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The Effect of the Target Security Breach on Asset Prices and Performance

A thesis

Submitted by

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Abstract

I present a comprehensive and quantitative analysis of Target's security breach in November 2013, the second largest information breach in U.S. history. First, I discuss the impact of the breach on equity prices based on daily time series data; then, I examine the effects of the breach using a series of asset pricing models with the retailing sector panel data. I follow up with the difference-in-difference method to estimate potential spillover effects of the security breach adding an environmental sector as a control group. The second part of this thesis uses similar econometric methods applied to a valuation multiple, the price to sales ratio. The analysis of the impact of the event on the price-to-sales ratio multiple provides insights on the inner working of the firms.

The hypotheses tested are whether or not the security breach has an effect on asset prices of the company and whether or not the security breach has an effect on the retailing sector. Using the price to sales ratio multiple, I test the hypothesis that potential competitive forces work to improve the sales of competitors in the retailing sector. The evidence of potential spillovers to the retailing rector is statistically weak.

Key Words: security breach, CAPM, Fama-French model, price to sales ratio, differences-in-differences

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I would also thank Professor Xiaozhe Hu of the Mathematics Department of Tufts University, my teacher in Numerical Analysis, who gave me guidance in simulation of asset-pricing process using numerical methods. Though it does not become the main focus of this paper, it helped me better understand asset-pricing in a mathematics view. Lastly, I would thank Alexander Ruggeri, my writing tutor at Academic Resource Center at Tufts, who helped me in finalizing this paper.

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1 Introduction

The classic CAPM model was first developed in the early 1960s by William Sharpe (1964), Jack Treynor (1962), John Lintner (1965) and Jan Mossin (1966). Since then, several scholars have attempted to relax basic assumptions of the CAPM. Among the main assumptions of the CAPM, some like small investors as price takers, investments are limited to publicly traded assets with unlimited borrowing or landing at risk-free rate and everyone uses the same estimates of expected return and the same variance matrix may be plausible. In this thesis, I discuss how a company and the industry it belongs react to a given shock related to a security breach. A certain event may have a positive or negative effect, which means a further positive or negative expectation on future stock price changes. For a security breach, it is a negative specific shock for a company. An investor can respond to the new information by selling or purchasing stocks thus affecting current and future price changes. Although the breached company is supposed to suffer from a drop on its price, the influence to its competitors remains an open question since there are own effects and potential substitution effects. Consumers may reduce their purchase in all retailing group if they think the information risk not only takes place in the breached company, but spreads to the whole sector. Meanwhile, investors may switch to its competitors since most goods sold in the retailing sector may be close substitutes and competition among firms is strong.

An event study is a useful tool in general financial economics. It is used by lawyers, accountants and insurers in estimating the impact of different types of

announcements on stock price performance and shareholder value. Two main methods are widely used in event studies. The first one incorporates the concept of estimation window (MacKinlay, 1997). Within a certain period of time, a constant mean is estimated in order to test if the abnormal return is statistically difference from zero. The second method by Salinger (1989) sets an event window and dummy variables to measure the effect of the announcement on stock returns. I use the Salinger (1989) methodology to explain the impact of the Target security breach on excess returns of company stock using both the single company time series data and a panel of firms of the retailing sector.

I conducted three types of analysis in the event study vain. A three factor Fama-French model is used to analyze the significance and impact of the security breach. The first model involves daily stock price data of Target Corporation only. The regression shows a negative impact of the security breach, yet the significance level is not as high as expected. The second data set contains twenty comparable companies in retailing industry based on their scale and past performance in the past ten years. The panel regression then considers the company fixed effect of the breach and I obtain a significant negative coefficient on the event dummy which means the security breach has a negative impact on Target considering company factors.

Moreover, I incorporate another industry to understand the potential spillover effects of the breach. As a follow up, I estimate a differences-in-differences regression across the retailing sector and the non-retailing sector of energy and environmental firms. The comparison group is eight selected companies from the energy and

environmental industry. I choose the energy and environment industry because it has few connections to retailing firms so that endogenous problems could be largely avoided on the right hand side of the regression. Secondly, they are usually less influenced by firm level news and are more affected by macroeconomic news, which is a key advantage for a differences-in-differences study. The chosen eight companies of energy and environmental industry are used as a control group, while the twenty companies in retailing sector are all considered as a treatment group in a five factor Fama-French model. The differences-in-differences regression shows a negative coefficient on the interaction variable. This means the credit card security breach has caused a spillover effect on the retailing industry as a whole; however, the statistical significance level of the effect is low.

To further understand these regression results of the asset-pricing model, in the third part a price to sales ratio analysis is conducted to study the firm level performance of the companies after the event. Price to sales ratio contains important information of the company and the key determinant of price to sales ratio is the profit margin. By using the price to sales ratio analysis, it is possible to uncover the breach impact separately from the price factor impact. Although price is considered to contain all information of the market theoretically, it is inevitably affected by other non-event factors and has a time lag issue. Price to sales ratio analysis in this paper shows the same result as in previous parts of the paper, but it contains more information concerning the inner growth of the company and the competitive problem among retailing companies after the breach.

2 Literature review

The literature on this topic can be generally classified into three categories. Theoretically, there are papers that try to estimate how information affects stock returns. This information involves macro level economic information[1] (Veronesi, 1999) or internal firm information[2] (Lubos 2009). Under this topic, there are several dimensions of the information; the precision, quality and self-learning behavior are studied. Veronesi's (1999) paper analyzes the relationship between public information precision about economic growth and stock market returns based on a dynamic asset-pricing model. The author found that higher precision of signals increases in the risk premium. Surprisingly, the evidence of Veronesi indicates that there is no risk premium for noisy signals. Furthermore, when signals are imprecise, the equity premium is independent of the investors' risk aversion. This is a reflection of the Mehra and Prescott (1985) equity premium puzzle that it cannot be explained by investors' high risk-aversion. Veronesi's analysis shows how public information changes investors' expectations thus affecting stock market prices.

In the same vein, Rodriguez (2002) examines hedging demand changes under incomplete information. He shows how learning affect both the covariance and duration component of the hedging portfolio, which, initially gives a clue on how the market absorbs certain kinds of information, how investors change their portfolio and how those reflect on the stock price of the company. The precision of the information is stimulated through the noise of a signal, along with which investors get a drift rate

1 Veronesi, Pietro. "How does information quality affect stock returns?." The Journal of Finance 55.2 (2000): 807-837.

2 Pastor, Lubos, and Pietro Veronesi. Learning in financial markets. No. w14646. National Bureau of Economic Research, 2009.

of dividends based on the observation of realized dividends. The precision indicators of external and dividend signals are all treated as exogenous variables that affect the Brownian motion of asset returns.

It has long been discussed that the observed movements of stock prices is not fully compatible with the rational investor assumption in a classic asset-pricing model. A long literature focuses on how external shocks affect excess volatility of stock prices. Binder[3] (1985) measured the effect of regulation on stock prices; Hand & Robert[4] (1992) measured bond rating's impact on stock prices. There is also a discussion on how audit choices influence stock returns[5](Dodd, 1984). Hou (2007) also discusses the information diffusion effect across industries and its lead-lag effect on stock returns. In particular, Hou's results are supportive of my conclusion that spillover effects exist in the retailing industry.

In addition, George (2001) tries to recover the hidden information from stock prices data by proposing a new method that measures announcement effects on stock returns which doesn't require the estimation window of the announcement. The unconditional probability of abnormal returns is estimated by an expectation-maximization (EM) algorithm which self-discovers the event window without setting it exogenously. My choice of the Salinger (1989) methodology requires the researcher to subjectively choose the event window.

Generally, the analytical approach presumes that the modeling process creates

3 Binder, John J. "Measuring the effects of regulation with stock price data." The RAND Journal of Economics (1985): 167-183.

4 Hand, John RM, Robert W. Holthausen, and Richard W. Leftwich. "The effect of bond rating agency announcements on bond and stock prices." The journal of finance 47.2 (1992): 733-752.

