactions (Pavlou et al. 2007). Second, disclosure of security related information (e.g., announcement of ITC adoption) may send cues to investors about their commitment to address security related risks (Gordon et al. 2010) and reduce potential litigation costs from customers due to inadequate security measures to protect their personal information. Previous research on patent infringement shows that litigation may hurt defendants' market value (Raghu et al. 2008). Third, adoption of ITC can deter potential adversaries who may prefer firms with weaker security measures to enhance their rate of successful attacks. Previous research shows that security and privacy assurance[13] may reduce transactional uncertainty and increase purchase conversion (Ozpolat et al. 2013). Finally, investment in ITC can provide more information to investors for evaluating firms' safety and help reduce information asymmetry. The reduced information asymmetry can generate higher market return and avoid lemon market problems (Gordon et al. 2010).

Adoption of ITC: Short- and Long-Term Impacts

Technology elicits both symbols and symptoms of trustworthiness (Riegelsberger et al. 2005). ITCs are protective measures against identity theft. The decision to adopt an ITC is a symbol of better online security and a safer transactional environment. The short-term market reaction may capture the initial response due to general market perception to symbols of ITC. Symptoms are by-products of trustworthy actions, which are reflected in customer reviews and external evaluations (Riegelsberger et al. 2005). As the quality of credence of information security is difficult to determine before use (Ray et al. 2011), people may rely on external reviews or self-experience to determine the effectiveness of an ITC after using it for some time. When customers and investors have used and experienced an ITC for a long time, their response to the ITC may change. This is also in line with the idea of two-stage process of cue utilization where customers collect specific information about cues in the first stage of cue acquisition and form judgments about attributes of interest in the second stage of attribute evaluation (Olson and Jacoby 1972). When customers have used the ITCs offered by a firm for some time they form an opinion about these security features and the providing firms. Such an opinion is reflected in long-term market reaction.

Hypotheses Development

Prior studies[14] generally agree that investments in IT can give rise to positive excess market return. Similar to IT investment, ITCs can mitigate security threats on organizational resources. When firms adopt ITCs, they encourage more customers to use their online services and alleviate investors' concerns about identity theft. Adoption of ITC may be viewed as cues by market participants that the adopters have realized the danger of threats associated with online transactions. Also, recognition of security threats and adoption of ITC allow firms to focus on core business activities (Gupta et al. 2000). Tightened security control in the areas of fraud detection and transaction verification can yield monetary benefits that are at least 25% higher than the cost of adoption of such security measures.[15] Apart from customers, investors

[13]For example, TRUSTe's certificate of compliance of privacy policy and VeriSign's digital certificate of Secure Socket Layer (SSL) connections.

[14]See Appendix A for details of prior studies.

[15]https://www.gartner.com/doc/496217/transaction-verification-complements-fraud-detection.

(particularly institutional investors) also care about data and cybersecurity because security measures directly affect firms' performance. The Council of Institutional Investors (CII 2016) published a report, "Prioritizing Cybersecurity," to raise the awareness of members to firms' cybersecurity practices in investment.[16] Many asset management companies (e.g., JP Morgan and Schroders[17]) have released reports to express their concern about data and cyber insecurity in investment. KPMG also reported that the majority of institutional investors (79%) are not keen to invest in businesses that have been hacked.[18] Therefore, we posit:

H1: Adoption of ITC increases short-term market return[19] of adopting firms.

Perception about ITC is a credence quality that may not be determined before actual usage or with little exposure (Ray et al. 2011). Through frequent interaction with ITC, customers and investors understand the technology better. Positive interaction experience may foster long lasting customer relationships (Riegelsberger et al. 2005) and positive long-term market return. Moreover, as customers use ITC more often, the cues acquired about ITC in the first stage of cue acquisition are evaluated in terms of their impact. As customers experience a safer online environment for conducting business and become free of worries related to identity theft, this helps them form a positive judgment about the impact of ITCs. Adopting ITC to deter identity theft may also be a cue of management's professionalism and far-sightedness. Investment in security is an enabler for business that reduces operational risks. The initiative to adopt security measures is a reflection of management's commitment to manage IT risks and treat information security as a strategic asset for the firm (von Solms 2006). Therefore, a long-term market return is a response to sound managerial practices. We hypothesize:

H2: Adoption of ITC generates a higher long-term market return[20] for the adopting firms.

Several factors may moderate the effect of ITC adoption.[21] Personal predisposition and security cues may moderate individuals' perceived security control (Ray et al. 2011). Personal predisposition is related to familiarity with ITC and concern about identity theft. U.S. investors may be more familiar with ITC and have higher awareness of identity theft. There are various reasons. First, the diffusion rate of e-commerce in the United States is much higher than the rest of the world (Gibbs and Kraemer 2004). Second, a number of major identity theft incidents have taken place in the United States. To check the exponential growth of identity theft, the U.S. Federal Government mandated all institutions to implement the "Red Flag" program to address the problem of identity theft in favor of customers by 2008.[22] With frequent exposure to e-commerce, investors in the United States are more aware of online threats. As per the cue utilization theory proposed by Cox (1967), an important determinant of cue usage is the confidence value of the cue or the ability of the consumer to correctly evaluate a cue. Since U.S. customers and investors are more aware of security breaches and ITCs, they exhibit a higher confidence value of the cue and react more positively to the cue generated by ITC adoption.

H3a: Firms listed in the United States exhibit higher short-term market return when they adopt ITC compared to firms listed in other countries.

Futijtsu found that American companies consistently contributed over 45% to the global enterprise information security market in 2013–2017 with a steady growth of 8.3% per year.[23] The increase in spending is not just in security technologies but in an ecosystem that allows people to benefit from the technologies. Therefore, investors in the United States should have more exposure to e-commerce and display heightened security awareness. Previous research shows that economic and regulatory measures, as well as cultural differences, may influence cross-country technology diffusion (Zhu and Kraemer 2005) and selection of electronic communication media (Straub 1994). Frequent usage of e-commerce services and ITC in the U.S. markets may allow investors to evaluate

[16]https://www.bitsighttech.com/blog/do-investors-care-about-cybersecurity.

[17]ttps://www.jpmorgan.com/jpmpdf/1320633569852.pdf and http://www.schroders.com/staticfiles/Schroders/Sites/global/pdf/Why-investors-should-care-about-data-security-risk.pdf.

[18]https://home.kpmg.com/uk/en/home/insights/2015/04/institutional-investors-shy-away-from-hacked-businesses.html.

[19]We define short-term market return as market return three days around the announcement of ITC adoption (i.e., one day before, on, and one day after the date of announcement).

[20]We define long-term market return as market return that occurred one to two years after the announcement of ITC adoption.

[21]Melville et al.'s (2004) IT business value model suggests that apart from focal firm factors, macro and competitive environments may moderate the business value of a firm upon adoption of IT. Macro environmental factors include country characteristics and government promotion. Competitive environmental factors include competitive advantage of a technology over time. Therefore, in H3–H5, we hypothesize that country, time, and government advocacy may moderate firm value that results from ITC adoption.

[22]https://www.forrester.com/report/Red+Flag+Compliance+Are+You+Ready/-/E-RES47212.

[23]http://ts.fujitsu.com/rl/ff2014/downloads/BOS-C117b-Security-as-an-Important-Contributor-to-Business-Success.pdf.

the effectiveness of ITC more accurately. Therefore, the United States as a country may affect investors' realization of long-term benefits of ITC more saliently than other countries.

H3b: Firms listed in the United States exhibit higher long-term market return when they adopt ITC compared to firms listed in other countries.

Time of adoption plays an important role in moderating individuals' perceived security control. Early adoption of ITC may send a strong cue to investors that the adopters are conscious about deterring identity theft. It also generates an impression of being responsive to the competitive e-commerce environment (Lee and Grewal 2004). Being the first to adopt ITC, adopters can enjoy unique market advantages and stay ahead of their competitors (Lieberman and Montgomery 1988). The year 2008 marked the boundary between early and late ITC adoption because most of the laws against identity theft were passed in that year.[24] Therefore, we hypothesize:

H4a: Early ITC adopters (pre-2009)[25] show higher short-term market return than late adopters.

Early adopters of new technology usually enjoy sustainable lead time advantages that include technological leadership and imposition of high switching costs on customers (Lieberman and Montgomery 1988). Technology leadership can create a differential advantage for the first mover (Kerin et al. 1992). Market pioneers who adopt ITC early can quickly attract a large number of security conscious customers. Over time, customers may become more attached to the e-commerce services provided by adopters. Although other competitors may adopt similar ITC over time, as customers are more familiar with the systems provided by the market pioneers, they may find it inconvenient to switch to other companies (Wade and Hulland 2004). As a result, firms may enjoy long-term advantages. Therefore, we posit:

H4b: Early ITC adopters (pre-2009) show higher long-term market return than late adopters.

In the face of identity theft, e-commerce firms adopt different types of ITC. Some advanced ITC such as 2FA[26] are advocated by governments and regulatory organizations in the United States, the European Union, India, Hong Kong, Singapore, and the Republic of Korea.[27] The strong government advocacy of 2FA may send a cue to investors that the adopter has implemented stronger ITC than their peers. This may generate a positive impression about the adopter among investors, which in turn may lead to higher trust (Miyazaki et al. 2005). Therefore, we posit:

H5a: Adoption of government-advocated sophisticated ITC generates a higher short-term market return for the adopting firm than adoption of any other ITC.

2FA with strong government advocacy may help the adopter achieve long-term competitive advantage for several reasons. First, adversaries find them difficult to crack. Adoption of such tools can help provide customers with a safe e-commerce environment and thereby increase patronage. The higher number of transactions can generate immediate cash flow, giving rise to a positive market reaction (Burton et al. 1999). Furthermore, the endorsement of the technology by governments may generate trust among customers and encourage more frequent use of related tools (King et al. 1994). More customer feedback on the use of ITC allows investors to realize the advantages of the technology and help them attain a long-term competitive advantage (Keen 1991).

[24]The U.S. Federal Government mandated that all banks should implement "Red Flag Rules" by November 2008 to take a more proactive approach to detect possible identity theft (Bose and Leung 2014). A number of states, such as Arkansas, California, and Texas, passed stringent laws against identity theft before 2008 (Bose and Leung 2014). The Monetary Authority of Singapore mandated the adoption of 2FA by the end of 2007 (Bose and Leung 2013); the Korea Financial Services Commissions required a similar mandate to be implemented by January 2008 (http://www.an16.afponline.org/docs/default-source/default-document-library/pdf/cp_afp-south_korea-pdf.pdf?sfvrsn=0).

[25]We also tried other time periods to define early adoption, for example, pre-2005. The results were found to be qualitatively similar.

[26]2FA requires users to possess two factors, "what you know" (e.g., password) and "what you own" (e.g., dynamic password generator, SMS-based one-time password, personal digital certificate) for the sake of authentication. Even if the password of a user is compromised, the adversaries cannot steal the user account without the additional security device (i.e., "what you own"). Therefore, 2FA is stronger than conventional password-based authentication system.

[27]The U.S. Federal Government recommended the use of 2FA whenever available (https://www.ftc.gov/news-events/blogs/techftc/2012/05/problem-passwords). The European Banking Authority required all member companies to deploy 2FA by August 2015 (http://www.secureidnews.com/news-item/eu-payment-service-providers-face-deadline-for-two-factor-implementation/). The Reserve Bank of India made 2FA compulsory for all online payments in India by August 1, 2009 (http://gadgets.ndtv.com/internet/features/two-factor-authentication-is-a-bother-can-it-get-better-641813). The Hong Kong Monetary Authority (http://www.info.gov.hk/hkma/eng/press/2004/20041007e4.htm) and the Monetary Authority of Singapore (http://www.mas.gov.sg/about_us/annual_reports/annual20052006/Index_B/B50_box10.htm) mandated the adoption of 2FA by 2005 and 2007, respectively. The Basic Act on Electronic Financial Transactions (2006) mandated that all banks in the Republic of Korea with Internet banking service should use 2FA by January 2007 (http://www.an16.afponline.org/docs/default-source/ default-document-library/pdf/cp_afp-south_korea-pdf.pdf?sfvrsn=0).

H5b: Adoption of government-advocated sophisticated ITC gives rise to a higher long-term market return for the adopting firms than adoption of any other ITC.

In the above set of hypotheses, we posit that individual factors have a disparate impact on both the short- and long-term market value of ITC adopters. However, previous research has shown that a standalone factor analysis may not be able to capture the interrelationship among the key factors, and to remediate this deficiency researchers should consider multiplicative interaction effects (Blalock 1965). Interaction effects have been widely studied in prior IS research. For example, Zhu and Kraemer (2002) found that the interaction effect of e-commerce capability and IT intensity is more significant than the effect of the standalone factors. Dewan and Ren (2007) found that the interaction effect among service firms is strongest when IT investment intensity is high and the investment took place recently. Therefore, we exhaustively test all two-way interactions of the three main factors and propose:

H6a(b): Firms listed in the United States that adopt ITC early (pre-2009) have higher short- (long-) term market return than other companies.

H6c(d): Government-advocated sophisticated ITC adopters listed in the United States have higher short- (long-) term market return than other firms.

H6e(f): Early (pre-2009) government-advocated sophisticated ITC adopters have higher short- (long-) term market return than other firms.

Research Method and Findings

We analyzed the short- and long-term impact of ITC adoption announcements. For the short-term analysis, we used the event study method. A limitation of the event study was the inability to account for cross-sectional dependency of events (Kothari and Warner 2007). To remediate this limitation, we used the CPA to determine the long-term impact of ITC adoption.

Analysis of Short-Term Impact

The event study was conducted for short-term market analysis.[28] Initially, 17,569 announcements were retrieved from Factiva. Next, announcements that might be affected by confounding news were eliminated,[29] leaving 526 announcements from 1995 to 2016 as shown in Table 1.[30]

The market model based on the CAPM as represented by equation (1)[31] was selected.

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{1}$$

The CAPM has been criticized in prior research for its inability to capture all market risks that led to miscalculation of market return (Fama and French 1992). To overcome the inadequacy of the CAPM, we used the Fama-French three-factor model as shown in equation (2).[32]

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft}\right) + \gamma_i SMB_t + \delta_i HML_t + \varepsilon_{it} \tag{2}$$

To make this model usable in an international context, Fama and French (1998) added an international book-to-market correction factor (*IHML*) in the CAPM. We combined the three-factor model for U.S. data with the two-factor international Fama-French model in equation (3).[33]

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mit} - R_{ft}\right) + D_i \left(\gamma_i SMB_t + \delta_i HML_t\right) + \left(1 - D_i\right) \zeta_i IHML_{it} + \varepsilon_{it} \tag{3}$$

[28]The steps of the event study are shown in Appendix C.

[29]We adopted a confounding window of five days (two days before and after the date of announcement), and the list of confounding events included earnings announcements, dividend declaration, and change of senior management.

[30]1995 was the earliest date of news announcement obtained from Factiva. A country-wise description of the sample data appears in Appendix D.

