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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).

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \qquad \text{(C1)}$$

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).

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

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:

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

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

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 non-parametric 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

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

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

$$CAR = \frac{\sum_{i=1}^{N} \sum_{t=S_1}^{S_2} AR_{it}}{N} \quad \text{(E2)}$$

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

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

where

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

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

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

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

$$Z = CSAR\sqrt{N} \quad \text{(E6)}$$

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]

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

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.

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

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

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)
$\ln(1 + Attack_{it\text{-}1})$	0.159*** (0.015)												
$\ln(Asset_{it\text{-}1})$	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)
$Top500(_{it\text{-}5:t\text{-}1})$	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.

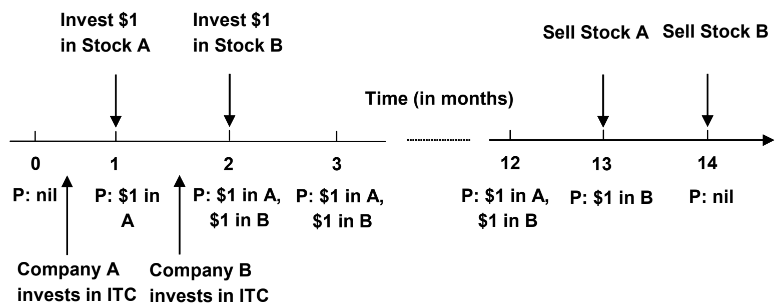

Figure H1. Example of the CPA for a 12-Month Portfolio

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]

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

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

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):

$$Y = X\beta + \varepsilon \quad \text{(H3)}$$

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):

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

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

$$M^{\beta} = \left(X'WX \right)^{-1} X'WMW'X \left(X'WX \right)^{-1} \qquad \text{(H5)}$$

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

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.

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

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)
$\ln(Asset_{it})$	Natural logarithm of total assets in year *t* for firm *i* (Bardhan et al. 2013)
$\ln(Size_{it})$	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)
$\ln(R\&D_{it})$	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.

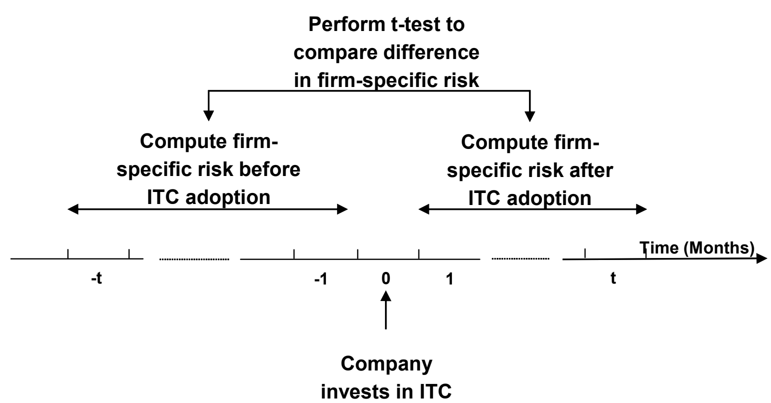

Figure K1. Time Line for Computation of Firm-Specific Risk

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

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

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

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).

$$FI = \overline{CAR} \times \overline{P} \times \overline{S} \qquad \text{(L1)}$$

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.

$$FI = \overline{CAR} \times \overline{MC} \qquad \text{(L2)}$$

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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