5 Hand, John RM, Robert W. Holthausen, and Richard W. Leftwich. "The effect of bond rating agency announcements on bond and stock prices." The journal of finance 47.2 (1992): 733-752.

event data while the simulation method uses stock returns generated by the market. Brown[6] (1980) and Warner (1984) focused on detecting abnormal returns with simulation; Fama[7] (1976) showed daily returns deviate from normality more than monthly returns and Scholes and Williams[8] (1977) showed the main reason for this is that daily data are not synchronous. Boehmer, Jim and Annette[9] (1991) brought up an interesting topic which many previous researchers neglected which is the change in variance during the event window. Their stochastic simulation shows that when minor changes in variance are caused by an event, zero average abnormal returns is rejected. They proposed a cross-sectional technique to overcome this anomaly. Thomas's[10] (1984) work compared several simulation methods and used a return generating model to detect the abnormal returns of the stocks. The paper used both mean-adjusted returns and market-adjusted modeling in estimating the parameters of the prediction model. Brown and Warner (1980) propose the correctness of sign test based on an equal number of negative and positive abnormal returns while Cowan's (1992) work provides the first documentation of the power and specification of the generalized sign test in an event study which is based on the percentage of positive abnormal returns during the event window. Before his work, Corrado (1989) reported rank tests, a nonparametric test, to detect abnormal stock price changes.

Dimson and Paul (1986) studied 862 printed press recommendations and found that size effect can distort long term performance measures, thus showing that the

6 Brown, Stephen J., and Jerold B. Warner. "Measuring security price performance." Journal of financial economics 8.3 (1980): 205-258.

7 Fama, Eugene F., and G. William Schwert. "Asset returns and inflation." Journal of financial economics 5.2 (1977): 115-146.

8 Scholes, Myron, and Joseph Williams. "Estimating betas from nonsynchronous data." Journal of financial economics 5.3 (1977): 309-327.

9 Scholes, Myron, and Joseph Williams. "Estimating betas from nonsynchronous data." Journal of financial economics 5.3 (1977): 309-327.

10 Scholes, Myron, and Joseph Williams. "Estimating betas from nonsynchronous data." Journal of financial economics 5.3 (1977): 309-327.

event study based on the market model tends to be biased. Schwert (1983) also pointed out that event studies should give explicit consideration to the size effect.

3 Empirical Event Study

The event methodology includes the use of the Sharpe (1963) market model and an adjustment for market movements in Fama, Fisher, Jensen and Roll (1969). The Fama-French three factors model is an adjustment to the classical Sharpe (1964)-Linter(1965) –Black (1972) capital asset pricing model (CAPM) with empirical indications of a capitalization factor and a scale factor of a company. Though the integrity of this method involves a joint hypothesis for market efficiency, most research showed that small adjustments to the traditional asset pricing model would be adequate to overcome such problems.

3.1 Case study of the Target security breach

For my event study, I choose the Target retail company security breach as an example. First, retailing companies are more affected by economic trends and other endogenous shocks compared to other industries. Also, retailing companies have relatively fewer profit-generating resources, which make the event a major factor in the stock price change. Technically, retailing firms update quarterly financial reports on time, this means it is easier to trace the performance of the company after a certain kind of event.

The Target Corporation was founded in 1902 and is headquartered in Minneapolis, Minnesota. Target Corporation (TGT) serves as a general merchandise retailer in the United States and Canada. Target Corporation sells its products through

stores; and digital channels, including Target.com. As of January 15, 2015, the company operated 1,934 stores, including 1,801 stores in the United States and 133 stores in Canada. It offers household essentials, including pharmacy, beauty, personal care, baby care, cleaning, and paper products and apparel for a variety range of customers. The company also provides home supplies as well as seasonal merchandise and in-store amenities, including Target Café, Target Clinic, Target Pharmacy, and Target Photo.[11] Target shoppers got an unwelcome holiday surprise in December 2013 when news broke that 40 million credit card users on Target stores had data stolen by accessing data on point of sale (POS) systems. Target later revised that number to include private data for 70 million customers. Data thieves then had the access to the magnetic strips found on the back of the stolen credit and debit cards and could potentially use that data to encode that information on a counterfeit card. This allows criminals to sell the cards in batches or use the cloned cards at retailers to purchase goods. The breach occurred between November 27 and December 15, 2013. Over 11 GB of data was stolen. Target missed internal alerts and found out about the breach when they were contacted by the Department of Justice.

The Target security breach is the second-largest security breach, second to the retailer TJX Cos. which affected at least 45.7 million card users. Consumers who made purchases between November 27 and December 15 may have had their credit account exposed. The breach included customer names, credit and debit card numbers, card expiration dates and there is no evidence the security numbers were affected. The

[11] Yahoo Finance, company description

data breach only affected in-store shopping. The timeline of this breach starts from November 27th and ends with the resignation of the CEO of Target Corp as follows:[12]

- **Nov. 27 - Dec. 15, 2013:** Personal information of 40 million customers who used credit and debit cards at U.S. stores are exposed to fraud. However, the public remains unaware of the data breach.
- **Dec. 18, 2013:** Data and security blog KrebsOnSecurity first reports the data breach.
- **Dec. 19, 2013:** Target publicly acknowledges the breach, saying it's under investigation. Customers jam Target's website and customer service hotlines.
- **Dec. 22, 2013:** Transactions at Target fell 3 percent to 4 percent compared to the year earlier on the last weekend of holiday shopping before Christmas.
- **Jan. 22, 2014:** Target lays off 475 employees at its headquarters in Minneapolis and worldwide and leaves another 700 positions unfilled.
- **Feb. 18, 2014:** Costs associated with the data breach topped $200 million[13]
- **May 5, 2014:** Target CEO Gregg Steinhafel resigns. Bob DeRodes, a former tech adviser in several federal government agencies, takes over as Target's chief information officer.

12 Wall Street Journal collection

13 Report from the Consumer Bankers Association and Credit Union National

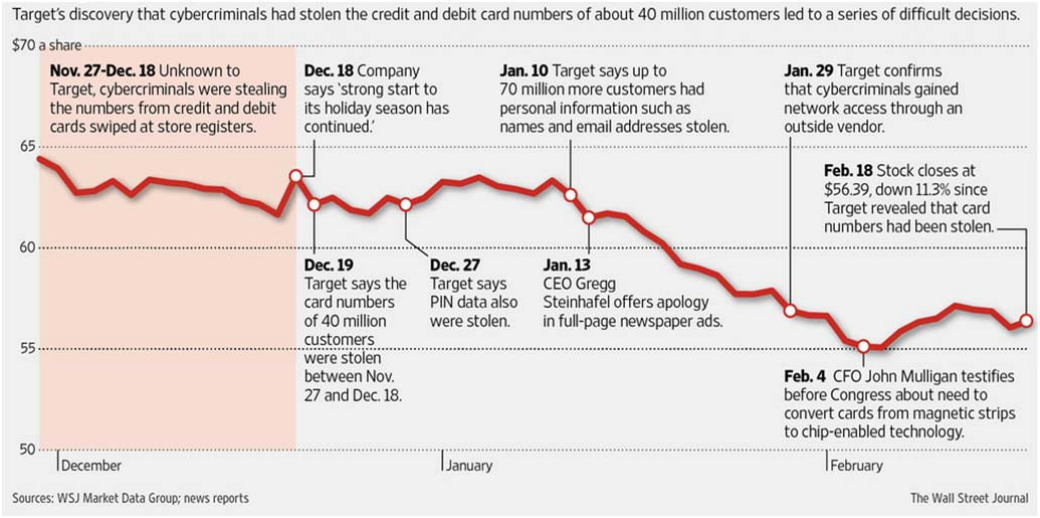


Figure 1: Target Stock Price through security breach timeline: December 2013, January and February 2014

Figure 1 shows Target's stock price changes with a three months event window. As shown in the graph, the price experienced a dramatic drop after the announcement of the security breach, then the price rebounded after about twenty days then it suffered a smooth and continuous drop till early February when the CEO of Target resigned. While the data theft did not happen online, it happened in the physical Target locations. Based on news reports, data thieves tampered with the (POS) point-of-sale systems that customers use at checkout registers to swipe their credit or debit cards when making purchases and gained access to the data that is stored on the magnetic stripe on the back of credit and debit cards. This shows a way to prevent future data management risk. The Target data breach involves many issues, such as stolen customer credit card and debit card numbers, reputational damage, legal and PR issues, potential legal liability for fraudulent charges, customer lawsuits, shareholder lawsuits, bank and credit union lawsuits, PCI DSS penalties, regulatory fines, POS network security failure, potential drop in share price, impacted P&L

reports and investigations by State Attorneys General, the Secret Service, FBI and Federal Trade Commission. Figure 2 shows the main groups of actors in this case.