[31]R_{it} was the rate of return for announcement i on day t, R_{mt} was the rate of return of market index m on day t, α_i was the y-intercept, β_i was the slope that measures the sensitivity of R_{mt}, and ε_{it} was the error term.

[32]R_{ft} was the risk-free rate or the return of U.S. treasury bills on day t, SMB_t was the size correction factor for day t, γ_i was the corresponding slope, HML_t was the book-to-market correction factor for day t, and δ_i was the corresponding slope. Daily data related to R_{ft}, SMB_t, and HML_t were retrieved from http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[33]In equation (3), R_{mit} was the rate of return of market index m in which firm i belonged to on day t, D_i was a dummy variable that took a value 1 when firm i was listed in a U.S. stock exchange and 0 otherwise, $IHML_{it}$ was the international book-to-market ratio correction factor for day t, and for the country where the announcing firm i was listed, and ζ_i was the corresponding slope. Daily data related to R_{ft}, SMB_t, HML_t, and $IHML_{it}$ were retrieved from http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

Table 1. Number of Announcements Retained in Each Filtering Stage

Stage of Filtering	Number of Announcements
Announcements that matched keywords	17,569
After filtering announcements that were irrelevant, redundant, and associated with non-listed firms	877
After filtering announcements that coincided with confounding news	581
After filtering announcements associated with thinly traded stocks or stocks with insufficient historical data	526

Table 2. Overall Short-Term Market Impact of Announcements Related to ITC

Event Window	Reaction of Stock Price											
	[-1]		[0]		[1]		[-1, 0]		[0, 1]		[-1, 1]	
Models	CAPM	FFM	CAPM	FFM	CAPM	FFM	CAPM	FFM	CAPM	FFM	CAPM	FFM
Sample size	526	425	526	425	526	425	526	425	526	425	526	425
Mean CAR	0.12%	0.00%	0.31%	0.28%	0.27%	0.30%	0.43%	0.28%	0.58%	0.58%	0.70%	0.58%
Z-test p-value	0.50	0.29	0.00	0.01	0.02	0.01	0.01	0.09	0.00	0.00	0.00	0.01
Median CAR	-0.10%	-0.07%	0.11%	0.11%	-0.01%	0.06%	0.08%	0.16%	0.26%	0.25%	0.20%	0.19%
Sign test p-value	0.12	0.25	0.00	0.01	0.00	0.10	0.01	0.01	0.00	0.01	0.01	0.02
Corrado's rank test p-value	0.46	0.32	0.00	0.00	0.01	0.01	0.01	0.04	0.00	0.00	0.00	0.00

Notes: CAPM: Capital Asset Pricing Model, FFM: Fama-French 3-Factor Model.

We discarded 101 announcements because *IHML* values were not available. Next, the CAR of stock prices was computed along with the parametric *Z* test, the sign *Z* test, and the Corrado's rank test.[34] We evaluated the short-term impact in terms of the CAR one day before, on, and one day after the announcement. To account for potential self-selection bias, we also implemented the Heckman model.[35] Finally, the overall financial impact was computed by multiplying the cumulative abnormal return with the product of the average stock price and the average number of outstanding shares (McWilliams and Siegel 1997).

Analysis of Long-Term Impact

To estimate the long-term market reaction due to adoption of ITC, we used the CPA.[36] In this method, we first constructed a portfolio made up of firms making the announcements, and measured the long-term return of that portfolio against a market index. The main advantage of the CPA was that it did not depend on the cross-sectional variance (Lyon et al. 1999), and the monthly returns were serially uncorrelated (Kothari and Warner 2007). Therefore, the statistical inference could be more accurate than the event study. To account for the non-U.S. data, we extended the original CPA for international data analysis. We also conducted the CPA for 18 and 24 months as part of sensitivity analysis, followed by a subsampling analysis.

Research Findings

Table 2 shows that positive mean CARs were obtained in all event windows. The insignificant CARs in the event window [-1] might imply that there was not much news leakage and the investors did not react strongly prior to the announce-

[34]The steps for the computation of the CAR of stock prices are shown in Appendix E. The details related to the nonparametric tests used in this research are provided in Appendix F.

[35]See Appendix G for details.

[36]The details of the CPA are shown in Appendix H.

ments. For both the CAPM and the FFM, the ARs and CARs in the event windows of [0], [1], [0,1], and [-1, 1] were positive and significant for both parametric and nonparametric tests. Hence, H1 is strongly supported. Table 3 shows the long-term ARs of the CPA as a result of ITC adoption over 12, 18, and 24 months. Positive ARs were attained over all time periods for the CAPM. The magnitude of the ARs increased over time. Although ARs were insignificant in the FFM over 12 months and 18 months, they were positive and significant in the CAPM and the FFM over 24 months. Therefore, H2 is partially supported.

Subsampling Analysis

Panel A of Table 4 indicates that the CARs of the US subsample are positive and statistically significant for all statistical tests, giving strong support to H3a. In Panel B of Table 4, our results demonstrated a first mover advantage when using the CAPM. For announcements made before 2009, the CARs were statistically significant and larger in magnitude in comparison to those for announcements made in and after 2009. However, in the FFM, the mean CAR of the pre-2009 subsample was slightly less than that of the Recent subsample. Therefore, H4a is partially supported. Panel C of Table 4 shows that the adoption of the government-advocated 2FA exhibited higher and significant CARs in the CAPM and the FFM than the adoption of non-2FA ITC. So H5a is supported. A similar result was observed in the cross-sectional regression.[37]

Panel A of Table 5 shows that U.S. firms exhibited significantly positive ARs in both the CAPM and the FFM, giving support to H3b. Panel B shows that the ARs for early adopters were not significant in most cases and always smaller in magnitude than that of late adopters. Thus, H4b is rejected. Panel C shows that the 2FA subsample exhibited positive and significant ARs in 24 months in both the CAPM and the FFM, but inconsistent results were obtained for the time period of 12 and 18 months. So, H5b is partially supported. The results were mostly consistent with the findings of the short-term analysis. We used *Tobin's Q* as an alternative measure of long-term return in a cross-sectional regression[38] and found that the U.S. factor was positive and significant. Furthermore, we found that after adopting ITC, firms experienced reduction in firm-specific risks in a time period of 24 months.[39]

Interaction Analysis

Panel A of Table 6 confirms the significant effects of US×Old on short-term market value in all tests and provides support to H6a. In Panel B, 2FA×US shows positive and significant CARs in the CAPM and the FFM, providing support to H6c. 2FA×Old was positive and significant in all tests, as shown in Panel C. However, the mean CAR of the interaction factor was higher than that of the counter subsample in the CAPM but not in the FFM. Therefore, H6e is partially supported.

The impact of US×Old on long-term market value was significant and positive in all windows in Panel A of Table 7. H6b is supported. 2FA×US gave rise to higher ARs than the non-2FA×US subsample in all three time periods in Panel B. They were positive and significant for 12 months but insignificant for 18 and 24 months. H6d is partially supported. The ARs for 2FA×Old were not significant in most cases in Panel C. Therefore, H6f is not supported. The overall results for all hypotheses are shown in Table 8.

Discussion

We demonstrated that the adoption of ITC positively impacted both short- and long-term firm value. Adoption of ITC gave rise to an increase in market capitalization of at least U.S. $583 million[40] in the event window [0, 1]. While the short-term market return in the event window of [0, 1] was 0.58% (mean CAR of the CAPM and the FFM), the range of long-term market return was much wider from 0.44% (AR using the FFM) to 1.50% (AR using the CAPM) at 24 months after the event. The higher long-term market return might be due to the familiarity with ITC and better evaluation of the cues related to adoption of ITC as well as development of long-term trust by adopters of ITC. When investors realized the benefits of ITC, they developed higher trust on the service providers and were more likely to continue their investment. This translated to higher long-term market value as reflected in the CPA.

The results related to short-term impact of ITC adoption were similar to the studies on IT investment by Dos Santos et al. (1993) and Im et al. (2001). Both types of IT investment were found to be positive in the event study. However, different from the findings of Im et al. (2001), earlier adopters had more positive and significant CARs than late adopters. In terms of magnitude of short-term impact, the adoption of ITC resulted in smaller CAR than that due to IT investment, as

[37]See Appendix I for details.

[38]See Appendix J for details.

[39]See Appendix K for details.

[40]See Appendix L for details of calculation of financial impact as a result of ITC adoption.

Table 3. Overall Long-Term Market Impact of Announcements Related to ITC

	Reaction of Stock Price					
Months	**12**		**18**		**24**	
Model	**CAPM**	**FFM**	**CAPM**	**FFM**	**CAPM**	**FFM**
Size	1,914	1244	2,441	1,559	2,850	1,799
AR	0.25%	0.33%	0.42%	0.23%	1.50%	0.44%
p-value	0.15	0.14	0.00	0.14	0.00	0.00

Notes: CAPM: Capital Asset Pricing Model, FFM: Fama-French 3-Factor Model.

Table 4. Moderating Effect of Factors in the Short-Term

Panel A: Moderating Effect of Country of Listing				
Model	**CAPM**		**FFM**	
Characteristic	US	OC	US	OC
Sample size	271	255	271	154
Mean CAR	0.79%	0.35%	0.69%	0.41%
Z-test p-value	0.00	0.01	0.00	0.04
Median CAR	0.35%	0.12%	0.25%	0.24%
Sign test p-value	0.00	0.07	0.01	0.14
Rank test p-value	0.00	0.03	0.00	0.09
Panel B: Moderating Effect of Time of ITC Adoption				
Model	**CAPM**		**FFM**	
Characteristic	O	R	O	R
Sample size	171	355	141	284
Mean CAR	0.70%	0.52%	0.55%	0.60%
Z-test p-value	0.00	0.01	0.00	0.02
Median CAR	0.44%	0.13%	0.46%	0.19%
Sign test p-value	0.00	0.02	0.01	0.07
Rank test p-value	0.00	0.01	0.00	0.01
Panel C: Moderating Effect of Type of ITC				
Model	**CAPM**		**FFM**	
Characteristic	2FA	N2FA	2FA	N2FA
Sample size	353	173	266	159
Mean CAR	0.66%	0.42%	0.64%	0.50%
Z-test p-value	0.00	0.07	0.00	0.06
Median CAR	0.32%	0.09%	0.31%	0.05%
Sign test p-value	0.00	0.08	0.00	0.27
Rank test p-value	0.00	0.16	0.00	0.09

Notes: US: Firms listed in the US; OC: Firms listed in countries other than US; O: Firms making announcements in "old" period (i.e., pre-2009), R: Firms making announcements in recent period (2009-16); 2FA: Firms that adopted two-factor authentication; N2FA: Firms that adopted ITC other than 2FA.

Table 5. Moderating Effect of Factors in the Long-Term

Panel A: Moderating Effect of Country of Listing												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	US	OC	US	OC	US	OC	US	OC	US	OC	US	OC
Size	234	1,681	234	1,010	251	2,194	251	1,308	254	2,602	254	1,545
AR (%)	1.08%	0.24%	1.08%	0.26%	0.88%	0.36%	0.89%	0.88%	0.83%	0.31%	0.83%	1.33%
p-value	0.05	0.24	0.05	0.34	0.07	0.02	0.07	0.00	0.08	0.03	0.89	0.00
Panel B: Moderating Effect of Time Period of Adoption												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	O	R	O	R	O	R	O	R	O	R	O	R
Size	967	991	694	585	1,300	1,210	917	701	1,576	1,395	1,091	793
AR (%)	0.33%	1.34%	0.44%	0.85%	0.43%	5.76%	025%	0.39%	0.44%	1.12%	0.31%	-1.35%
p-value	0.30	0.00	0.24	0.001	0.08	0.00	0.39	0.00	0.03	0.00	0.21	0.00
Panel C: Moderating Effect of Type of ITC												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	2FA	N2FA	2FA	N2FA	2FA	N2FA	2FA	N2FA	2FA	N2FA	2FA	N2FA
Size	1,528	815	992	550	1,967	1.096	1,258	723	2,310	1,352	1,463	877
AR (%)	0.25%	0.49%	0.10%	0.80%	0.82%	0.28%	0.10%	0.66%	1.40%	0.28%	0.35%	0.60%
p-value	0.14	0.15	0.65	0.05	0.00	0.27	0.55	0.04	0.00	0.19	0.01	0.03

Table 6. Interaction Effect in the Short-Term

Panel A: Interaction Effect of US×Old				
Model	**CAPM**		**FFM**	
Characteristic	UO	NUO	UO	NUO
Sample size	78	448	78	347
Mean CAR	0.94%	0.51%	0.64%	0.57%
Z-test p-value	0.00	0.00	0.02	0.01
Median CAR	0.69%	0.14%	0.66%	0.21%
Sign test p-value	0.00	0.00	0.02	0.03
Rank test p-value	0.00	0.00	0.00	0.00
Panel B: Interaction Effect of 2FA×US				
Model	**CAPM**		**FFM**	
Characteristic	2U	N2U	2U	N2U
Sample size	183	343	183	242
Mean CAR	0.78%	0.47%	0.72%	0.48%
Z-test p-value	0.00	0.00	0.00	0.03
Median CAR	0.47%	0.12%	0.38%	0.11%
Sign test p-value	0.00	0.03	0.00	0.18
Rank test p-value	0.00	0.01	0.00	0.04
Panel C: Interaction Effect of 2FA×Old				
Model	**CAPM**		**FFM**	
Characteristic	2O	N2O	2O	N2O
Sample size	127	399	105	320
Mean CAR	0.61%	0.57%	0.49%	0.61%
Z-test p-value	0.00	0.00	0.01	0.01
Median CAR	0.35%	0.19%	0.38%	0.24%
Sign test p-value	0.00	0.01	0.06	0.02
Rank test p-value	0.00	0.00	0.00	0.00

Notes: UO: US listed firms with announcements released pre-2009; NUO: Firms other than UO; 2U: US listed firms that adopted 2FA; N2U: Firms other than 2U; 2O: Firms that adopted 2FA with announcements released before 2009; N2O: Firms other than 2O.