Figure 2 Shareholders of the security breach

This incident is one of the largest data security breaches in history and has already spawned several class action lawsuits and regulatory investigations. In addition to litigation costs, Target and several banks of affected customers have been required to expend significant resources towards investigation of the breach itself, customer notifications and interaction with regulatory agencies. Recent news coverage of the incident suggests that large banks such as Chase and Citi will look to Target for reimbursement of their own investigation and notification costs, thus further increasing the chance of litigation arising out of the breach. Additionally, Target's reputation has been affected and it has had to deal with public relations in both traditional media and social networking. Target received sharp criticism for its purported delay in advising its customers of the breach and for its mixed messages concerning whether customer PIN information was stolen. According to the Ponemon

2013 Cost of Data Breach Study, the average cost of a breached record is $188. This means that based on the 40,000,000 Target customers that had their credit and debit card numbers stolen, the total cost amounts to $752,400,000. Putting that amount aside for a moment, the cost just to mail notification letters to the 40,000,000 customers affected is $18,480,000. These amounts, needless to say are significant. However, for a company such as Target these will not force Target out of business even if they don't have a cyber/data breach insurance policy. Cyber insurance might cover paying for customer damage due to identity theft as well as defense costs in the event or offering a one-year credit monitoring service to the customer affected.

It is possible that Target's general liability insurance may be triggered by the class action lawsuits alleging violations of privacy. General liability insurance, however, likely will not cover Target's costs associated with investigation, communications and business interruption, all of which could be significant given the magnitude of the breach. It was reported that Target does have $100m of cyber insurance, with a $10m self-insured retention. Typically, when a business carries a high level of coverage, a "tower" is built with several insurers sharing in the risk. In effect, insurers do not want to take on the entire risk themselves. This is the case with Target's cyber insurance policy coverage limits, which are split up amongst several insurers.

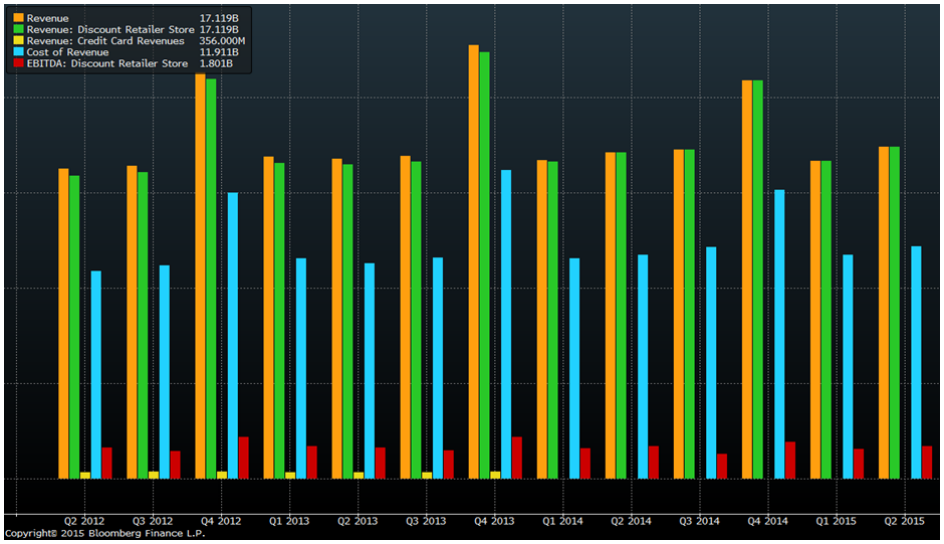


Figure 3 Revenue trend after the breach

It seems that revenues had not been affected much after the breach as Figure 3 shows where the usual cyclical drop from the fourth quarter to the first quarter is seen. But in Figure 4, it clearly shows Target's strategy after the breach to reduce operating costs in order to recover from the loss during the breach.

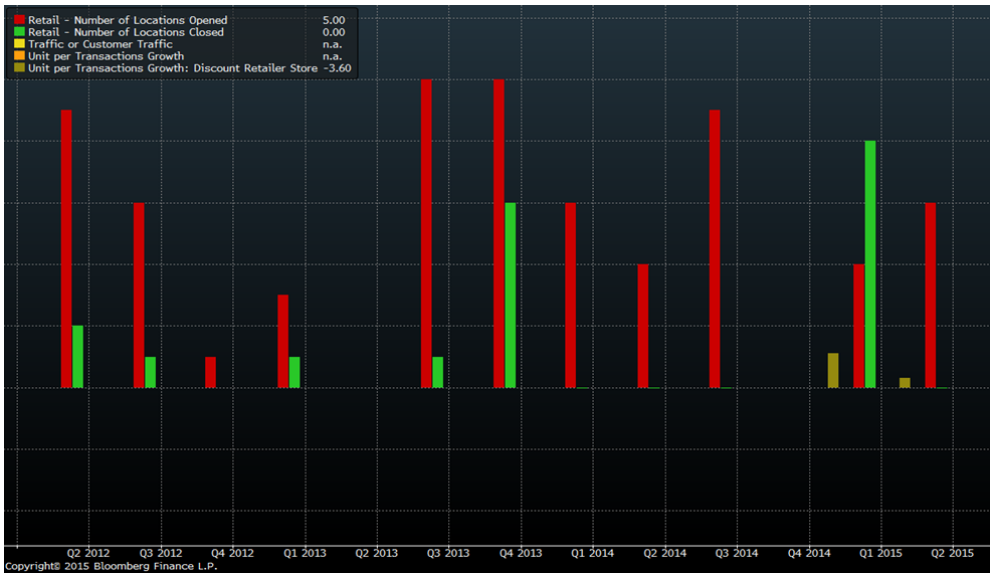


Figure 4 New stores opened and closed - Target

However, the crisis management does not seem to be a success. Table 1 shows

several accounting multiples after the breach. The growth rate of Target does not show a cyclical trend. Instead, it suffers a continuous loss right after the breach and the growth even becomes worse one year after the breach. This indicates that Target fails to control the crisis and also the new policy introduced is not fully effective.