Table 7. Interaction Effect in the Long-Term

Panel A: Interaction Effect of US×Old												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	UO	NUO	UO	NUO	UO	NUO	UO	NUO	UO	NUO	UO	NUO
Size	155	1,770	155	1,100	178	2,280	178	1,398	187	2,686	187	1,635
AR (%)	1.69%	1.55%	1.77%	-1.01%	1.45%	1.01%	1.44%	-0.38%	1.45%	-2.22%	1.46%	-1.00%
p-value	0.03	0.00	0.03	0.00	0.04	0.00	0.05	0.00	0.03	0.00	0.04	0.00
Panel B: Interaction Effect of 2FA×US												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	2U	N2U	2U	N2U	2U	N2U	2U	N2U	2U	N2U	2U	N2U
Size	222	1,808	222	1,138	235	2,331	235	1,449	238	2,749	238	1,698
AR (%)	1.10%	0.19%	1.11%	0.20%	0.70%	0.25%	0.70%	0.33%	0.67%	-0.11%	0.68%	-0.15%
p-value	0.06	0.30	0.06	0.42	0.18	0.00	0.19	0.02	0.18	0.13	0.18	0.03
Panel C: Interaction Effect of 2FA×Old												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	2O	N2O	2O	N2O	2O	N2O	2O	N2O	2O	N2O	2O	N2O
Size	810	1,261	591	768	1,088	1,602	780	962	1,316	1,886	924	1,132
AR (%)	0.13%	0.14%	0.13%	0.19%	1.80%	0.12%	0.15%	0.28%	0.49%	0.20%	0.16%	0.31%
p-value	0.67	0.49	0.70	0.46	0.00	0.48	0.58	0.05	0.01	0.22	0.50	0.05

Table 8. Summary of Findings

	Hypothesis	**Result**
H1:	Adoption of ITC increases short-term market return of adopting firms.	Supported
H2:	Adoption of ITC generates a higher long-term market return for the adopting firms.	Partially supported
H3a:	Firms listed in the United States exhibit higher short-term market return when they adopt ITC compared to firms listed in other countries.	Supported
H3b:	Firms listed in the United States exhibit higher long-term market return when they adopt ITC compared to firms listed in other countries.	Supported
H4a:	Early ITC adopters (pre-2009) show higher short-term market return than late adopters.	Partially supported
H4b:	Early ITC adopters (pre-2009) show higher long-term market return than late adopters.	Not supported
H5a:	Adoption of government-advocated sophisticated ITC generates a higher short-term market return for the adopting firm than adoption of any other ITC.	Supported
H5b:	Adoption of government-advocated sophisticated ITC gives rise to a higher long-term market return for the adopting firms than adoption of any other ITC.	Partially supported
H6a:	Firms listed in the United States that adopt ITC early (pre-2009) have higher short-term market return than other companies.	Supported
H6b:	Firms listed in the United States that adopt ITC early (pre-2009) have higher long-term market return than other companies.	Supported
H6c:	Government-advocated sophisticated ITC adopters listed in the United States have higher short-term market return than other firms.	Supported
H6d:	Government-advocated sophisticated ITC adopters listed in the United States have higher long-term market return than other firms.	Partially supported
H6e:	Early (pre-2009) government-advocated sophisticated ITC adopters have higher short-term market return than other firms.	Partially supported
H6f:	Early (pre-2009) government-advocated sophisticated ITC adopters have higher long-term market return than other firms.	Not supported

shown in prior literature.[41] This was not surprising since ITC was a special class of IT. Although ITC were essential to ensure the safety of electronic transactions from security breaches, the adoption of such a technology alone could not directly generate revenues like IT investments. Understandably, the investors showed a subdued reaction to such announcements.

We were unable to compare the long-term return with extant literature due to the paucity of research on IT investment using the CPA. However, the positive return in the study might suggest that ITC investment had complimentary effects on business performance. Furthermore, the CPA showed that ITC adopters took at least 24 months to realize the significant and positive abnormal return generated by ITC. The long realization time might be due to varying degrees of information security awareness in different countries. Generation of information security awareness was a time-consuming activity. In our analysis of annual reports of all sample firms,[42] we found that there were many U.S. listed firms with security related statements but not so many such firms in other countries. Identity theft awareness might be an important factor to determine the long-term effect of ITC adoption. Furthermore, ITC adoption might be a cue of management's professionalism and far-sightedness. The positive long-term effect might be a reaction to sound managerial practices.

Our subsampling analysis revealed some interesting results. U.S. country factor had a significant short- and long-term impact. The United States was ahead of other countries in terms of penetration of e-commerce and the familiarity of its citizens about ITC. The lack of technological infrastructure, financial resources, and technological readiness impeded the diffusion of electronic services in developing countries (Javalgi et al. 2004). This in turn could lead to their lack of awareness about adoption of ITC. Customers and investors in the United States showed a higher confidence value for evaluation of cues due to their familiarity with security technologies and security breaches and exhibited a more positive and significant reaction to adoption of ITC. An implication of our research was that the market recognized the importance of ITC only when it reached a certain level of technological maturity.[43]

Announcements made in earlier time periods gave rise to a strong impact in the short-term but only moderate impact in the long-term. When ITC was first introduced, early adopters had first mover advantages because investors had high expectations about the tools. Such an adoption sent a strong cue to investors that the early adopters were innovative and customer-centric. Thus, they were rewarded highly by the market. However, when people became more familiar with the tools over time, the surprise related to adoption of the tools declined. Therefore, in terms of short-term market reaction, earlier adopters experienced more positive and significant market return. However, the long-term market return was not significant in most statistical tests. With the passage of time, more firms adopted ITC due to mandatory government policies and enactment of identity theft laws. As a result, the competitive edge of ITC adoption deteriorated over time due to ubiquitous adoption. Early adopters of ITC, therefore, did not sustain their advantage in the long run.

2FA was one of the high quality ITCs strongly recommended by regulatory bodies around the globe. Some countries (e.g., European Union, India, the Republic of Korea, Hong Kong, and Singapore) even mandated the adoption of 2FA for high-risk online transactions. In the short-term event study, the results also showed that the CARs immediately after the announcement of 2FA adoption were positive and significant. Government advocacy may influence the cue of ITC to investors. Compliance with government policies may lead to fewer lawsuits and penalties for firms. The adoption of government advocated ITC may imply lower expenses for firms in the future due to reduced identity theft related lawsuits and penalties. Therefore, the market rewarded such an adoption positively and immediately. Such a positive effect was more salient when 2FA was adopted by U.S. firms, before 2009, and first introduced to the market. This might be associated with the heightened concern about information security in the United States. However, when people became more familiar with the technologies, the surprise of investors declined over time. Furthermore, with more usage, people became more aware of the weaknesses of 2FA over time. Thus, we found that abnormal reaction of early adopters of 2FA were not significant in the CPA.

We contributed to the cue utilization theory by identifying various antecedent factors that may influence the confidence value of a cue in the context of information security. Although ITC adoption sent a cue of online safety to investors, the market reaction varied. We showed that lead-time advantage and familiarity with ITC played significant roles in influencing investors' confidence value of the cue. The cue of ITC adoption was the strongest when such an adoption was early and occurred in the United States where investors had

[41]Investment in innovative IT generated a CAR of 1.03% (Dos Santos et al. 1993) whereas our research shows that adoption of ITC generated mean CARs of 0.58% (using the CAPM and the FFM) in the event window of [0, 1].

[42]See Appendix N for details.

[43]Our additional analysis (see Appendix M) showed that firms in countries with higher information and communications development exhibited more positive and significant short- and long-term impact.

adequate prior knowledge and exhibited familiarity with related technology or associated risks. The strong cue led to positive and significant short-term and long-term market returns.

Extant research on information security focused on the value of internal compliance for internal stakeholders such as employees (D'Arcy et al. 2009). Our study might complement the literature in this area by providing new insights from the perspective of an external stakeholder. Our study showed that prior experience about identity theft and ITC was important in ascertaining both short- and long-term market value of ITC adoption.[44]

Our study made new methodological contributions to IS research on IT business value. Traditional IS researchers primarily focused on the immediate market response to IT investment and lacked attention to long-term business value. Traditional methods such as the event study only revealed the short-term market value of certain IT investment over a few days. However, IT investment such as investment in ITC required a longer time for customers and investors to familiarize themselves with the technology. As a result, the short-term analysis might not fully reflect the actual benefits of the investment. Our use of the CPA might remediate the shortcomings of the event study method and introduce a new way to analyze the long-term business value of IT investment.

Furthermore, this research highlighted that some hypothesized variables alone might not be able to explain the positive return associated with ITC adoption. It was only when one variable was combined with another variable that the impact was found to be positively significant. For instance, Old was insignificant as a standalone factor in the CPA. However, US×Old was significant in the CPA. Interaction effects have not been frequently tested in prior event studies (Oh et al. 2006). Our research emphasized the need to study interaction effects.

[44]In our main analysis, the U.S. listed firms enjoyed higher market returns in both the short- and long-term than their international peers. Such higher market returns might be related to more security experience of investors. As shown in Table N1 in Appendix N, about 84.9% of U.S.-listed firms provided security related information in their annual reports one year before ITC adoption whereas only 60.7% of non-U.S. firms did so. U.S. investors might have gained some knowledge about ITC or the security threat of identity theft before the announcement of ITC adoption. Therefore, they appreciated ITC adoption more than their counterparts in other countries.

Limitations and Future Research Directions

Since we analyzed the impact on firm value using the event study and the CPA, only listed companies were investigated. Non-listed companies were not analyzed. Also, due to the limited availability of *IHML* data, only companies listed in 20 non-U.S. countries could be analyzed. In future, we plan to adopt multidimensional analyses and use data items such as sales, number of customers, and customer satisfaction to measure firm performance after ITC adoption. In this study, we analyzed the behavior of investors on receiving the news about investments in ITC. The rationale leading to such behavior was unknown. Detailed semi-structured interviews might be conducted in future to discover the rationale used by managers for adopting ITC. As shown in this study, U.S. and non-U.S. investors demonstrated remarkable differences in their reaction to the announcements. This implied that it might be worthwhile to study if culture had a role to play. Finally, the findings of this research were restricted to ITC. We could extend the study to other security measures, such as anti-brand spoofing and network intrusion detection in future.

Conclusion

In this research, we analyzed the short- and long-term impact of adoption of ITC on the market value of the firm. Adopting the event study, we analyzed the short-term impact (one day before, on, and one day after the date of announcement) using the CAPM and the FFM. Using the CPA, we investigated the long-term change in stock prices 12, 18, and 24 months after the announcement took place. We observed that firms listed in the United States yielded significant and positive return in the short- and long-term when they adopted ITC, whereas firms that were early adopters of ITC showed a significantly positive reaction in the short-term. The interaction analysis showed that government-advocated ITC played an important moderating role when it was adopted by U.S.-listed firms. Our research provided strong encouragement to firms to adopt ITC, as it led to a change in average market capitalization of at least U.S. $583 million per announcement.

With regard to academic contributions, our study introduced the CPA to analyze the long-term impact of IT investments. This is complementary to the event study, which measured the instant market reaction. Long-term analysis might give investors more time to assess the post-investment performance of adopters. We encourage future researchers to make use of the CPA in analyzing return on investment for other types of IT. Furthermore, this study demonstrated that the interaction effects of moderating factors should be considered so as to capture the latent multiplicative effects.

From a practical point of view, our research highlighted the importance of being an early mover in the adoption of ITC. The market generated immediate rewards for early movers. Similar to early movers, U.S.-listed companies also yielded positive and significant short-term market return when they adopted ITC. As U.S. customers and investors were more aware of the benefits of ITC, the positive return lasted for a longer time period. Furthermore, our research stressed the need to adopt sophisticated ITC. Newer and more secure technologies could safeguard customers against identity theft. In the short term, the market strongly rewarded U.S. firms that were adopters of sophisticated ITC. However, over time, the weakness of existing ITC might become more well known. So, relying on one type of ITC might not generate sustainable long-term market value. It is advised that firms should regularly update their ITC to keep abreast of the latest technologies.

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RESEARCH NOTE

ADOPTION OF IDENTITY THEFT COUNTERMEASURES AND ITS SHORT- AND LONG-TERM IMPACT ON FIRM VALUE

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Appendix A

Previous Research on Ascertaining Value of IT Investment Using Event Studies

Previous studies on IT investment using event studies investigated different aspects of IT. For example, Dos Santos et al. (1993) studied IT innovativeness and Chatterjee et al. (2002) focused on different functionality aspects of IT (e.g., infrastructure and application). Apart from general IT investment, there were also a few studies specific to IT applications (e.g., ERP, e-business, and security). Nevertheless, the steps of the event study adopted in previous studies were similar. All previous studies first analyzed abnormal return based on subsamples followed by subsampling analysis. Most studies adopted a three-day event window around IT investment announcements. Both parametric and non-parametric tests (e.g., sign test and Corrado's rank test) were used to determine the level of significance of abnormal return in the estimation period. Furthermore, most of the sample data were from the United States. Meng and Lee (2007) was the only study that compared the reaction of IT investment in the United States with that in China. A summary of previous research on IT investment using event studies is shown in Table A1.

Table A1. Summary of Previous Research on IT Investment Using Event Studies

Area of Study	Time Period	Number of Announcements	Source of Data	Stock Markets	Tests Used	Abnormal Return in Estimation Period
Impact of information security investment on market value (Chai et al. 2011)	1997–2006	101 (69 announcements related to commercial exploitation and 32 related to information security improvement; 45 before Sarbanes-Oxley Act (SOX) and 56 after SOX)	LexisNexis Academic Universe	US stock exchanges	Parametric test on abnormal stock return and sign test	CAR: 1.36%** (full sample) Commercial exploitation: 1.84%** Information security improvement: 0.27% Before SOX: 0.88% After SOX: 1.96%** t= [-1, 1]
Impact of IT infra-structure investment on market value (Chatterjee et al. 2002)	1992–1995	112 (82 infrastructure and 30 application-based)	LexisNexis Academic Universe's major news-papers and wire services	NYSE, AMEX, and NASDAQ	Parametric test on abnormal stock return and Corrado's rank test	CAR: 0.60%* (full sample) 0.70%* (infrastructure investment) 0.33% (application-based investment) (for time period t= [0] only) t = [-2,2]
Impact of transfor-mational IT investment on market value (Dehning et al. 2003)	1981–1996	353 (IT investment strategic role: automate: 172, informate: 95, transform: 48; industry IT strategic role: automate: 210, informate: 95, transform: 48)	LexisNexis Wire Index (News/Wires Library)	NYSE, AMEX, and NASDAQ	Parametric test on abnormal stock return	IT investment strategic role: Automate: 0.051%, informate: 0.403%, transform: 1.512%** Industry IT strategic role: Automate: 0.003%, informate: 0.557%, transform: 1.405%** t = [-1,1]
Impact of e-commerce announcements on market value (Dehning et al. 2004)	1998–2000	542	PR Newswire and Business Wire from LexisNexis	NYSE, AMEX, and NASDAQ	Parametric test on abnormal stock return	CAR: 4.6% (for the event window [-1,1]) t = [-1,1]
Impact of IT invest-ment on firm value (Dos Santos et al. 1993)	1981–1988	97 (full sample) (25 for innovative, 42 for not innovative, 30 for unclassified)	PR Newswire and PTS Prompt	NYSE, AMEX, and NASDAQ	Parametric test on abnormal stock return	CAR: 0.09% (full sample) 1.03%* (innovative IT investment) t = [0,1]
Impact of IT invest-ment on firm value (Im et al. 2001)	1981–1996	238 (137 old sample and 101 new sample)	Dataset of Dos Santos et al. (1993), PR Newswire and PTS Prompt, and Business and Industry	NYSE, AMEX, and NASDAQ	Parametric test on abnormal stock return	CSAR: 2.0% (full sample) 16.1%* (new sample) t = [0,1]
Analysis of IT invest-ments between US and China (Meng and Lee 2007)	1999–2002	63 for US and 65 for China	Business Wire, PR Newswire, Dow Jones Business News and Dow Jones International News from Factiva	NYSE, AMEX, NASDAQ, and Chinese stock market	Parametric test on abnormal stock return	CAR for US: 0.37% CAR for China: 107.8%** t = [0,2]
Impact of ERP announcements on market value (Ranganathan and Brown 2006)	1997–2001	116	LexisNexis Academic Universe database	US stock exchanges	Parametric test on abnormal stock return and nonpara-metric sign test	CAR: 1.49%*** t = [-2,2]
Impact of e-commerce announcements on market value (Subramani and Walden 2001)	Q4 1998	251 (Conventional firm: 115, Net firm:136)	PR Newswire and Business Wire from LexisNexis	US stock exchanges	Parametric test on abnormal stock return	CAR: Full sample: 7.5%*** B2B: 4.9%* B2C:9.6%*** (for the event window [-5,5]) t = [-5,5], [-10,10]

*Significant at 5% level of significance
**Significant at 1% level of significance
***Significant at 0.1% level of significance

Appendix B

Examples of Announcements Related to Adoption of ITC

Example 1

Title: IBM & Equifax Team On Internet Security Vault
Date: 8-Jun-98
Publication: Newsbytes News Network

In a teleconference today, IBM [NYSE:IBM] and Equifax announced that Equifax will use the IBM Vault Registry in a newly unveiled security service to bring digital certificate authentication and encryption to e-commerce applications like online banking.

Example 2

Title: E*TRADE FINANCIAL Delivers First Two-Factor Authentication Security Solution to Retail Customers The E*TRADE Complete™ Security System with Digital Security ID Available to U.S. Customers
Date: March 1, 2005
Publication: PR Newswire (U.S.)

E*TRADE FINANCIAL Corporation today announced the availability of a ground-breaking two-factor security solution that protects a customer's identity and account information from access by an unauthorized person. Available in Q2 2005, the token-based security solution provides US-based retail customers an added layer of security at their point of access to the Internet to safeguard their personal financial information. E*TRADE FINANCIAL customers can opt-in to the security token program at their own discretion.

Example 3

Title: St George locks down net banking
Date: 4-Oct-05
Publication: The Australian

ST GEORGE Bank is to upgrade its internet banking network early next year, joining a select list of local financial institutions offering two-factor authentication for consumer internet banking.

Example 4

Title: Mizuho Strengthens Security and Reduces Costs with SafeNet's Strong Authentication
Date: 26-Jun-14
Publication: PR Newswire Europe

One of the largest Japanese financial services companies, Mizuho has implemented SafeNet's strong authentication solution, allowing for the creation of one-time password.

Appendix c

Steps to Conduct an Event Study

The event study has been widely used in the fields of accounting, finance, and IS to evaluate the short-term market reaction as a result of the occurrence of an event. It involves six steps: collection of announcements, filtering of announcements, retrieval of stock data and further filtering, construction of abnormal return model, calculation of abnormal return, and analysis of subsamples (Bose and Leung 2013).

In the first step, we collected relevant identity theft countermeasures announcements from an international news database, Factiva. To retrieve relevant announcements, we used keywords such as anti-identity theft, anti-phishing, phishing countermeasures, personal certificate, one-time password, and dynamic password generator. Initially, 17,569 announcements were retrieved.

In the second step, we filtered repeated announcements and announcements related to non-listed companies. In addition, we removed announcements that might be affected by confounding news. We adopted a confounding window of five days (two days before and after the date of announcement), and the list of confounding events included announcements of earnings, declaration of dividends, and change of senior management.

In the third step, we eliminated announcements related to thinly traded stocks. Previous studies have shown that such stocks were more volatile and might over-react to events being studied and those thinly traded stocks were defined as stocks with an average stock price less than U.S. $1 or average daily trading volume less than 50,000 shares in the estimation period (Subramani and Walden 2001). After the extensive filtering process, 526 announcements from 1995 to 2016 were retained for subsequent analysis.

In the fourth step, we constructed a model to compute abnormal return. We considered two models, namely, the CAPM (equation C1) and the FFM (equation C2).

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{C1}$$

where R_{it} was the rate of return for announcement i on day t, R_{mt} was the rate of return of market index m on day t, α_i was the y-intercept, β_i was the slope that measured the sensitivity of R_{mt}, and ε_{it} was the error term.

The CAPM is a commonly used market model in the event study (Brown and Warner 1985). However, it has been criticized in prior research for its inability to capture all market risks that led to miscalculation of abnormal market return (Fama and French 1992). To overcome the inadequacy of the CAPM, we used the Fama-French three-factor model (FFM) for US data and the Fama-French two-factor international model for non-U.S. data as shown in equation (C2).

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mit} - R_{ft} \right) + D_i \left(\gamma_i SMB_t + \delta_i HML_t \right) + \left(1 - D_i \right) \zeta_i IHML_{it} + \varepsilon_{it} \tag{C2}$$

where R_{it} was the rate of return for announcement i on day t, R_{mit} was the rate of return of market index m in which firm i belonged to on day t, D_i was a dummy variable that took a value 1 when the announcement i was listed in a US stock exchange and 0 otherwise, R_{ft} was the risk-free rate of the return of U.S. treasury bills on day t, SMB_t was the size correction factor for day t, HML_t was the book-to-market correction factor for day t, $IHML_{i,t}$ was the international book-to-market correction factor, α_i was the y-intercept, β_i was the slope that measured the sensitivity of $R_{mit} - R_{ft}$, and γ_i was the slope that measured the sensitivity of SMB_t, δ_i was the slope that measured the sensitivity of HML_t, ζ_i was the slope that measured the sensitivity of $IHML_{i,t}$, and ε_{it} was the error term.

We used the stock price data for 200 trading days that ended one month prior to the event date, so as to obtain the coefficient estimates in equations (C1) and (C2) (Sabherwal and Sabherwal 2005). Prior research only used one market index (e.g., S&P 500). As our sample data involved global firms, we considered multiple market indices for a particular stock, and selected the market index that resulted in the best R^2. The list of 35 market composite indexes used in this research is shown in Table D2 in Appendix D. As R^2 indicated the usefulness of a market model, we enhanced the reliability of the research by choosing a model with the highest explained variance (MacKinlay 1997).

In the fifth step, we computed abnormal return (AR_i) using equation (C3) for the CAPM and equation (C4) for the FFM as shown below:

$$AR_{it} = R_{it} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{mt} \right) \tag{C3}$$

$$AR_{it} = R_{it} - R_{ft} - \left[\hat{\alpha}_i + \hat{\beta}_i \left(R_{mit} - R_{ft} \right) + D_i \left(\hat{\gamma}_i SMB_t + \hat{\delta}_i HML_t \right) + \left(1 - D_i \right) \hat{\zeta}_i IHML_{it} \right] \quad \text{(C4)}$$

where parameters with a caret were coefficient estimates obtained in earlier regressions.

Next, we computed cumulative abnormal return over an event window. An example using the CAPM is illustrated in Appendix E. We further conducted a parametric test and two nonparametric tests, namely, sign test and Corrado's rank test. The details of the two nonparametric tests are shown in Appendix F.

In the final step, we performed subsample analysis and split the full sample into different subsamples. We compared the CAR between U.S. and non-U.S. subsamples, between early (pre-2009) and late adopters of ITC, and between 2FA and non-2FA subsamples. Parametric and nonparametric tests were performed to determine the statistical significance.

Appendix D

Country-Wise Description of Sample Data

Table D1 shows the country-wise description of sample data. The market indices used in the analysis are shown in Table D2.

Table D1. Countrywise Description of Sample Data

Continents	Countries	Market indices*	Year (YO/YR)	ITC Type (A/O)	Sample Size
Africa	Nigeria	NGSE30, NGSEINDEX, NGSEBNK10	YO:0 YR:3	A:3 O:0	3
	South Africa	JASIN, JFINA	YO:2 YR:2	A:3 O:1	4
Asia	China	SSEC, SZSC, CSIFN	YO:0 YR:4	A:3 O:1	4
	Hong Kong	HSI, HSNF	YO:4 YR:2	A:3 O:3	6
	India	BSESN, BSE100	YO:4 YR:29	A:21 O:12	33
	Israel	TA100	YO:1 YR:0	A:0 O:1	1
	Japan	N225, TOPX, TOPX100, TOPX500, KQ11	YO:12 YR:34	A:25 O:21	46
	Kuwait	GCCI, KWSE	YO:1 YR:0	A:1 O:0	1
	Malaysia	KLSE, JKSE, JKFINA,	YO:2 YR:1	A:2 O:1	3
	Oman	MSI, MBNK	YO:0 YR:2	A:2 O:0	2
	Qatar	QSI	YO:0 YR:3	A:3 O:0	3
	Saudi Arabia	TASI, TBFSI	YO:0 YR:2	A:1 O:1	2
	Singapore	STI	YO:7 YR:9	A:14 O:2	16
	Republic of Korea	KS200, KS205, KS11	YO:8 YR:0	A:7 O:1	8
	Taiwan	TWII, TFNI,	YO:0 YR:5	A:3 O:2	5
	Thailand	SETI, SETF	YO:1 YR:4	A:5 O:0	5
	United Arab Emirates	NBAK, NBAE, NBAB, ADI	YO:1 YR:3	A:3 O:1	4
	Vietnam	HNXI, VNI30	YO:0 YR:1	A:0 O:1	1
Australasia	Australia	AORD, AXDFK, AXBAK, AXKI	YO:8 YR:8	A:14 O:2	16

Table D1. Countrywise Description of Sample Data (Continued)

Continents	Countries	Market indices*	Year (YO/YR)	ITC Type (A/O)	Sample Size
Europe	Austria	ATX	YO:2 YR:1	A:3 O:0	3
	Belgium	BFX, BEGF, BEB	YO:1 YR:1	A:1 O:1	2
	Denmark	OMXC20, CX8300GI, CX8300PI	YO:1 YR:1	A:0 O:2	2
	Finland	OMXHPI, OMXH25	YO:1 YR:1	A:1 O:1	2
	France	FCHI, FRFIN, FRB	YO:0 YR:5	A:2 O:3	5
	Germany	GDAXI, GDAXHI, CXPVX, CXPBX	YO:2 YR:0	A:1 O:1	2
	Greece	ATG, FTATFIN, FTATBNK	YO:3 YR:0	A:1 O:2	3
	Ireland	ISEQ, IFIN	YO:2 YR:0	A:2 O:0	2
	Italy	MIBTEL, MHFS, MHBK	YO:2 YR:0	A:2 O:0	2
	Netherlands	AEX, NLB1, NLFIN	YO:5 YR:7	A:9 O:3	12
	Norway	OBXP, OBX	YO:0 YR:1	A:0 O:1	1
	Spain	IBEX	YO:0 YR:4	A:2 O:2	4
	Sweden	OMXS30	YO:2 YR:5	A:4 O:3	7
	Switzerland	SSMI, C8300T	YO:0 YR:3	A:2 O:1	3
	Turkey	XU100, XBank	YO:1 YR:6	A:3 O:4	7
	United Kingdom	FTSE, FTASX8350	YO:11 YR:9	A:14 O:6	20
North America	Canada	GSPTSE, SPTTFS	YO:4 YR:2	A:3 O:3	6
	Mexico	INMX, MXX	YO:3 YR:0	A:2 O:1	3
	United States	NYSE: GSPC Nasdaq: GSPC, NDX, IXIC	YO:78 YR:193	A:183 O:88	271
South America	Brazil	BVSP	YO:2 YR:4	A:5 O:1	6
Total			YO:171 YR:355	A:353 O:173	526

*Refer to Table D2 for details about the composite indices used in different countries.

Announcements in the above table are associated with:

YO: Pre-2009, YR: 2009-2016

A: Two-factor authentication

O: Other types of ITC

Table D2. List of Market Composite Indices		
Symbol	**Country**	**Full Form of Index**
AORD	Australia	ASX All Ordinaries Index
AXBAK	Australia	S&P/ASX 300 Banks (Industry Group)
AXDFK	Australia	S&P/ASX 300 Diversified Financials (Industry Group)
AXKI	Australia	S&P/ASX Financials-x-a-r
ATX	Austria	ATX Austrian Traded Index
BEB	Belgium	BEL Banks Financial Index
BEGF	Belgium	BEL General Financial Index
BFX	Belgium	BEL 20 Index
BVSP	Brazil	Sao Paulo SE Bovespa Index
GSPTSE	Canada	Toronto SE 300 Composite Index
SPTTFS	Canada	S&P/TSE Canadian Financials Sector Index
CSIFN	China	CSI Financials Index
SSEC	China	Shanghai SE Composite Index
SZSC	China	Shenzhen SE Composite Index
CX8300GI	Denmark	OMX Copenhagen Bank GI Index
CX8300PI	Denmark	OMX Copenhagen Bank PI Index
OMXC20	Denmark	OMX Copenhagen 20 Index
OMXH25	Finland	OMX Helsinki 25 Index
OMXHPI	Finland	OMX Helsinki All Share Index
FCHI	France	CAC 40 Index
FRB	France	CAC Banks Financial Index
FRFIN	France	CAC Financials Financial Index
CXPBX	Germany	PRIME Xetra Bank Index
CXPVX	Germany	PRIME Xetra Financial Sevices Index
GDAXHI	Germany	HDAX Index
GDAXI	Germany	DAX Index
ATG	Greece	ASE Main General Index
FTATBNK	Greece	Athens Stock Exchange FTSE Banks Index
FTATFIN	Greece	Athens Stock Exchange FTSE Financial Services Index
HSI	Hong Kong	Hang Seng Index
HSNF	Hong Kong	Hang Seng Finance Index
BSE100	India	Bombay SE 100 Index
BSESN	India	Bombay SE Sensitive Index
IFIN	Ireland	ISEQ Financial Index
ISEQ	Ireland	ISEQ Overall Index
TA100	Israel	Tel Aviv 100 Index
MHBK	Italy	Milan SE Bank Historical Index
MHFS	Italy	Milan SE Financial Services Historical Index
MIBTEL	Italy	MIBTEL General Index
KQ11	Japan	JASDAQ Index
N225	Japan	Nikkei 225 Index
TOPX	Japan	Topix Stock Price Index
TOPX100	Japan	Topix 100 Market Index
TOPX500	Japan	Topix 500 Market Index
GCCI	Kuwait	Gih Gcc Ilsmc Index
KWSE	Kuwait	Kuwait Stock Exchange Market Price Index
JKFINA	Malaysia	Jakarta SE Finance Index