Table 1 Income statement of Target Corp from Q1 2013 to Q2 2015

Target Corp (TGT US) - corp										
In Millions of USD except Per Share	Q2 2015	Q1 2015	Q4 2014	Q3 2014	Q2 2014	Q1 2014	Q4 2013	Q3 2013	Q2 2013	Q1 2013
3 Months Ending	08/02/2014	05/03/2014	02/01/2014	11/02/2013	08/03/2013	05/04/2013	02/02/2013	10/27/2012	07/28/2012	04/28/2012
Cash Flow/Basic shr	1.57	0.82	2.79	1.02	1.38	5.03	3.05	1.34	1.77	1.96
Net Inc Growth	**-61.70**	**-16.06**	**-45.89**	**-46.47**	**-13.21**	**-28.55**	**-2.04**	**14.77**	**0.00**	**1.16**
Op income growth	-27.65	-27.41	-21.16	-39.60	-9.80	9.57	-1.88	10.12	-3.46	1.66
Sales Growth	**1.69**	**-0.29**	**-8.07**	**1.94**	**2.01**	**-0.95**	**6.75**	**3.21**	**3.32**	**5.85**
Price Earnings Ratio (P/E)	17.03	16.78	15.72	17.16	17.90	17.30	14.27	14.65	13.94	13.20
Price to Book Ratio	2.31	2.38	2.21	2.53	2.82	2.74	2.38	2.56	2.53	2.43
Price/Sales	0.52	0.55	0.50	0.56	0.63	0.63	0.55	0.59	0.57	0.55
Price/Cashflow	9.65	10.30	5.54	6.16	6.62	6.30	7.53	7.31	7.36	6.88
Cash Flow - 1 Yr Growth	13.08	-83.90	-10.62	-26.57	-24.48	147.13	-19.60	37.25	-9.35	24.24
EBITDA Growth Year over Year	-14.87	-21.14	-24.65	-25.48	-6.22	7.17	-2.47	6.49	-1.33	2.14
Total Debt to EV	0.28	0.25	0.28	0.27	0.24	0.25	0.31	0.31	0.32	0.31
VWAP (Vol Weighted Average Price)	59.67	62.13	56.52	64.63	71.45	70.51	61.22	63.86	61.55	58.21
Last Price	59.85	62.01	56.64	64.62	71.50	70.50	61.15	63.92	61.52	58.26
T debt/Com eqty	86.16	77.99	84.91	91.53	90.44	86.04	106.58	113.47	116.46	110.00
Market Capitalization to Book Value	2.31	2.38	2.21	2.53	2.82	2.74	2.38	2.56	2.53	2.43
Free Cash Flow	503.0	49.0	1,764.0	-278.0	-137.0	2,329.0	1,038.0	142.0	390.0	478.0

Source: Bloomberg

After the resignation of the CEO, Target makes changes to expand to Canada and to focus more on online services. It is the main reason in figure 4, it closed a great number of retail stores in the U.S. Unfortunately, the expansion to Canada did not prove to be strong and aftershocks of the massive data breach resulted in a 62% drop in the net income from $611 million a year earlier to $234 million. Adding new stores in Canada only helped the sales climb 0.7%. The data breach costs, although offset by $38 million insurance payouts, made Target wrestle with weak U.S sales. With an aim to further reduce costs, Target started to lose reputation on its trendy clothes with affordable prices. Retailing industry always comes with fierce competition and the cut-cost strategy undoubtedly put Target into the dilemma of potential customer loss.

What is it that businesses and retailers can learn from the attack? Firstly, Point-of-Sale (PoS) targeted malware is on the rise. Over the past few years, experts in the Information and Technology sector have noticed a steady increase in malware that specifically targets PoS systems, and this Target breach illustrates just how popular it has become with cyber criminals.

It has also brought to public attention that the US must update its credit and debit card standards. Without going into all the technical details, most of the data stored on magnetic stripe cards are stored in clear text, and you can easily recover or clone the data with a cheap reader. EMV (stands for Europay, MasterCard, and Visa - the original card schemes that developed it; the standard covers the processing of credit and debit card payments using a card that contains a microprocessor chip) cards actually have small microprocessors on them. It makes it much harder for attackers to clone cards and use them for in-person, fraudulent purchases. To reap the benefit of EMV's additional security, retailers, payment processors, and everyone that takes cards will have to update their infrastructure to use these new cards. Over the past years the US seems to have started this migration. However, these cards still have their magnet stripes to fall back on. Until the entire industry makes the jump, no one will realize the benefits of EMV.

Figure 5: Target Daily Price Data from April 1st,2005 to December 31st, 2014

Figure 5 shows the daily stock price of Target, with the breach period highlighted. The impact may involve innovations in Target's information system, staff mode, the new technology of online and in-store shopping and large shareholder change. On the customer side, it may affect their future purchases in Target or other retailing companies, expectation of security intensive fields and purchase method choice.

Here, we first examine the event study with daily data of Target from April 1st, 2005 to December 31st, 2014. Figure 6 shows daily stock return trends in a ten-year window. The variance of stock return became larger during the 2008 to 2009 financial crisis, where the dots are dense. The breach does not change the trend of the stock returns. Figure 7 also shows the extreme values of stock price are more likely to occur during year 2008. The dots marked the observations that are one standard deviation above minimum price. The security breach does not show great influence due to an overall minimum stock price chosen.

Figure 6: Daily returns data

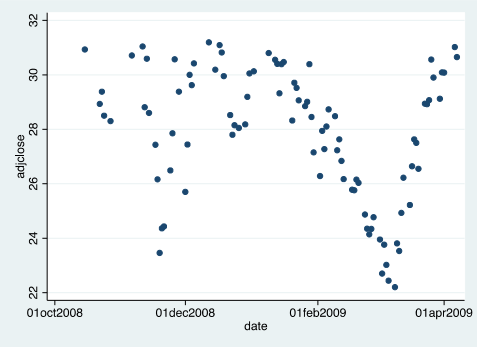


Figure 7: Frequency allocation one Std deviation above minimum

3.2 Daily time series model

The daily stock returns of Target Corp tend to be smooth after the financial crisis of 2008, and for the window chosen after the breach. There is a large decline in the stock price after January 2014. Specifically, prices that are one standard above the minimum price mostly happened during the crisis as shown in Figure 3.

The daily stock data of Target from Yahoo Finance are from April 1st, 2005 to December 31st, 2014 containing adjusted close price (adjusted by dividend), highest price, lowest price and volume. Daily French-Fama three-factor data comes from Kenneth French data library[14]. There is a choice in the database named *rmrf*, which is supposed to be market returns minus risk free rate. In the following parts if the paper, to avoid second hand data, this paper no more uses this *rmrf* variable. Instead, it calculated market return based on S&P index from FRED[15]. However, in this case, since three is no daily risk free rate, the model just treats *rmrf* as a given variable. Daily data is not balanced since there are gaps for holidays and weekends so the return was calculated based on the same gap assumption. There are 2369 observations

[14] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[15] Federal Reserve Bank of St. Louis Economics Research

with daily stock price data.

A breach dummy was generated to study its impact on company returns. The dummy was set to be one from December 1st through January 31st. The sign of the dummy is negative but not as large as expected, but the t-value is statistically significant at the 5% level. *pre_tgt* is premium of the market which equals to return of the company minus risk free rate. *smb* and *hml* are Fama French factors as mentioned above.

The following table shows regression results based on the traditional CAPM model. The Breach dummy is chosen to be one from Dec 18th, 2013 to Jan 20th, 2014. The result cannot reject a non-zero coefficient of the breach at 95% significant level. This model also has a significant market beta level which is above 0.9.

Table 2a Daily time series analysis based on CAPM

Linear regression					Number of obs	1923
					F(2, 1920)	178.68
					Prob > F	0
					R-squared	0.401
					Root MSE	0.01478
pre_co	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
pre_mkt	.9599265	0.0508658	18.87	0	0.8601684	1.059685
breach	-.0049411	0.0022297	-2.22	0.027	-0.009314	-0.0005683
_cons	-.000011	0.0003385	-0.03	0.974	-0.0006748	0.0006528

French Fama three-factor model is first introduced by Eugene Fama and Kenneth French in 1994[16]. The Fama-French three factors model is an extension of the traditional CAPM by adding size and value factors in additional to the market risk

16 Fama, Eugene F., and Kenneth R. French. "Industry costs of equity." Journal of financial economics 43.2 (1997): 153-193.

factor in CAPM. It considers the fact that small cap stocks outperform markets on a regular basis. Small company stocks (small cap) tend to act very differently than large company stocks. The value factor captures the property in owning out-of-favor stocks that have attractive valuations. Value stocks are those who tend to have lower earnings growth rate, higher dividends and lower prices compared to their book value. In the long run, value stocks have generated higher returns than growth stocks, which have higher stock prices and earnings. It is all due to the higher risk of value stocks.