Table D2. List of Market Composite Indices (Continued)		
Symbol	**Country**	**Full Form of Index**
JKSE	Malaysia	Jakarta Composite SE Index
KLFI	Malaysia	KLSE Financial Index
KLSE	Malaysia	KLSE Composite Index
INMX	Mexico	INMEX Index
MXX	Mexico	IPC Index
AEX	Netherlands	Amsterdam Exchanges Index
NLB1	Netherlands	AEX Banks Index
NLFIN	Netherlands	AEX Financial Index
NGSE30	Nigeria	NSE 30 Index
NGSEBNK10	Nigeria	NSE Banking Index
NGSEINDEX	Nigeria	Nigerian Stock Exchange All Share Index
OBX	Norway	Oslo Stock Exchange Equity Index
OBXP	Norway	OBX Price Index
MBNK	Oman	Muscat Financial Index
MSI	Oman	Muscat SE General Index
QSI	Qatar	Qatar Exchange General Index
TASI	Saudi Arabia	Tadawul FF Index
TBFSI	Saudi Arabia	Saudi Arabian Banking and Financial Services Index
STI	Singapore	Straits Times Index
JASIN	South Africa	Johannesburg Stock Exchange All Share Industrials Index
JFINA	South Africa	Financials Index
KS11	Republic of Korea	KOSDAQ Index
KS200	Republic of Korea	Korea SE Kospi 200 Index
KS205	Republic of Korea	Korea SE Kospi Finance Index
IBEX	Spain	IBEX 35 Index
OMXS30	Sweden	Stockholm Options Marknad OMX Value Index
C8300T	Switzerland	SWX SP Banks Total Return Index
SSMI	Switzerland	Swiss Market Index
TFNI	Taiwan	Taiwan SE Banking & Insurance Index
TWII	Taiwan	Taiwan SE Weighted Index
SETF	Thailand	SET Finance Index
SETI	Thailand	SET Index
XBank	Turkey	BIST Banks Index
XU100	Turkey	Istanbul SE Ulusal 100 Index
ADI	United Arab Emirates	Abu Dhabi Securities Exchange General (Main) Index
DUBNK	United Arab Emirates	Banking Index
NBAB	United Arab Emirates	National Bank of Abu Dhabi Banking Index
NBAK	United Arab Emirates	National Bank of Abu Dhabi Banking Sector Index
NBAE	United Arab Emirates	National Bank of Abu Dhabi Emirates Stock Market Index
FTSE	United Kingdom	FTSE 100 Index
FTASX8350	United Kingdom	FTSE All Share Banks Index
GSPC	United States	S&P 500
IXIC	United States	NASDAQ Composite Index
NDX	United States	NASDAQ 100 Index
HNXI	Vietnam	Hanoi Stock Exchange Index
VNI30	Vietnam	Vietnam 30 Index

Appendix E

Computation of Abnormal Return of Stock Prices

The abnormal return (AR_{it}) of stock price for firm i on day t was computed using the formula

$$AR_{it} = R_{it} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{mt}\right) \tag{E1}$$

where R_{it} was return of stock i on day t, R_{mt} was market return on day t, $\hat{\alpha}_i$ and $\hat{\beta}_i$ were coefficient estimates.

The cumulative abnormal return for firm i (CAR) was computed using the formula

$$CAR = \frac{\sum_{i=1}^{N}\sum_{t=S_1}^{S_2} AR_{it}}{N} \tag{E2}$$

where N was the total number of firms with distinct announcements, and $[S_1,S_2]$ was the event window. AR_{it} was usually transformed to the standardized abnormal return (SAR_{it}) using the formula

$$SAR_{it} = \frac{AR_{it}}{\sqrt{Var(AR_{it})}} \tag{E3}$$

where

$$Var(AR_{it}) = p_i^2\left[1 + \frac{1}{D} + \frac{(R_{mt} - R_m)^2}{\sum_{t=-T_1}^{-T_2}(R_{mt} - R_m)^2}\right] \tag{E4}$$

p_i^2 was residual return variance obtained from the regression for firm i, D was the number of trading days in the estimation window, and ranged from T_1 days to T_2 days before the date of the event announcement, and R_m was the average return of market index m over D days. The cumulative standardized abnormal return ($CSAR$), which aggregated all SARs in the sample, was computed using the formula

$$CSAR = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=S_1}^{S_2}\frac{SAR_{it}}{\sqrt{S_2 - S_1 + 1}} \tag{E5}$$

Assuming that $CSAR$ followed a normal distribution, we used a one-tailed parametric Z test to test its statistical significance. The test statistic (Z) was given by the formula

$$Z = CSAR\sqrt{N} \tag{E6}$$

Appendix F

Nonparametric Tests

Both sign test and Corrado's rank test were commonly used nonparametric tests in the event study (MacKinlay 1997). The details of both tests are shown below.

Sign Test

The test statistic of the sign test was given by the formula

$$Z_t = \frac{p_t - Nr}{\sqrt{N(1-r)r}} \tag{F1}$$

where p_t was the number of positive abnormal returns of stock price for all announcements on day t, N was the number of announcements, and r was the fraction of positive abnormal return of stock price in the estimation period. Z_t followed the standard normal distribution, and determined whether the number of positive abnormal returns on day t was different from the number of positive abnormal returns in the entire estimation period.

Corrado's Rank Test

The abnormal return in the estimation and event windows was transformed using the formula

$$K_{it} = rank\left(AR_{it}\right) \tag{F2}$$

where $K_{it} = 1$ corresponded to the smallest AR_{it}.

The test statistic (C_t) was given by the formula

$$C_t = \frac{\frac{1}{N}\sum_{i=1}^{N}(K_{it} - \overline{K})}{\sqrt{Var(\overline{K})}} \tag{F3}$$

where N was number of announcements,

$$\overline{K} = \frac{D + S_2 - S_1}{2} + 0.5$$

where D was the number of days used in the estimation window, $[S_1, S_2]$ was the event window, and

$$Var(\overline{K}) = \frac{1}{(D + S_2 - S_1)} \sum_{t=1}^{D+S_2-S_1}\left(\frac{1}{N}\sum_{i=1}^{N}(K_{it} - \overline{K}_i)\right)^2$$

The test statistic was distributed asymptotically as unit normal. In comparison to the parametric test, the Corrado's rank test was better specified and provided higher power.

Appendix G

Self-Selection and the Heckman Model

Some firms with strong capability in IT might self-select to invest in ITC. As a result, firm characteristics might influence the market return due to ITC investment. In the context of outsourcing, self-selection has been observed when firms selected the mode of service delivery (Chang and Gurbaxani 2012) and the type of outsourcing contract (Mani et al. 2013). To address the potential self-selection bias, we repeated our analysis using the Heckman model (Heckman 1979). Some prior event studies (e.g., Chen et al. 2009; Li and Prabhala 2007; Mani et al. 2013) have also used the Heckman model to address self-selection bias.

The Heckman model consisted of two stages. In the first stage, we regressed the probability of investment in ITC on various firm, industry, and country related factors (Z_{it}) using the probit model as shown in equation (G1).[1]

$$\begin{aligned} Pr\left(ITC_{it}=1\right) = \beta Z_{it} + \varepsilon_{it} = \beta_0 + \beta_1 \ln\left(Attack_{it-1}\right) + \beta_2 \ln\left(Asset_{it-1}\right) \\ + \beta_3 Top500_{it-5:t-1} + \beta_4 IT_i + \beta_5 Finance_i + \beta_6 US_i + \varepsilon_{it} \end{aligned} \tag{G1}$$

In the second stage, we regressed the CAR on inverse Mill's ratio and other factors as shown in equation (G2).[2] We computed the inverse Mill's ratio as shown in equation (G3).[3] The self-selection bias is expected to occur if the estimate of the inverse Mill's ratio is significant.

$$\begin{aligned} CAR\left(ITC_{it}=1\right) = \beta_0 + \beta_1 \lambda_{it} + \beta_2 \ln\left(Asset_{it-1}\right) + \beta_3 Top500_{it-5:t-1} \\ + \beta_4 IT_{\ i} + \beta_5 Finance_i + \beta_6 US_i + \varepsilon_{it} \end{aligned} \tag{G2}$$

$$\lambda_{it} = \phi\left(\beta Z_{it}\right) \Big/ \Phi\left(\beta Z_{it}\right) \tag{G3}$$

In the first stage of the Heckman model, we regressed the probability of ITC investment in each year for all firms in our sample with various firm-related factors as shown in equation (G1). The frequency of identity theft was defined as the number of identity theft incidents reported in the news media for a particular firm in the year previous to the year when it invested in ITC. We searched for news[4] related to identity theft from Factiva, and counted the number of non-duplicated news articles associated with the company in that year. The number of security incidents was an important factor for senior management to consider for deciding the quantum of security investment. Security investment decision models have been proposed based on the expected occurrence of security incidents (Gordon et al. 2003). Firm size, measured by total assets, was a firm factor that could influence intensity of investment in IT (Harris and Katz 1991). IT capability was used to determine the technological expertise of a company and measured by appearance of the firm on the *InformationWeek* 500 list[5] (Bharadwaj et al. 1999). A firm with strong IT capability might self-select to invest in information security so as to maintain its leadership in IT. Apart from firm capability, we also controlled for the industrial sector to which the firm belonged. Prior studies on IT investment (e.g., Chatterjee et al. 2002; Dehning et al.

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[1]The notation of equation (G1) was as follows: ITC_{it}: Binary variable that denoted whether a firm i adopted ITC in year t; $\ln(1 + Attack_{it-1})$: Natural logarithm of one plus the number of identity theft attacks on firm i in year t-1; $\ln(Asset_{it-1})$: Natural logarithm of total assets of firm i in year t-1; $Top500_{it-5:t-1}$: Natural logarithm of one plus firm i's number of appearances on *InformationWeek* Top 500 between year t-5 and year t-1; IT_i: Binary variable that denoted whether firm i was an IT firm; $Finance_i$: Binary variable that denoted whether firm i was a financial services firm; US_i: Binary variable that denoted whether firm i was listed in the U.S.; ε_{it} Disturbance term.

[2]CAR(ITC_{it}=1): Cumulative abnormal return of firm i that adopted ITC at time t.

[3]In equation (G3), ϕ was the probability density function and Φ was the cumulative distribution function of the standard normal distribution.

[4]We used keywords such as identity theft and phishing in news search on Factiva. A similar approach has been used in previous research to identify related news on cybercrime (e.g., Bose and Leung 2014).

[5]In 2013, only the top 250 of *Information Week* 500 were available. From 2014 onwards, *InformationWeek* Elite 100 was used because *InformationWeek* 500 was no longer available.

2003; Jarvenpaa and Ives 1991) have suggested that IT might have greater impact on financial services companies and they might self-select to adopt ITC. In addition, continuous IT investment was necessary for firms in the IT industry to stay in business (Dos Santos et al. 2012). Thus, IT firms might have a higher propensity to invest in new ITC as well. Apart from firm and industry factors, we also considered the country factor. In the past decades, the United States had significantly higher growth in output in information and communication technologies than other developed countries. Thus, U.S. firms were more likely to invest in ITC and should be controlled. Table G1 shows the descriptive statistics and correlation coefficients between all variables.

In the second stage of the Heckman model, we regressed individual firms' CAR on the inverse Mill's ratio and various firm-, industry-, and country-related factors. The inverse Mill's ratio was a self-selection correction parameter. For identification purpose, we removed one factor in the first stage that affected the decision to invest but did not directly influence the market return (Chen et al. 2009). Therefore, we used the same set of firm, industry, and country factors except $Attack_{it}$. Managers might use $Attack_{it}$ as a criterion for ITC investment. However, its impact on market return might not be direct because investors were likely to evaluate how ITC (rather than number of security incidents) could impact the future performance of the firm.

Table G2 shows the results of the Heckman model. The results in the first stage showed that the impact of frequency of attacks on investment in ITC was positive and significant at the 5% level of significance. This was in conformance with extant research that suggested security incidents in the past might influence the decision of senior managers about making investment in ITC. Similarly, size as measured by $\ln(Asset_{it-1})$ and industries related to IT and financial service industries were positive and significant. However, US_{it} and $Top500_{it-5:t-1}$ were found to be insignificant.

In the second stage, we regressed the CAR obtained in the CAPM and the FFM for different event windows on inverse Mill's ratio (λ_{it}) and other firm-, industry-, and country-related factors. The maximum variance inflation factors (VIFs) of the CAPM and the FFM were 3.84 and 3.23, respectively. The low VIFs implied that multicollinearity was not an issue. The second stage results consistently showed that the estimates of λ_{it} were insignificant, suggesting that self-selection was not an issue. The results were similar to the study on product recall strategies and λ_{it} was not significant (Chen et al. 2009). As a robustness test, we also tried varying firm characteristics in the Heckman model. Instead of using data from the past four years of the *InformationWeek* 500 list to compute $Top500_{it-5:t-1}$, we also used the *InformationWeek* 500 list from the past one, two, and three years to determine the IT capability of the firm. Instead of $\ln(Asset_{it-1})$, we also used the logarithm of market capitalization to measure the size of the company. Apart from using year as the unit of analysis in the first stage of the Heckman model, we also used month as the unit of analysis and found that the results were qualitatively similar. The estimates of λ_{it} were insignificant in the second stage of the model under all situations. Therefore, self-selection bias did not affect our analysis.