Table 2b Daily time series analysis based on Fama French

Linear regression — Number of obs = 1923; F(4, 1918) = 113.05; Prob > F = 0.0000; R-squared = 0.4012; Root MSE = .01478

pre_co	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
pre_mkt	.97038	.0584389	16.61	0.000	.8557695	1.084991
smb	-.0004161	.0010987	-0.38	0.705	-.0025709	.0017387
hml	-.0003872	.0010098	-0.38	0.701	-.0023677	.0015933
event	-.0049518	.0022566	-2.19	0.028	-.0093774	-.0005262
_cons	-6.85e-06	.0003384	-0.02	0.984	-.0006705	.0006568

$$pre\_tgt = 0.97\,pre\_mkt - 0.0004\,smb - 0.0003hml - 0.004breach\_dummy$$
$$(0.0584) \qquad (0.001) \qquad (0.001) \qquad (0.0022)$$

The above regression shows a 0.97 market beta with negative sign on event dummy. The coefficient of the breach dummy is reported to be nonzero at a 5% significance level.

3.3 Sector panel data

Data description

The company level data starts from April 2005 to December 2014, quarterly data. The variable ‘price’ is calculated by taking the average of adjusted-close price within each quarter. The time range for the price in the retailing sector is April 1st, 2005 to

October 20th, 2014 and April 1st. The risk free rate is the 3-month Treasury Bill return rate from FRED, quarterly data. The market return rate is obtained from the S&P500 and the three factors, small-big, high-low French-Fama are from Kenneth French website.

Table 3 Variable setting of Fama-French model

Company Variable (quarterly)	original form
Price	daily
Periodic Total Debt to EV	quarterly
EBITDA	quarterly
Free Cash Flow/Basic Shr	quarterly
Tot Debt to Common Equity	quarterly
Return on Common Equity	quarterly
Price Earnings Ratio (P/E)	quarterly
Price to Book Ratio	quarterly
Price to Sales Ratio	quarterly
French-fama Variable	
market return S&P	quarterly
small(market capitalization) minus big factor	quarterly
high(book-to-market ratio)minues low factor	quarterly
risk free (3-month tbill)	annally
Regression variable	
Target breach dummy: equals to one after the breach	
Target company dummy	
Breach dummy: equals to one only for quarter four, 2013	

The twenty comparable companies are chosen from retailing companies that are listed in Table 4. These companies were chosen based on market value, company scale, growth rate and product similarity.

Here is a description of the twenty companies.

Table 4 Description of 20 Retail companies

Company name	**Stock code**	**Description**
Amazon.com Inc.	AMZN US	Amazon.com, Inc. operates as an online retailer in North America and internationally. The company serves consumers through retail Websites and include merchandise and content purchased for resale from vendors and those offered by third-party sellers. It manufactures

		and sells electronic devices and provides online publisher platfor. Amazon.com, Inc. was founded in 1994 and is headquartered in Seattle, Washington.
AutoZone, Inc.	AZO US	AutoZone, Inc. retails and distributes automotive replacement parts and accessories in the United States. The company offers various products for cars, sport utility vehicles, vans, and light trucks, including new and remanufactured automotive hard parts, maintenance items, accessories, and non-automotive products. It also provides A/C compressors, batteries and accessories as well as discretionary products.
Costco Wholesale Corporation	COST US	The company offers branded and private-label products in a range of merchandise categories. It provides dry and institutionally packaged foods and institutional supplies, appliances, electronics, health and beauty aids, hardware, garden and patio, and office supplies and engages in the travel business. Costco Wholesale Corporation also sells its products through online. The company, formerly known as Costco Companies, Inc., was founded in 1976 and is based in Issaquah, Washington.
CVS Health Corporation	CVS US	CVS provides integrated pharmacy health care services in the United States.The Pharmacy Services segment offers pharmacy benefit management services and specialty pharmacy services, retail pharmacy network management services, prescription management systems, clinical services, disease management programs, and medical pharmacy management services.
Dollar General Corporation	DG US	Dollar General Corporation, a discount retailer, provides various merchandise products in the southern, southwestern, midwestern, and eastern United States. The company offers consumable products and laundry and other home cleaning supplies. It also provides seasonal products and automotive and home office supplies. Dollar General Corporation was founded in 1939 and is based in Goodlettsville, Tennessee.
Genuine Parts Company	GPC US	Genuine Parts Company distributes automotive replacement parts, industrial replacement parts, office products, and electrical/electronic materials in the United States, Canada, Mexico. It distributes automotive replacement parts for imported vehicles.The company also distributes industrial replacement parts and related supplies.
Nordstrom Inc.	JWN US	Nordstrom, Inc., a fashion specialty retailer, offers apparel, shoes, cosmetics, and accessories for men, women, and children in the United States and Canada. The Retail segment offers a selection of brand name and private label merchandise through various channels. The Credit segment operates Nordstrom fsb, a federal savings bank. he company was founded in 1901 and is based in Seattle, Washington.

L Brands, Inc.	LB US	L Brands, Inc. operates as a specialty retailer of women intimate and other apparel, beauty and personal care products, and accessories. Its products include clothes and bathware. L Brands, Inc. was founded in 1963 and is headquartered in Columbus, Ohio.
Liberty Interactive Corp	LINTA US	Liberty Interactive Corporation (Liberty), incorporated on February 28, 2006, owns interests in subsidiaries and other companies, which are engaged in the video and on-line commerce industries in North America, Europe and Asia.
Lowe's Companies Inc.	LOW US	Lowes Companies, Inc. operates as a home improvement retailer. The company offers products for maintenance, repair, remodeling, and home decorating. It provides home improvement products under the categories of kitchens and appliances and installation services through independent contractors. Lowes Companies, Inc. was founded in 1946 and is based in Mooresville, North Carolina.
Macy's, Inc.	M US	Macy's, Inc., together with its subsidiaries, operates stores and Internet Websites in the United States. Its stores and Websites sell a range of merchandise. In addition, it operates as a beauty products and spa retailer. Macys, Inc. was founded in 1830 and is headquartered in Cincinnati, Ohio.
Netflix, Inc.	NFLX US	Netflix, Inc., an Internet television network, engages in the Internet delivery of TV shows and movies directly on TVs, computers, and mobile devices in the United States and internationally. It also provides DVDs-by-mail membership services. Netflix, Inc. was founded in 1997 and is headquartered in Los Gatos, California.
O'Reilly Automotive Inc.	ORLY US	OReilly Automotive, Inc., together with its subsidiaries, engages in the retail of automotive aftermarket parts, tools, supplies, equipment, and accessories in the United States. The company provides new and remanufactured automotive hard parts.OReilly Automotive, Inc. was founded in 1957 and is headquartered in Springfield, Missouri.
The Priceline Group Inc.	PCLN US	The Priceline Group Inc. provides online travel and travel related reservation and search services. The company operates Booking.com, which provides online accommodation reservation services; and priceline.com that offers hotel, rental car, and airline ticket reservations services, as well as vacation packages and insurance. The Priceline Group Inc. was founded in 1997 and is headquartered in Norwalk, Connecticut.
Ross Stores Inc.	ROST US	Ross Stores, Inc., together with its subsidiaries, operates off-price retail apparel and home fashion stores. It primarily offers apparel, accessories, footwear, and home fashions. Ross Stores, Inc. was founded in 1957 and is headquartered in Dublin, California.
The TJX Companies, Inc.	TJX US	The TJX Companies, Inc. operates as an off-price apparel and home fashions retailer in the United States and internationally. The company sells family apparel such as home basics. The TJX

		Companies, Inc. was founded in 1956 and is headquartered in Framingham, Massachusetts.
Target Corp.	TGT US	Target Corporation operates as a general merchandise retailer in the United States and Canada. It offers household essentials, and paper products. In addition, it offers in-store amenities and it provides REDcard credit and debit cards, which offer 5 percent discount on purchases.Target Corporation was founded in 1902 and is headquartered in Minneapolis, Minnesota.
Walgreens	WAG US	The Walgreen Company is the largest drug retailing chain in the United States. As of May 31, 2014, the company operated 8,217 stores in all 50 states, the District of Columbia, Puerto Rico and the U.S. Virgin Islands.
Wal-Mart Stores Inc.	WMT US	Wal-Mart Stores, Inc. operates retail stores in various formats worldwide. It operates discount stores, supermarkets, supercenters, hypermarkets, warehouse clubs, cash and carry stores, home improvement stores, specialty electronics stores, restaurants, apparel stores, drug stores, and convenience stores. The company was founded in 1945 and is headquartered in Bentonville, Arkansas.