Table G1. Descriptive Statistics and Correlation of Variables Used in the Heckman Model

	Mean	SD	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) ITC_{it}	0.10	0.30	0	1	1						
(2) $\ln(Attack_{it-1})$	0.80	1.58	0	7.82	0.21	1					
(3) $\ln(Asset_{it-1})$	23.31	2.85	11.49	32.04	0.08	0.19	1				
(4) $Top500_{it-5:t-1}$	0.21	0.48	0	1.79	0.06	0.15	0.28	1			
(5) IT_i	0.41	0.49	0	1	0.03	-0.39	0.09	0.05	1		
(6) $Finance_i$	0.44	0.50	0	1	0.01	0.49	-0.06	-0.13	-0.73	1	
(7) US_i	0.45	0.50	0	1	0.02	-0.35	0.23	0.37	0.27	-0.37	1

Table G2. Results Obtained Using the Heckman Model

Variables	Stage1	Stage 2											
		CAPM						FFM					
Event Window		**[-1]**	**[0]**	**[1]**	**[-1,0]**	**[0,1]**	**[-1,1]**	**[-1]**	**[0]**	**[1]**	**[-1,0]**	**[0,1]**	**[-1,1]**
λ_{it}		0.010 (0.009)	0.002 (0.004)	-0.001 (0.004)	0.012 (0.009)	0.001 (0.005)	-0.214 (0.262)	0.001 (0.005)	0.001 (0.004)	-0.002 (0.005)	0.002 (0.007)	-0.001 (0.006)	-0.000 (0.007)
$\ln(1 + Attack_{it-1})$	0.159*** (0.015)												
$\ln(Asset_{it-1})$	0.030** (0.011)	0.003** (0.001)	-0.001* (0.000)	-0.002*** (0.001)	0.002 (0.001)	-0.003*** (0.001)	-0.015 (0.034)	-0.000 (0.001)	-0.001** (0.001)	-0.002** (0.001)	-0.002* (0.001)	-0.003*** (0.001)	-0.003*** (0.001)
$Top500_{(it-5:t-1)}$	0.027 (0.056)	-0.006 (0.005)	0.000 (0.002)	-0.001 (0.002)	-0.006 (0.005)	0.000 (0.003)	-0.071 (0.144)	-0.000 (0.003)	0.001 (0.002)	+0.000 (0.003)	+0.000 (0.004)	0.001 (0.003)	+0.000 (0.004)
IT_i	0.270*** (0.083)	0.004 (0.009)	0.001 (0.004)	-0.004 (0.004)	0.005 (0.009)	-0.003 (0.005)	-0.572** (0.260)	0.007 (0.005)	+0.000 (0.004)	-0.006 (0.005)	0.007 (0.007)	-0.005 (0.006)	0.001 (0.007)
$Finance_i$	0.199** (0.088)	-0.002 (0.009)	0.001 (0.004)	-0.002 (0.004)	-0.001 (0.009)	-0.001 (0.005)	-0.537** (0.263)	-0.000 (0.005)	0.005 (0.004)	-0.002 (0.005)	0.004 (0.007)	0.003 (0.006)	0.002 (0.007)
US_i	-0.038 (0.064)	0.014** (0.006)	-0.001 (0.002)	0.003 (0.003)	0.013** (0.006)	0.002 (0.004)	0.155 (0.176)	-0.004 (0.003)	-0.002 (0.003)	0.001 (0.004)	-0.006 (0.005)	-0.001 (0.004)	-0.005 (0.005)
Constant	-2.329*** (0.276)	-0.083** (0.038)	0.019 (0.016)	0.045** (0.019)	-0.064 (0.042)	0.065*** (0.023)	1.341 (1.171)	0.005 (0.023)	0.030* (0.018)	0.053** (0.024)	0.035 (0.032)	0.082*** (0.028)	0.087** (0.034)
N	4,920	526	526	526	526	526	526	425	425	425	425	425	425
R^2	0.06	0.02	0.01	0.04	0.01	0.05	0.01	0.02	0.04	0.01	0.02	0.02	0.01
Max. VIF	2.55	3.84	3.84	3.84	3.84	3.84	3.84	3.23	3.23	3.23	3.23	3.23	3.23

***Significant at 1% level; **Significant at 5% level; *Significant at 10% level.

Appendix H

Steps of the Calendar Portfolio Analysis (CPA)

Advantages of the CPA

Fama (1998) strongly advocated the use of CPA. There were various reasons for this. First, the monthly return in CPA was less susceptible to systematic errors generated by models with imperfect expected return proxies. Second, using the CPA, the portfolio variance automatically accounted for the cross-correlations of event-firm abnormal return. Third, the distribution of the estimators of abnormal performance using CPA was better approximated by normal distribution and thus allowed for classical statistical inference. Loughran and Ritter (2000) found that the CPA approach might detect the lower boundary of long-term abnormal returns because it averaged over months of both "hot" and "cold" months. The CPA was more conservative than other long-term stock performance analysis methods. Comparing various long-term stock performance methods, Mitchell and Stafford (2000) empirically found that the CPA was robust to most statistical problems and had more power to identify reliable evidence of abnormal performance of sample firms. The results provided support to Fama's (1998) advocacy of the use of the CPA in long-term firm performance analysis.

The main advantage of the CPA was that it did not depend on the cross-sectional variance (Lyon et al. 1999), and the monthly returns were serially uncorrelated (Kothari and Warner 2007). Therefore, the statistical inference could be more accurate than the conventional event study. An event study generally assumed stock market efficiency. When a company made a major decision and made it public, it is assumed that investors would take immediate action and the stock price of the company would fully incorporate such public information. The assumption might be true for a short period of time. However, in the long run, when more events occurred, an event study might not be able to account for cross-sectional dependency and overlapped events, leading to incorrect statistical inference (Barber and Lyon 1997; Kothari and Warner 2007). Therefore, event study was not suitable for long-term analysis of stock performance of a company. Instead, the CPA could complement the event study by detecting delayed market reaction (Hendricks and Singhal 2001).

Steps of the CPA

The CPA consisted of two main steps. First, we constructed a portfolio made up of firms making the announcements. Second, we measured the long-term return of that portfolio against a market index. As different countries had different market composite indices, we split the entire sample into various subgroups based on the country of listing of the firm. A portfolio was formed for each country.

Figure H1 illustrates how we constructed a country-specific 12-month calendar portfolio. In this example, we assumed that there were only two announcements associated with companies A and B in the same country X. First, we constructed an investment portfolio P, at the beginning of the month following the day of the announcement. For a 12-month calendar portfolio, we invested U.S. $1 on the associated stock, and held it for 12 months.

To determine the abnormal return as a result of our calendar portfolio, we developed a regression model. The conventional regression model for the CPA was the CAPM. For U.S. data, some previous studies used the FFM (Sorescu et al. 2007). To account for the non-U.S. data, we extended the original CPA for international data analysis. To the best of our knowledge, this was the first use of the CPA for examining international data.

Different from the event study, the CPA did not require filtering confounding events that occurred in the time period of the analysis (Sorescu et al. 2007). The main reason was that the confounding events were idiosyncratic and the net effect of those events would cancel each other out in the long run (Kothari and Warner 2007; Sorescu et al. 2007). In fact, the assumption of idiosyncratic confounding events has been empirically validated by Lyon et al. (1999) and Mitchell and Stafford (2000). It has been found that the abnormal return of a simulated event drawn from a randomly selected sample of firms for CPA was zero one year after the event date (Mitchell and Stafford 2000). In our CPA, since the duration of analysis was at least a year, it was likely that the assumption was valid.

As shown in Figure H1, company A announced ITC adoption before month 1. We purchased U.S. $1 at the beginning of month 1. As company B made the announcement of ITC adoption before month 2, we purchased stock B at the beginning of month 2. Therefore, at the end of month 2, we had U.S. $1 invested in stock A, and U.S. $1 invested in stock B. At the beginning of month 13, stock A was sold so that by the end of month 13, the portfolio only contained U.S. $1 worth of stock B. At the end of month 14, the content of the portfolio became null.

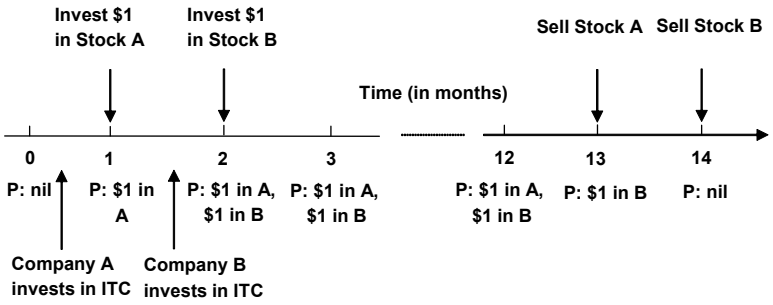

Figure H1. Example of the CPA for a 12-Month Portfolio

For each month when the portfolio was non-empty, we computed the return of the portfolio, R_{pt}. The abnormal return (AR) of the portfolio (α_p) calculated using the CAPM and the FFM was as shown in equations (H1) and (H2) respectively.[6]

$$R_{pt} - R_{ft} = \alpha_p + \beta_p \left(R_{mt} - R_{ft} \right) + \varepsilon_{pt} \tag{H1}$$

$$R_{pt} - R_{ft} = \alpha_p + \beta_p \left(R_{mpt} - R_{ft} \right) + D_p \left(\gamma_p SMB_{pt} + \delta_p HML_{pt} \right) + \left(1 - D_p \right) \zeta_p IHML_{pt} + \varepsilon_{pt} \tag{H2}$$

The situation became more challenging with non-U.S. data. We constructed separate portfolios for each country and for every month. If firm C was listed in country Y (different from country X for firms A and B), and made a relevant announcement before month 1, then the investor bought U.S. $1 worth of stock C and held it for 12 months. In that case, in month 1, the investor invested U.S. $1 in stock A listed in country X, and U.S. $1 in stock C listed in country Y. Hence, the CPA for month 1 gave rise to two separate equations instead of one. The equations for computation of CAR for stocks A and C would use different rate of return of market index, R_{mpt} and international book-to-market correction factor, $IHML_{pt}$ corresponding to different countries.

As the number of stocks in the portfolio P varied from one month to another, we used a weighted least squares regression method, where the square root of the number of stocks in the portfolio in a particular month was used as the weight (Sorescu et al. 2007). An example to compute weighted least squares is illustrated in the next subsection.

To further analyze the long-term impact of the event over different time periods, we also conducted the CPA for 18 and 24 months as part of a procedure for sensitivity analysis. Furthermore, subsampling analysis was conducted to determine if the moderating variables were also significant in the long term.

An Example to Compute Weighted Least Squares

We use the following example to explain how to compute coefficient and test statistics using weighted least squares *(WLS)*. Assuming that we had n observations and four independent variables (namely, intercept, $R_{mt} - R_{ft}$, SMB_t and HML_t), the guiding equation would be as shown in (H3):

$$Y = X\beta + \varepsilon \tag{H3}$$

where Y was a vector dependent variable, β was a vector coefficient of X, X was a vector independent variable, and ε was the disturbance term.

[6]Note that the time period under consideration here is month rather than day.

$$y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}, X = \begin{pmatrix} 1 & x_{12} & x_{13} & x_{14} \\ 1 & x_{22} & x_{23} & x_{24} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & x_{n2} & x_{n3} & x_{n4} \end{pmatrix}, \beta = \begin{pmatrix} \alpha \\ \beta_2 \\ \beta_3 \\ \beta_4 \end{pmatrix}, \varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix}$$

where y_is were the scalar dependent variables of sample data i (for $i = 1, \ldots n$), x_{ij} was data i's scalar value of independent variable j, α was the slope, β_j was the scalar coefficient of independent variable j, and ε_i was the scalar disturbance term of data i.

To compute WLS, first, we obtained a weight matrix, W, which was the square root of total number of stocks in a portfolio. Then we obtained estimate, as shown in equation (H4):

$$\hat{\beta} = \arg\min_{\beta} \left\| W^{\frac{1}{2}} (Y - X\beta) \right\|^2 = (W'WX)^{-1} X'WY \tag{H4}$$

The variance-covariance matrix of parameter β, M^{β}, was computed as follows:

$$M^{\beta} = (X'WX)^{-1} X'WMW'X (X'WX)^{-1} \tag{H5}$$

The variance of parameter β_i was M_{ii}^{β}. The test statistics was computed as $\dfrac{\hat{\beta}}{\sqrt{M_{ii}^{\beta}}}$.

Appendix I

Cross-Sectional Regression on Short-Term Abnormal Return

In the event study, we analyzed individual hypothesized variables, namely, US, Old, and 2FA, separately in subsampling analysis. In the subsampling analysis, it was difficult to observe the joint effect of the hypothesized variables on abnormal return. Therefore, we implemented a cross-sectional regression to analyze the joint effect of hypothesized variables (Dos Santos and Peffers 1995; MacKinlay 1997). In the regression, we combined all hypothesized variables, namely, US, Old, and 2FA, and other control variables that were known to influence short-term abnormal return. The dependent variable CSAR measured the standardized short-term market reaction as a result of ITC adoption in the event window [0, 1]. Cross-sectional regression has been commonly used in previous event studies (Andoh-Baidoo and Osei-Bryson 2007; Bose and Leung 2014; Chatterjee et al. 2001). It served as a robustness check alongside the event study. The regression is shown in equation (H1). Following previous studies, quantile regression with Huber-White estimator of variance was used because this regression was known to be robust to outliers and non-normality of disturbance term, and could minimize cross-sectional and cross-correlational heteroscedasticity (Bose and Leung 2014; Koenker and Hallock 2001). The definition of variables used is shown in Table I1 and the results are shown in Table I2. Following previous studies, we controlled for size, which was measured by the logarithm value of total assets (Acquisti et al. 2006; Cavusoglu et al. 2004; Kannan et al. 2007), IT capability (i.e., IW500) (Bharadwaj et al. 1999), dummies of industries that were frequent targets of identity theft (i.e., IT and Finance) (Bose and Leung 2014) and time related dummy variable.

$$\begin{aligned} CSAR_{it} = {} & \beta_0 + \beta_1 \ln\left(Asset_{it}\right) + \beta_2 IW500_{it} + \beta_3 IT_i + \beta_4 Finance_i \\ & + \beta_5 US_i + \beta_6 Old_{it} + \beta_7 2FA_{it} + YearDummy + \varepsilon_{it} \end{aligned} \tag{I1}$$

Table I1. Definition of variables used in quantile regression

Variable	Definition
$CSAR_{it}$	Cumulative standardized abnormal returns of firm *i* at time *t*
$\ln\left(Asset_{it}\right)$	Natural logarithm of total assets in year *t* for firm *i* (Acquisti et al. 2006; Cavusoglu et al. 2004; Kannan et al. 2007)
$IW500_{it}$	Indicator variable showing whether firm *i* belonged to Information Week 500 in the past five years (Bharadwaj et al. 1999)
IT_i	Indicator variable showing whether firm *i* was an IT firm (Bose and Leung 2014)
$Finance_i$	Indicator variable showing whether firm *i* was a financial services firm (Bose and Leung 2014)
US_i	Indicator variable showing whether firm *i* was a U.S.-listed firm
Old_{it}	Indicator variable showing whether firm *i* adopted ITC before 2009
$2FA_{it}$	Indicator variable showing whether firm *i* adopted 2FA
$YearDummy$	Dummy variables for year

As shown in Table I2, we found that US and Old were both positive and significant at the 10% and 5% level of significance, respectively. It suggested that U.S. country factor and time of adoption were significant factors that contributed to the positive CSAR. The results were similar to the event study analysis except that 2FA was not significant in the cross-sectional analysis. The negative and significant coefficient estimate of IT suggested that the market did not reward IT firms that adopted ITC. Investors might perceive ITC adoption by IT firms as natural (and not surprising) when compared with ITC adoption by non-IT firms.