The first regression with a panel of retailing companies is based on classic CAPM asset pricing model. The Target dummy is set to be one if quarter is after the breach in quarter 4 of 2013. The regression shows a 0.91 market beta with a negative sign of target dummy，which means there is a negative effect on the retailing sector after the breach and, moreover, this negative impact applied to all retailing companies. Both market premium and the security breach dummy have a significant level in the regression.

Table 5 Panel with quarterly analysis within retailing based on CAPM

Random-effects GLS regression				Number of obs =	685
Group variable: co				Number of groups =	19
R-sq: within = 0.2396				Obs per group: min =	19
between = 0.0174				avg =	36.1
overall = 0.2324				max =	37
				Wald chi2(2) =	60.62
corr(u_i, X) = 0 (assumed)				Prob > chi2 =	0.0000
			(Std. Err. adjusted for 19 clusters in co)		

pre_co	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
pre_mkt	.9108054	.1172764	7.77	0.000	.6809478	1.140663
target_dummy	-.0287788	.0081601	-3.53	0.000	-.0447723	-.0127854
_cons	.0289317	.006277	4.61	0.000	.0166289	.0412345
sigma_u	.0156196					
sigma_e	.12455731					
rho	.01548194	(fraction of variance due to u_i)				

$$pre\_co = 0.86\,pre\_mkt + 0.004\,smb - 0.012\,hml - 0.0952013\_q4 - 0.029\,tgt\_dummy + [co1 - co19]$$
$$(.11) \qquad (.0012) \qquad (.001) \qquad (.0057) \qquad (.006)$$

The following shows the retailing industry analysis based on Fama-French model. The significant level of the breach dummy is reduced to eighty percent, with which the result cannot draw a conclusion of how the breach really affected the retailing companies on an industry level. The reason might be the unbalanced time frequency of this model, the way this model chooses the dummy and the model itself. Intuitively, when think about the spillover effect of the security breach to the whole company, one often neglect the compensate effect of an event. In addition to the loss of trust of retailing companies as a whole, it is possible that people seek other retailing companies other than Target to purchase, which may also cause the raise in revenue of the competitors of Target's. Thus it provides a way in explaining the insignificance of breach dummy.

Table 6 Quarterly time series analysis within retailing based on Fama-French

Random-effects GLS regression				Number of obs =	685
Group variable: co				Number of groups =	19
R-sq: within = 0.2461				Obs per group: min =	19
between = 0.0174				avg =	36.1
overall = 0.2387				max =	37
				Wald chi2(4) =	87.84
corr(u_i, X) = 0 (assumed)				Prob > chi2 =	0.0000
			(Std. Err. adjusted for 19 clusters in co)		
	Robust				
pre_co	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
pre_mkt	.8736798	.1154397	7.57	0.000	.6474222 1.099937
smb	.0040196	.0014576	2.76	0.006	.0011626 .0068765
hml	-.0010734	.0010713	-1.00	0.316	-.0031731 .0010263
target_dummy	-.0129072	.0108027	-1.19	0.232	-.0340801 .0082656
_cons	.0262535	.0059664	4.40	0.000	.0145596 .0379474
sigma_u	.01569768				
sigma_e	.12421092				
rho	.01572062	(fraction of variance due to u_i)			

3.4 Cross-industry time series panel

3.4.1 Difference in difference method

A classic use of the differences-in-differences method was Card and Krueger (1994). Basically, it calculates the effect of a treatment group on an outcome (policy) by comparing the average change over time between the treatment group and the control group and it measures the difference in the difference between the treatment and control group over time. As Figure 8 shown below, the first difference is the treatment gap of treatment group between time 1 and time 0. The second difference is the treatment gap of control group through time 1 and time 0. Thus difference in difference means the gap between two differences, which is treatment group difference subtracting from control group difference.

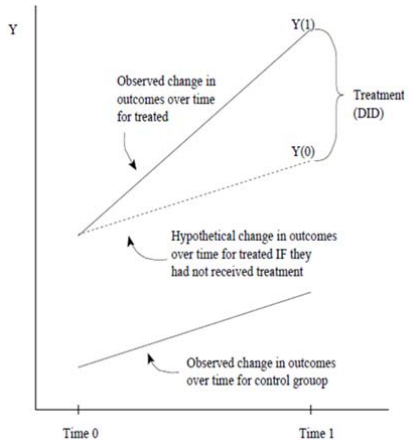


Figure 8 Differences-in-differences method

In this way, assuming the outcome variable to be y, denoting time dummy before and after the policy to be 0 and 1, the difference in difference can be calculated as $(y_{treated,1} - y_{treated,0}) - (y_{control,1} - y_{control,0})$.

In my study, I compared the stock market price of retailing companies along with an unrelated industry, the environmental companies, to see if Target security breach has a spillover effect to the retailing industry as a whole. The CAPM model shows a significant negative impact of the breach to the whole retail industry, but when it comes to the Fama-French model, which is supposed to be a more accurate asset pricing model, the confidence level dropped. The thought of involving an unrelated industry is to avoid general market trends. The environmental sector is often less affected by outside shocks and has a positive connect to general economy trends. When the economy goes well, the demand of energy and environmental industry might increase. Besides, it is unrelated to the retail industry. Thus it can be used as a control group for the differences-in-differences study.

In this case, the differences-in-differences regression can be written as follows:

$$pre\_co = \beta_0 pre\_mkt + \beta_1 tgt\_dummy + \beta_2 industry + \delta industry * tgt\_dummy + ...$$
$$\delta = (y_{retail,after} - y_{retail,before}) - (y_{environment,after} - y_{environment,before})$$

This equation shows the coefficient of the interaction variable is the differences-in-differences estimator.

3.4.2 Difference in difference regression

The eight companies in environment industry are listed below. The time range for environmental group is 2005 to December 31st 2014 for the environmental companies

Table 7 Eight environmental companies and their brief introduction.

Company name	Stock code	Description
Progressive Waste Solutions Ltd.	BIN US	Progressive Waste Solutions Ltd. operates as a vertically integrated non-hazardous solid waste management company in North America. The company engages in the collection, transfer, disposal, and recycling of non-hazardous solid waste to commercial, industrial, and residential customers. It was founded in 2001 and is headquartered in Vaughan, Canada.
Clean Harbors, Inc.	CLH US	Clean Harbors, Inc. provides environmental, energy, and industrial services in North America. The company's Technical Services segment provides hazardous material management services and non-hazardous waste at its incineration, landfill, wastewater, and other treatment facilities. Clean Harbors, Inc. was founded in 1980 and is headquartered in Norwell, Massachusetts.
US Ecology, Inc.	ECOL US	US Ecology, Inc., through its subsidiaries, provides environmental services to commercial and government entities in the United States. It operates in two segments, Environmental Services; and Field & Industrial Services. It serves oil refineries and other industrial customers. US Ecology, Inc. was founded in 1952 and is headquartered in Boise, Idaho.
Perma-Fix Environmental Services Inc.	PESI US	Perma-Fix Environmental Services, Inc. operates as an environmental and technology know-how company in the United States. The companys Treatment segment offers nuclear, low-level radioactive, mixed, hazardous, and non-hazardous waste treatment, processing, and disposal services through licensed and permitted treatment and storage facilities. It was founded in 1990 and is based in Atlanta, Georgia.
Republic Services, Inc.	RSG US	Republic Services, Inc., together with its subsidiaries, provides non-hazardous solid waste collection, transfer, recycling, and disposal services for commercial, industrial, municipal, and residential customers in the United States. The company's residential collection operations include the curbside collection of refuse and commercial and industrial collection operations. Republic Services, Inc. was founded in 1996 and is based in Phoenix, Arizona.
Skanska AB (publ)	SKA-B.ST SS	Skanska AB (publ), a construction and project development company, develops and constructs commercial properties, and residential and public-private partnerships projects in the Nordic region, Europe, and the United States. It operates through four segments:

		Construction, Residential Development, Commercial Property Development, and Infrastructure Development.Skanska AB was founded in 1887 and is headquartered in Stockholm, Sweden.
Waste Connections Inc.	WCN	Waste Connections, Inc. provides solid waste collection, transfer, disposal, and recycling services primarily in the United States. It offers collection services to residential, commercial, industrial, and E&P customers; landfill disposal services; and recycling services for various recyclable materials. The company also owns and operates transfer stations that receive compact and load waste to be transported to landfills or treatment facilities. Waste Connections, Inc. was founded in 1997 and is headquartered in The Woodlands, Texas.
Waste Management, Inc.	WM US	Waste Management, Inc., through its subsidiaries, provides various waste management environmental services to residential, commercial, industrial, and municipal customers in North America. It offer collection service and material recovery facility and operates landfill gas-to-energy facilities in the United States. Waste Management, Inc. was incorporated in 1987 and is headquartered in Houston, Texas.

The first results in Table 8.1 shows differences-in-differences (DID) regressions of the CAPM model. The breach dummy has a positive sign but is highly not significant. Also since the two industries are not comparable, the coefficient of industry1, although it is significant, shows no information about the breach. Importantly, the DID estimator is negative, but significant only at the 10% level. Therefore there is not much evidence to confirm a spillover impact within retailing group.

Table 8.1 DID under CAPM model

Random-effects GLS regression		Number of obs	= 981
Group variable: co		Number of groups	= 27
R-sq: within	= 0.2622	Obs per group: min	= 19
between	= 0.1209	avg	= 36.3
overall	= 0.2572	max	= 37
		Wald chi2(4)	= 98.05
corr(u_i, X)	= 0 (assumed)	Prob > chi2	= 0.0000

(Std. Err. adjusted for 27 clusters in co)

pre_co	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
pre_mkt	.9076894	.0919584	9.87	0.000	.7274542	1.087925
target_dummy	.0089627	.0208223	0.43	0.667	-.0318483	.0497737
industry1	.0212529	.0107939	1.97	0.049	.0000973	.0424085
industry1_target_~y	-.0376358	.0224966	-1.67	0.094	-.0817283	.0064568
_cons	.0077014	.0090884	0.85	0.397	-.0101115	.0255143
sigma_u	.01505046					
sigma_e	.11778734					
rho	.01606456	(fraction of variance due to u_i)				

The following regression conducts DID regression under Fama-French model. The results are generally the same, with a decrease in market beta. There is no strong evidence to get the conclusion that the retailing industry performed worse after the security breach.

$$pre\_co = 0.86\,pre\_mkt + 0.003smb - 0.0004hml + 0.02breach + 0.021industry1 + -0.037industry1 * breach$$

$$(0.087) \qquad (0.001) \qquad (0.0008) \qquad (0.224) \qquad (0.0108) \qquad (0.0225)$$

Table 8.2 DID under Fama French model

Random-effects GLS regression		Number of obs =	981
Group variable: co		Number of groups =	27
R-sq: within = 0.2662		Obs per group: min =	19
between = 0.1210		avg =	36.3
overall = 0.2611		max =	37
		Wald chi2(6) =	143.42
corr(u_i, X) = 0 (assumed)		Prob > chi2 =	0.0000

(Std. Err. adjusted for 27 clusters in co)

pre_co	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
pre_mkt	.868042	.0876727	9.90	0.000	.6962068	1.039877
smb	.002908	.0011424	2.55	0.011	.0006689	.0051471
hml	-.0004378	.0008126	-0.54	0.590	-.0020305	.0011549
target_dummy	.0207933	.0224635	0.93	0.355	-.0232344	.0648211
industry1	.021266	.0108023	1.97	0.049	.000094	.0424381
industry1_target_~y	-.0376489	.0225243	-1.67	0.095	-.0817957	.006498
_cons	.0057852	.0092538	0.63	0.532	-.0123518	.0239222
sigma_u	.01509337					
sigma_e	.11759089					
rho	.01620796	(fraction of variance due to u_i)				

4 Price-to-Sales Ratio Analysis

Price-to-sales ratio (PS) is a valuation metric for stocks. It is calculated by dividing the company's market capitalization (the number) by the revenue in the most recent year. This ratio shows how much investors value every dollar of the company's sales. A low PS ratio can also be effective in valuing growth stocks that have suffered a temporary setback.

The reason for the ratio study is an unsatisfied confident level of the DID in the third part of the thesis. I consider a PS ratio regression model controlling for more firm level information including payout ratio, earnings growth rate and profit margin. Actually, with the definition of PS ratio, it is possible to rewrite it into other forms. With a two-stage equity valuation model, where g_n denotes dividend growth rate, PS ratio could be rewrite as:

$$PS = \frac{P_0}{Sales} = \frac{Net\ \ profit\ margin \cdot payout\ \ ratio \cdot (1+g_n)}{r - g_n} \quad (4.1)$$

Here the PS ratio is linked with growth rate of the company. It is the reason why PS ratio can be treated as a growth indicator in corporate finance.

In a highly cyclical industry, investors can use PS instead of price to earnings ratio to determine how much they are paying for a dollar of the company's sales rather than a dollar of its earnings. This ratio is used for spotting recovery situations or for double checking that a company begins to suffer losses.

Retailing companies typically displays a much higher PS ratio, so our PS ratio analysis is first conducted within the retailing group. Then, in the DID study, the PS ratio of the energy industry are only used to control the market change of PS ratio during the given event window. In this way, the analysis could avoid directly comparing PS ratio in two different industries.

4.1 PS Ratio for Retailing with fixed effects

The regression model used in this paper comes from the *Investment Valuation: Tools and Techniques for Determining the Value of Any Asset* by Aswath Damodaran (2012). When analyzing price-earnings and price to book value ratios, the models often use regressions to control for difference in risk, growth and payout ratio across firms.

The general model can be written, including EGR (earnings growth rate) as

$$PS = \beta_0 + \beta_1 Beta + \beta_2 EGR + \beta_3 Margin + \beta_4 Payout \quad (4.1.1)$$

where

PS=price/sales ratio at the end of each quarter

Beta=company beta of the stock

Margin=profit margin=Net income/sales

Payout=payout ratio=dividend/earnings

The model used in this part is an extension of a simple PS ratio and net profit margin regression which also takes account the company beta, payout ratio and earnings growth rate. This model allows a much broader view of the companies across sections. The panel data is used to estimate the PS ratio as a function of fundamental variables such as profit margin, dividend payout, beta and growth rate in earnings.

The quarterly data are from Bloomberg. There is no company beta for most firms so I used a best beta indicator as an approximation. Due to the inconsistency of PS ratio, it is not calculated from sales and equity.

The following table shows a regression of PS ratio for the panel. The company beta is significant and has a positive impact to the PS ratio.