Table I2. Results of Quantile Regression	
Variable	**Coefficient (Standard Error)**
$\ln(Asset_{it})$	-0.0026 (0.0163)
$IW500_{it}$	-0.0674 (0.0999)
IT_i	-0.3149* (0.1863)
$Finance_i$	-0.2260 (0.1981)
US_i	0.1633* (0.0984)
Old_{it}	1.2890** (0.5544)
$2FA_i$	0.1199 (0.0865)
$Constant$	0.0987 (0.3785)
With Year dummies and robust estimators	
N	526
R^2	0.0439

***Significant at 1% level; **Significant at 5% level; *Significant at 10% level.

Appendix J

Cross-Sectional Regression on Tobin's *Q*

We used *Tobin's Q* as an alternative variable to study the long-term impact of market value as a result of ITC adoption. *Tobin's Q* was a forward looking measure that could capture a firm's future performance potential from a capital market perspective (Bharadwaj et al. 1999). *Tobin's Q* has been used in a number of studies (e.g., Bardhan et al. 2013; Bharadwaj et al. 1999; Brynjolfsson 1996; Melville et al. 2004; Tanriverdi 2005). We ran a cross-sectional regression to analyze whether the hypothesized variables, namely, US, Old, and 2FA, had an impact on a firm's long-term market value. It might be considered as a robustness check for the CPA. We followed previous literature on *Tobin's Q* and defined it as (MVE + PS + DEBT) / TA where MVE was the market value at the end of a year; PS was the liquidating value of a firm's outstanding preferred stock; DEBT was current liabilities minus current assets plus book value of inventories and long-term debt for a firm (Bharadwaj et al. 1999). We followed previous literature on IT business value and controlled for corporate assets, firm size (measured by number of employees), IT capability (measured by presence of the firm in *the InformationWeek* 500 list in the most recent five years), industry *Tobin's Q*, a variable that indicated whether a firm had a negative earnings announcement, research and development expenses and year dummy variable (Bardhan et al. 2013; Bharadwaj et al. 1999). We used U.S. dollars as the unit of currency. Foreign currency was converted to U.S. dollars using the exchange rate in the same time period of analysis. The regression is shown in equation (J1). Following previous studies, quantile regression with Huber-White estimator of variance is used. We computed industry *Tobin's Q* by collecting data from CompuStat. Other data were collected from Thomson Reuters. As some data were not available (CompuStat had data up until the year 2015 at the time of research), six announcements were not included in the analysis. Apart from using $TobinQ_{i,t}$, we also used $TobinQ_{i,t+1}$ as a dependent variable in a robustness check.

$$\begin{aligned} TobinQ_{i,t} = {} & \beta_0 + \beta_1 \ln\left(Asset_{it}\right) + \beta_2 \ln\left(Size_{it}\right) + \beta_3 IW500_{it} + \beta_4 Industry\_TobinQ_{it} \\ & + \beta_5 Loss_{it} + \beta_6 \ln\left(R\,\&\,D_{it}\right) + \beta_7 US_{it} + \beta_6 Old_{it} + \beta_8 2FA_{it} + YearDummy + \varepsilon_{it} \end{aligned} \tag{J1}$$

Table J1. Definition of variables used in quantile regression

Variable	Definition
$TobinQ_{i,t}$	Tobin's *Q* by the end of the fiscal year after the investment in ITC (Bharadwaj et al. 1999)
$\ln\left(Asset_{it}\right)$	Natural logarithm of total assets in year *t* for firm *i* (Bardhan et al. 2013)
$\ln\left(Size_{it}\right)$	Natural logarithm of one plus number of employees in year *t* for firm *i* (Bardhan et al. 2013)
$IW500_{it}$	Indicator variable showing whether firm *i* belonged to the Information Week 500 list in the past five years (Bharadwaj et al. 1999)
$Industry\_TobinQ_{it}$	Average Tobin's *Q* of firms in the same industry (with the same first three NAICS code) as firm *i* in year *t* (Bardhan et al. 2013)
$Loss_{it}$	Indicator variable showing whether firm *i* suffered from a loss in year *t* (Bardhan et al. 2013)
$\ln\left(R\,\&\,D_{it}\right)$	Natural logarithm of one plus Research and Development expenses of firm *i* in year *t* (Bardhan et al. 2013)
US_i	Indicator variable showing whether firm *i* was a U.S.-listed firm
Old_{it}	Indicator variable showing whether firm *i* adopted ITC before 2009
$2FA_{it}$	Indicator variable showing whether firm *i* adopted 2FA
$YearDummy$	Dummy variables for year

As shown in Table J2, we found that US was positive and significant at the 1% level for both models. Old was negative and significant at the 1% level when a contemporary *Tobin's Q* was used whereas 2FA was positive and significant at the 10% level when a one-year-lagged *Tobin's Q* was used. The results were similar to the CPA analysis where US was found to be positive and significant. Also, the AR generated by Old

sample in the CPA was not as high as the Recent sample. The AR of 2FA sample in the CPA was found to be significant when a longer duration was used. With regard to the control variables, the results showed that firms with more assets were more diversified and sluggish in the pace of innovation, and thus had a smaller *Tobin's Q* (Chen et al. 2005). Firms that experienced loss also had a lower *Tobin's Q* (Bardhan et al. 2013) and firms with higher research and development expenses had a higher *Tobin's Q* (Bardhan et al. 2013).

Table J2. Results of Quantile Regression

Variable	$TobinQ_{i,t}$	$TobinQ_{i,t+1}$
$\ln(Asset_{it})$	-0.0569*** (0.0161)	-0.0556* (0.0290)
$\ln(Size_{it})$	0.0042 (0.0111)	-0.0007 (0.0089)
$IW500_{it}$	0.0613 (0.0712)	-0.0525 (0.1393)
$Industry\_TobinQ_{it}$	0.0000 (0.0001)	0.0000 (0.0023)
$Loss_{it}$	-0.1275 (0.0781)	-0.2034** (0.0998)
$\ln(R\&D_{it})$	0.0310*** (0.0045)	0.0261*** (0.0061)
US_i	0.5060*** (0.0803)	0.7401*** (0.2545)
Old_{it}	-3.5433*** (0.3801)	-0.2398 (0.3179)
$2FA_{it}$	0.0470 (0.0600)	0.1056* (0.0627)
Constant	4.8930*** (0.5393)	1.9693*** (0.7037)
With Year dummies and robust estimators		
N	520	488
R^2	0.2296	0.2434

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Appendix K

Firm-Specific Risk Factor Analysis

In the CPA, we found that ITC adoption brought in significant and positive long-term return for adopters in 24 months. Such benefits might be associated with reduction in operational risks as ITC adoption could alleviate risks of adopting firms due to decrease in security threats. Such reduced risks could be measured using an accounting approach. In this appendix, we evaluated whether individual firms experienced reduction in risks after ITC adoption and implemented a firm-specific risk factor analysis. We measured a firm's risk by calculating the residual standard deviation of the firm's monthly market model. The same approach has been used in prior research for calculating the firm-specific risk prior to a trading partner's announcement of quarterly earnings (Pandit et al. 2011). As shown in Figure K1, we measured the firm-specific risk *t* months (12, 18, and 24 months) before and after the adoption of ITC. We used equations (K1) and (K2) as the market models and summarized the results in Table K1.

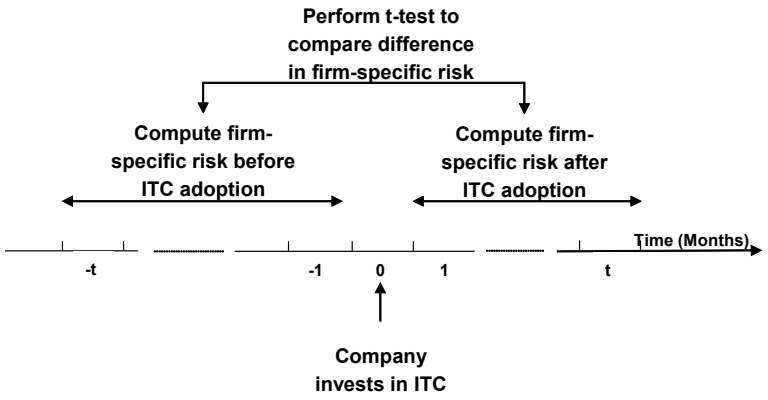

Figure K1. Time Line for Computation of Firm-Specific Risk

Table K1. t-test of Firm-Specific Risks Before and After Adoption of ITC

Time Period (Months)	12	18	24
Sample size	395	376	353
CAPM			
Mean risk before	0.0817	0.0803	0.0932
Mean risk after	0.0850	0.0805	0.0814
t-test	-0.95	-0.08	1.60*
FFM			
Mean risk before	0.0822	0.0827	0.0898
Mean risk after	0.0833	0.0816	0.0809
t-test	-0.32	0.40	1.97**

**Significant at 5% level; *Significant at 10% level

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft} \right) + \varepsilon_{it} \tag{K1}$$

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i} \left(R_{mit} - R_{ft} \right) + D_i \left(\beta_{2i} SMB_t + \beta_{3i} HML_t \right) + \left(1 - D_i \right) \beta_{4i} IHML_{it} + \varepsilon_{it} \tag{K2}$$

We evaluated the changes in firm-specific risks 12 months after the adoption of ITC. As a robustness check, we also evaluated such changes 18 and 24 months after the adoption. As shown in Table K1, we did not observe any significant changes in risk in both the CAPM and the FFM 12 months after the adoption of ITC. The risks were similar at 18 months after the adoption, except that in the CAPM we observed a slight increase in risk. However, when we compared the risks 24 months before and after ITC adoption, they declined significantly over time as shown in the pairwise sample t-tests.[7] Such reduction in market risks might explain why ITC adopters enjoyed positive long-term market return in earlier analysis.

Appendix L

Calculation of Financial Impact Resulting from Adoption of ITC in an Event Study

McWilliams and Siegel (1997) suggested that the financial impact (FI) as a result of an event could be computed as a product of abnormal return, stock price, and number of shares outstanding. To determine the average FI of all sample firms, we used equation (L1).

$$FI = \overline{CAR} \times \overline{P} \times \overline{S} \tag{L1}$$

where $\overline{CAR}$ was the mean cumulative abnormal return of sample firms in an event window as a result of an event study, $\overline{P}$ was average stock price of sample firms, and $\overline{S}$ was average number of shares outstanding of sample firms.

Some might argue that stock price and outstanding shares varied significantly across firms. Therefore, the product of average stocks price and average shares outstanding might not correctly represent the average market capitalization of all firms. In view of this, we also computed overall financial impact by multiplying average abnormal return with average market capitalization of adopters as shown in equation (L2). Market capitalization is computed as the product of stock price and number of outstanding shares.

$$FI = \overline{CAR} \times \overline{MC} \tag{L2}$$

where $\overline{CAR}$ was the cumulative abnormal return of sample firms in an event window as a result of an event study, MC was market capitalization measured by the product of price of an individual firm and its number of shares outstanding, and $\overline{MC}$ was average market capitalization of sample firms.

As shown in Table L1, when equation (L1) was used, the adoption of ITC generated a market value gain of U.S. $587 million using the CAPM and U.S. $583 million using the FFM. Equation (L2) generated slightly higher market value gains of U.S. $604 million and $613 million using the CAPM and the FFM, respectively.

[7]As some firms were either not yet listed or delisted some months before or after ITC adoption, they were not included in the risk analysis. Therefore, the sample size of firms in different time periods were different as shown in Table K1.

Table L1. Calculation of Financial Impact		
Variable	CAPM	FFM
$\overline{CAR}$	0.584%	0.578%
$\overline{P}$ (in U.S. $)	48.83	51.35
$\overline{S}$ (in million)	2,059.33	1,964.68
$\overline{MC}$ (in U.S. $ million)	103,443.55	106,076.07
FI using (L1) with mean CAR (in U.S. $ million)	587	583
FI using (L2) with mean CAR (in U.S. $ million)	604	613

Appendix M

Subsample Analysis by Information and Communication Technologies (ICT) Development

In the subsampling analysis, we found that U.S. country factor played a significant role in explaining both short- and long-term impact for companies which adopted ITC. To investigate whether such a significant effect was due to better IT infrastructure, we performed a subsample analysis based on information and communication technologies (ICT) development of countries of individual sample firms. The measurement of ICT development was through the Network Readiness Index (NRI) developed by the World Economic Forum. NRI measured whether a country possessed necessary drivers to realize the potential of digital technologies, and whether such technologies had significant impact on the country's economy and society. NRI was derived from 53 indicators from four perspectives, namely, environment (i.e., political, regulatory, business, and innovation environments), readiness (i.e., infrastructure, affordability, and skills), usage (i.e., individual, business, and government usage), and impact (i.e., economic and social impacts) based on the World Economic Forum's Executive Opinion Survey and other sources (e.g., United Nations Education, International Telecommunication Union, The World Bank, etc.). The World Economic Forum (https://www.weforum.org/) have published NRI of over 100 economies in 'The Global Information Technology Report' since 2001.[8] We collected all reports from 2001 to 2016 and computed the average NRI of countries represented in the sample, as shown in Table M1. The value of NRI ranged from 1 (lowest) to 7 (highest). Advanced economies usually showed a value of NRI above 5. We used 5 as a threshold to indicate a country/region with high NRI or ICT development.

We performed subsample analysis and conducted the event study with the event window [0, 1] and the CPA. The event study results are shown in Table M2 and the CPA results are shown in Table M3. As shown in Table M2, countries with advanced ICT development showed significant and positive CAR after adoption of ICT in both the CAPM and the FFM. In contrast, countries with low ICT development showed insignificant CAR in both the CAPM and the FFM. It should be noted that in the FFM, most Fama-French country factors were from advanced economies. As a result, in the low NRI (LNRI) subsample, there were fewer firms due to unavailability of Fama-French country factors.

As depicted in Table M3, the results of the CPA showed that the HNRI subsample showed positive AR in all time periods, which was higher than that of the LNRI subsample. In months 18 and 24, the AR of the HNRI subsample was positive and significant whereas that of the LNRI subsample was not significant. The results were consistent with our U.S. subsample analysis that ITC could bring in long-term return to adopters.

[8]The most recent report is available from http://reports.weforum.org/global-information-technology-report-2016/.

Table M1. Average NRI of Sample Firms				
Continent	**Country**	**Number of Sample Firms**	**Average NRI from 2001 to 2016**	**High NRI (1:Yes; 0: No)**
Africa	Nigeria	3	3.15	0
	South Africa	4	3.93	0
Asia	China	4	3.96	0
	Hong Kong	6	5.32	1
	India	33	3.85	0
	Israel	1	5.08	1
	Japan	46	5.18	1
	Kuwait	1	3.92	0
	Malaysia	3	4.66	0
	Oman	2	4.27	0
	Qatar	3	4.80	0
	Saudi Arabia	2	4.53	0
	Singapore	16	5.73	1
	Republic Korea	8	5.28	1
	Taiwan	5	5.30	1
	Thailand	5	3.97	0
	United Arab Emirates	4	4.91	0
	Vietnam	1	3.60	0
Australasia	Australia	16	5.25	1
Europe	Austria	3	5.16	1
	Belgium	2	4.99	0
	Denmark	2	5.57	1
	Finland	2	5.70	1
	France	5	5.03	1
	Germany	2	5.26	1
	Greece	3	3.95	0
	Ireland	2	4.98	0
	Italy	2	4.21	0
	Netherlands	12	5.52	1
	Norway	1	5.50	1
	Spain	4	4.49	0
	Sweden	7	5.73	1
	Switzerland	3	5.51	1
	Turkey	7	3.96	0
	United Kingdom	20	5.35	1
North America	Canada	6	5.36	1
	Mexico	3	3.81	0
	United States	271	5.60	1
South America	Brazil	6	3.89	0

Table M2. Moderating Effect of ICT Development in the Short Term				
Model	**CAPM**		**FFM**	
Characteristic	**HNRI**	**LNRI**	**HNRI**	**LNRI**
Sample size	432	94	419	14
Mean CAR	0.65%	0.22%	0.60%	0.24%
Z-test p-value	0.00	0.22	0.00	0.37
Median CAR	0.34%	-0.30%	0.25%	0.10%
Sign test p-value	0.00	0.24	0.00	0.43
Rank test p-value	0.00	0.25	0.00	0.41

HNRI: High NRI subsample (i.e., countries with average NRI higher than 5 in 2001-2016); LNRI: Low NRI subsample (i.e., countries with average NRI lower than or equal to 5 in 2001-2016)

Table M3. Moderating Effect of ICT Development in the Long Term												
Months	**12**				**18**				**24**			
Model	**CAPM**		**FFM**		**CAPM**		**FFM**		**CAPM**		**FFM**	
Type	**HNRI**	**LNRI**	**HNRI**	**LNRI**	**HNRI**	**LNRI**	**HNRI**	**LNRI**	**HNRI**	**LNRI**	**HNRI**	**LNRI**
Size	1243	671	1550	891	1784	1066	1152	92	1435	124	1645	154
AR (%)	0.31%	0.11%	1.67%	-0.02%	1.56%	-0.02%	0.39%	-0.57%	0.29%	-1.51%	0.39%	-1.35%
p-value	0.17	0.71	0.00	0.92	0.00	0.93	0.10	0.37	0.08	0.02	0.00	0.02

Appendix N

Analysis of Information Security-Related Statements in Annual Reports

We analyzed annual reports released by adopters of ITC one year before (t-1), in the same year of (t), and one year after ITC adoption (t+1). We examined the annual reports and identified paragraphs associated with online/e-commerce security, compliance, identity theft, and online fraud. The statements showed that the companies cared about online security. It might justify their action to adopt ITC to safeguard the identity of customers.

The statistics of firms whose annual reports contained security-related statements are shown in Table N1. Out of 526 sample firms, there were between 67 and 88 firms without annual reports. Because some annual reports were very old at the time of retrieval, they were not available in any year on company websites. Also, for some recent announcements, the t+1 annual reports (e.g., for years 2016 and 2017) were not available at the time of research. So, the number of missing annual reports was higher for t+1. In addition, some firms' annual reports were written in foreign languages that could not be analyzed by the authors (e.g., Arabic and Japanese). They were not included in the analysis. Nevertheless, we had several interesting findings from the analysis of the annual reports of ITC adopters.

Comparing between U.S. and non-U.S. firms, we found that U.S. firms had more security-related statements in their annual reports than the non-U.S. firms. The difference in percentage was more than 20%. The results seemed to corroborate with our earlier arguments that U.S. firms were more conscious about information security than those in other countries. This might be related to more tightened regulations in the United States with regard to online security and protection of personal information. Comparing between "Old" and "Recent" groups, we found that over time firms became more aware of information security. We found that the "Recent" group had higher proportion of firms whose annual reports contained information security related statements than the "Old" group with the difference in percentage greater than 5%. When we compared the groups for 2FA and non-2FA, there was almost no difference at all. Table N1 summarizes the above observations in more details.

Table N1. Statistics of Annual Reports of Firms with Security Related Statements			
Group	***t*-1**	***t***	***t*+1**
U.S.	84.9% (208 out of 245)	86.5% (211 out of 244)	88.2% (209 out of 237)
Non-U.S.	60.7% (130 out of 214)	62.5% (135 out of 216)	66.3% (134 out of 202)
Old	68.8% (95 out of 138)	68.3% (97 out of 142)	74.5% (108 out of 145)
Recent	75.7% (243 out of 321)	78.3% (249 out of 318)	79.9% (235 out of 294)
2FA	73.1% (226 out of 309)	74.7% (230 out of 308)	78.2% (230 out of 294)
Non-2FA	74.7% (112 out of 150)	76.3% (116 out of 152)	77.9% (113 out of 145)
All firms	73.6% (338 out of 459)	75.2% (346 out of 460)	78.1% (343 out of 439)
# of firms with annual reports	459	460	439
# of firms without annual reports	68	67	88

t-1 is one year before ITC adoption; *t* is the year of ITC adoption; *t*+1 is one year after ITC adoption

Reasons for ITC Adoption

Many firms viewed that identity thefts were a kind of ***operational risk***. Adoption of ITC could effectively mitigate such kind of risks from an operational perspective. Furthermore, better information security measures could enhance ***corporate reputation and brand image***. Providing customers with a safe online environment was also often viewed as a kind of ***corporate mission and commitment***. It was also a direct response to ***customer demand*** and ***market needs***. Some also viewed that fraud prevention was a ***focused/strategic area*** for future development. In different countries, related laws had been established to request e-commerce service providers to safeguard online security and customer data and privacy. Adoption of better security measures was a kind of ***legal compliance***. It could also help mitigate ***financial loss*** due to lawsuits from identity theft victims and loss in confidence about e-commerce security. Besides, online security measures were viewed as ***innovative products*** that could help generate ***competitive advantages***. We summarize each area and show related excerpts in the following paragraphs.

Excerpts from the Annual Reports of ITC Adopters

Online Security as an Operational Risk

> "[There are] many other types of operational risks such as those pertaining to payment systems, **computer systems fraud**" – National Australia Bank Annual Report 2005.

> "Our business is subject to certain risks and concentrations including … exposure to risks associated with **online commerce security and credit card fraud**." – Expedia 2007.

> "For selected [operational] risks, we establish specialized support groups, for example, Information Security....These specialized groups develop corporate wide risk management practices, such as an **information security program**." – Bank of America 2004.

Security Measures to Enhance Corporate Reputation and Brand Image

> "While systems and processes are designed to support complex transactions and to avoid systems failure, **fraud**, **information security failures**, processing errors and breaches of regulation, any failure could lead to a material adverse effect on AEGON's results of operation and corporate reputation." – AEGON Annual report 2004.

"Adverse publicity about us, our service or the viability, **reliability or security of on-demand application** services generally from third party reviews, industry analyst reports and adverse statements made by competitors" – Salesforce, 2006.

"Financial crime risk management received increasing focus in 2005 … We are concerned by the general **rise in identity theft** and we are taking extra precautions to protect our brand."– Barclays PLC. 2005.

"The achievement [in data protection and privacy] reassures Bradesco's commitment to the continuous improvement of information security, **strengthening its image** in the market." – Bradesco 2006.

Security Measures to Fulfill Corporate Mission and Commitment

"We are opening the door to the future, aiming to create a lifestyle infrastructure that will enable customers to use mobile phones with greater ease and **security**." – NTT DoCoMo 2004.

"Our Fraud Investigation Team focuses on **identifying and preventing fraud** before it occurs, detecting fraud in process, mitigating loss if fraud does occur and delivering information to law enforcement around the world to better combat online fraud." – eBay 2006.

"As a **critical infrastructure provider** of the Singapore financial system, we contribute to the industry development of security standards and practices to **address global cyber security risks**. We are also progressively investing in new technology capabilities to **improve our ability** to anticipate, assess and manage these risks as they evolve over time." – Singapore Exchange Limited 2016.

Security Measures as a Response to Customer Demand

"In Commercial, we are increasingly seeing clients and brokers looking at the **security** and quality of companies where they place business and with our strong balance sheet and reputation for **technical excellence**, we are well positioned." – EMC 2008.

"During the year, Cyberbanking was further upgraded [with two factor authentication] to **serve customers better**." – Bank of East Asia 2005.

"New Web-based technology…has transformed Bank of America's collections and **fraud protection** activities into a **loyalty-building program** that helps customers manage troublesome debt and protect their accounts by identifying and preventing credit card fraud." – Bank of America 2005.

"Becoming **aware** that our customers' **online security** could be compromised,…Westpac and other banks in New Zealand joined in challenging such research companies on the privacy of online banking, with the company eventually changing its mode of operation." – Westpac 2005.

Security Measures as a Response to Market Needs or External Environment

"Recent advances in IT have led to a rapid **increase in and diversification of information-processing environments and objectives**....Therefore, strengthening the management system to maintain **information security** against system threats such as information leakage, unauthorized changes and destruction of information is becoming extremely crucial. To **respond** to these circumstances, the Bank formulated an **Information Security Policy** as a basic policy on safety measures concerning the protection of information assets (information and information systems)." – Kyoto Bank 2005.

"There have been instances where millions of computers worldwide were affected by being infected by **viruses** though the Internet. Similar incidents could occur on our **mobile communication network**. If such viruses enter our network or terminals, our system or mobile phones could fail. In such an instance, our **network's credibility and our customer's satisfaction** might significantly decrease." – NTT DoCoMo 2004.

"We rely on technology, particularly the Internet, to conduct much of our activity. Our technology operations are vulnerable to **disruptions** from human error, natural disasters, power loss, computer viruses, spam attacks, **unauthorized access** and other similar events. Disruptions to or instability of our technology or external technology that allows our customers to use our products and services could **harm our business and our reputation**." – E*Trade Financial Corp. 2006.

"During 2005 additional **attention** was directed towards evolving best practice in the areas of **internet fraud**, counterparty risk management policy following the publication of the Corrigan report in July 2005." – HSBC 2005.

ITC as a Focused/Strategic Area for Future Development

"We have **focused** our year 2000 program primarily in the following areas: (a) our information technology systems (b) electronic data interchange systems; (c) non-information technology systems (embedded technology) including office business machines, and **security**, **backup power**, and other building systems." – Equifax 1998.

"Key focus areas over the past year have included **fraud prevention**, payments risk management and **remote banking security.**" – Australia and New Zealand Bank Annual Report 2001.

"The **evolution of the service** during 2005 focused on **security** and on the migration of customers from traditional channels to the newly-developed ones." – Unicredit Group 2005.

Legal Compliance to Protect Online Safety

"In light of the **Personal Information Protection Act** that came into effect in Japan in April 2005 and recent increases in **counterfeit credit card-related crimes**, there are growing calls for technology solutions to help protect **information security**." – Fujitsu 2005.

"In 2006, Postbank and ING Bank carried out a project to ensure compliance with a **new law** concerning **client identification**." – ING Annual report 2006.

"In order to ensure full **compliance with legislative and regulatory provisions** currently in effect as regards disclosure of transactions with related parties, UniCredit adopted some time ago a procedure for **identifying related-party transactions**." – UniCredit Group 2004.

"We have increased the resources dedicated to compliance with the **Bank Secrecy Act** and the **USA Patriot Act**. These laws are intended to assist authorities in **identifying illicit financial transactions**, particularly those that might involve funds used for terrorist activities. The laws require that we do more to document the identity of our customers, that we develop a greater understanding of the sources and uses of customers' funds, and that we report any suspicious activities or transactions to federal authorities in a timely manner." – Zions Bancorporation 2006.

"**Federal and state law and regulation** require financial institutions to protect the **security and confidentiality of personal information**, including health related and customer information, and to notify customers and other individuals about their policies and practices relating to their collection and disclosure of health-related and customer information and their practices relating to **protecting the security and confidentiality** of that information. State laws regulate use and disclosure of social security numbers and require notice to affected individuals, law enforcement, regulators and others if there is a breach of the security of certain personal information, including social security numbers." – Prudential Financial Inc. 2007.

"There are also certain specific **state statutes and rules** that regulate conduct in areas such as **privacy**, **data security** and telemarketing." – Times Warner 2004.

"In addition, in February 2005, the Bank formulated new **Regulations on the Handling of Personal Information** and established a **Privacy Policy** (a statement on protection of personal information), while seeking to further reinforce its systems for adequately protecting personal information in line with the enactment of the **Personal Information Protection Act** as of April 1, 2005." – Kyoto Bank 2005.

"A number of regulators in the U.S., notably the Federal Reserve, the Federal Deposit Insurance Corporation (**FDIC**), the Office of the Comptroller of the Currency (**OCC**) and the Securities and Exchange Commission (**SEC**), have been delving into the topic to **identify cyber-security risks** inherent in financial institutions and to assess the financial industry's current practices and overall resilience. Furthermore, the U.S. Congress has taken a keen interest in cyber-security and the financial industry may see additional legislation in this area as a result. The **EU**, for its part, has made the mitigation of **cyber-risk** a priority in its work program for 2015, which is also likely to be followed by **new legislation**." – UBS 2014.

"The United States Federal Trade Commission (**FTC**) has an on-going program of investigating the privacy practices of companies and has commenced **enforcement actions** against many, resulting in multimillion dollar settlements and multi-year agreements governing the settling companies' privacy practices. The FTC, CFPB, and several states have expanded their area of concern to include privacy practices related to online and mobile applications. **Many state laws** require us to provide notification to affected individuals, state officers and consumer reporting agencies in the event of a **data breach** of computer databases or physical documents that contain certain types of non-public personal information and present a risk for **unauthorized use or potential harm**." – Western Union 2015.

ITC Adoption to Mitigate Financial Loss

"Substantial **data breaches** could significantly harm our business, **damage our reputation**, expose us to a risk of loss or **litigation** and **possible** liability and/or cause customers and potential customers to lose confidence in our security, which would have a negative effect on the value of our brands." – Expedia 2006.

"If our **security measures** are **breached** as a result of third-party action, employee error, malfeasance or otherwise, and, as a result, someone obtains **unauthorized access** to one of our customers' data, our **reputation will be damaged**, our business may suffer and we would incur significant **liability**. Because techniques used to obtain unauthorized access or to sabotage systems change frequently and generally are not recognized until launched against a target, we may be unable to anticipate these techniques or to implement adequate preventative measures. If an actual or **perceived breach of our security** occurs, the **market perception of the effectiveness of our security measures could be harmed** and we could **lose sales and customers**." – Salesforce.com 2005.

"The **profitability** of the Company could also be affected by **rules and regulations** which impact the business and financial communities generally, including changes to the laws governing taxation, electronic commerce, and **security of client data**." – Charles Schwab Corp., 2005.

"If our **security measures** are **breached** and **unauthorized access** is obtained to a customer's data, our data or our information technology systems, our service may be perceived as not being secure, customers may curtail or stop using our service and we may **incur significant legal and financial exposure and liabilities**." – Part City Group, 2015.

ITC as Innovative Products

"UniCredit Pass: a real **innovation in online security**. The new authentication technology enables UniCredit Banca customers to carry out online banking operations with **maximum safety** and simplicity." – Unicredit Group 2005.

"The **big novelty** of the year 2002 was the introduction of chip technology on payment cards, pioneered in Hungary by K&H Bank. This new technology is a significant step in increasing the s**ecurity of card payments**." – K&H Bank 2002.

ITC to Generate Competitive Advantages

"We believe the **principal competitive factors** in our market include the following: performance, **security**, scalability, flexibility and **reliability of the service**" – Salesforce.com 2006.

"IT work is an integral part of all the Bank's operating areas. The aim of these efforts is to contribute to higher customer value and increase internal efficiency, which in time will lead to greater value for the customer. **Security aspects have a high priority**." – ForeningsSparbanken, 1998.

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