Table 9 PS ratio for retailing group

Fixed-effects (within) regression	Number of obs = 746					
Group variable: co	Number of groups = 18					
ps_avg	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
payout	-0.0001991	0.0003313	-0.6	0.548	-0.0008495	0.0004513
beta	0.0684323	0.027473	2.49	0.013	0.014496	0.1223686
profit_mar	0.0063055	0.001815	3.47	0.001	0.0027421	0.0098688
EGR	-0.000603	0.0003013	-2	0.046	-0.0011944	-0.0000116
_cons	1.149102	0.033834	33.96	0	1.082678	1.215527
sigma_u	1.1877635					
sigma_e	0.59653652					
rho	0.7985689	(fraction of variance due to u_i)				
F test that all u_i=0: F(17, 724) = 99.37		Prob > F = 0.0000				

4.2 PS Ratio Analysis with Breach dummy

The following regression is based on PS ratio for Target company dummy, breach dummy and interaction with random effects. Most companies (retailing group) performed better after the breach in the fourth quarter of 2013. However, Target

performed worse after the breach and the overall performance has been affected. The sign of the breach dummy remains to be positive, thus it is hard to verify the spillover effect from Target to the whole retailing group in the PS model. However, all the dummy variables shows significant results.

Table 10 PS ratio event study - random effects

Random-effects GLS regression				Number of obs = 746		
Group variable: co				Number of groups = 18		
ps_avg	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
payout	-0.0004527	0.0003188	-1.42	0.156	-0.0010775	0.0001721
beta	0.0648403	0.0263367	2.46	0.014	0.0132213	0.1164592
profit_mar	0.0042441	0.0017584	2.41	0.016	0.0007976	0.0076905
EGR	-0.0004433	0.000289	-1.53	0.125	-0.0010096	0.0001231
tgt	-0.5854673	0.8695435	-0.67	0.501	-2.289741	1.118807
breach	0.5743512	0.0634735	9.05	0	0.4499454	0.698757
tgt_breach	-0.6523987	0.2568927	-2.54	0.011	-1.155899	-0.1488982
_cons	1.251761	0.2079208	6.02	0	0.8442436	1.659278
sigma_u	0.8307499					
sigma_e	0.56530206					
rho	0.68350729 (fraction of variance due to u_i)					

4.3 PS ratio regression

4.3.1 PS ratio regression with company fixed effects

The following regression modifies the previous independent variables by adding an interaction variable of Target company, the breach dummy and company fixed effects. This regression doesn't change much of the coefficients of Target and the breach dummy along with their significance levels. The interaction is highly significant with a negative sign, which means a negative impact for Target after the breach. Also, the absolute value of the coefficient of the interaction variable is greater than the Target dummy itself.

Table 11 PS ratio event study robust

(Std. Err. adjusted for 18 clusters in co)

ps_avg	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
payout	-0.0004527	0.0002897	-1.56	0.118	-0.0010204	0.000115
beta	0.0648403	0.0429394	1.51	0.131	-0.0193193	0.1489998
profit_mar	0.0042441	0.0034425	1.23	0.218	-0.002503	0.0109912
EGR	-0.0004433	0.0004729	-0.94	0.349	-0.0013701	0.0004836
tgt	-0.5854673	0.2679599	-2.18	0.029	-1.110659	-0.0602755
breach	0.5743512	0.2145621	2.68	0.007	0.1538172	0.9948853
tgt_breach	-0.6523987	0.2313238	-2.82	0.005	-1.105785	-0.1990123
_cons	1.251761	0.2567699	4.88	0	0.7485012	1.755021
sigma_u	0.8307499					
sigma_e	0.56530206					
rho	0.68350729 (fraction of variance due to u_i)					

4.3.2 PS ratio regression with company and time fixed effects

The sign of 2013q4 are positive but it suffers a severe drop in absolute value compared to the former quarter. Traditionally, regardless of other factors, most consumers did more purchases during the fourth quarter because of holiday seasons and Thanksgiving sale. The target dummy has a positive sign, which is high above zero. In terms of the event dummy, the model set all the quarter after the breach to be one regardless of how far it is from the event window. This could result in a possible problem where Target recovered from the breach or due to the cyclicality of the retailing sector. The interaction is still negative and significant which is consistent with the previous model with no control over time and company factors.

Table 12 PS ratio regression with time and company effect

					(Std. Err. adjusted for 18 clusters in co)	
ps_avg	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
payout	-0.0001827	0.0002597	-0.7	0.482	-0.0006918	0.0003264
beta	0.0303393	0.0304655	1	0.319	-0.029372	0.0900506
profit_mar	0.0036379	0.0039935	0.91	0.362	-0.0041893	0.011465
EGR	-0.0005278	0.0004888	-1.08	0.28	-0.0014859	0.0004302
tgt	-1.32602	0.0625323	-21.21	0	-1.448581	-1.203459
breach	0.3790943	0.1371162	2.76	0.006	0.1103515	0.6478372
tgt_breach	-0.6636614	0.2625993	-2.53	0.011	-1.178347	-0.1489762
quarter						
214	0.2888691	0.1773145	1.63	0.103	-0.058661	0.6363992
2013q4	0.0715607	0.2276434	0.31	0.753	-0.3746121	0.5177335
216	0.031102	0.2760475	0.11	0.91	-0.5099411	0.5721451
217	0.0989901	0.2601393	0.38	0.704	-0.4108736	0.6088538
company						
Target Corp	3.349003	0.1320285	25.37	0	3.090232	3.607774
_cons	2.144156	0.0590452	36.31	0	2.02843	2.259883

4.4 PS ratio DID

4.4.1 PS ratio for energy industry robust regression

There are eight companies in the environment-energy sector. The robust regression shows the breach does not affect the environment-energy sector. The regression also shows a lower company beta of energy industry compared with retailing industry.

Table 13 PS ratio regression for control group

Random-effects GLS regression			Number of obs =	202		
Group variable: co			Number of groups =	8		
ps_avg	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
payout	-0.0013177	0.0007717	-1.71	0.088	-0.0028302	0.0001948
beta	0.125526	0.0943462	1.33	0.183	-0.0593893	0.3104412
profit_mar	0.0076321	0.0031917	2.39	0.017	0.0013764	0.0138877
EGR	-0.000983	0.0009777	-1.01	0.315	-0.0028992	0.0009331
breach	0.2696051	0.171409	1.57	0.116	-0.0663504	0.6055606
_cons	1.45559	0.200885	7.25	0	1.061862	1.849317
sigma_u	0.83339666					
sigma_e	0.38570159					
rho	0.82359428 (fraction of variance due to u_i)					

4.4.2 DID robust regression PS ratio regression

The model is

$$PSratio = -0.00049\,payout\_ratio + 0.77\,beta + 0.005\,profitmgn - 0.005\,EGR$$
$$-0.65\,tgt - 0.23\,industry + 0.53\,industry * breach$$

Table 14 PS ratio DID study

Random-effects GLS regression	Number of obs = 948					
Group variable: co	Number of groups = 26					
					(Std. Err. adjusted for 26 clusters in co)	
ps_avg	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
payout	-0.0004981	0.000316	-1.58	0.115	-0.0011175	0.0001212
beta	0.0774005	0.0430392	1.8	0.072	-0.0069547	0.1617557
profit_mar	0.0052293	0.0028393	1.84	0.066	-0.0003357	0.0107943
EGR	-0.0005296	0.000482	-1.1	0.272	-0.0014743	0.0004151
tgt	-0.6595232	0.2862744	-2.3	0.021	-1.220611	-0.0984356
industry	-0.2316444	0.3614843	-0.64	0.522	-0.9401406	0.4768517
indus_breach	0.5315824	0.2007383	2.65	0.008	0.1381427	0.9250222
_cons	1.480124	0.2357328	6.28	0	1.018097	1.942152
sigma_u	0.92295309					
sigma_e	0.53574944					
rho	0.74797168 (fraction of variance due to u_i)					

The interaction and target dummy are both significant, while the industry dummy is not. This differs from the results of the Fama-French model where the target dummy is not significant. The coefficient of the Target dummy is greater than the industry dummy in absolute value, which potentially shows that Target suffers more than the other retailing companies due to the breach, while the overall performance after the breach for retailing group is better. There is not much evidence to show that the price-to-sales ratios are different between the two sectors. The interaction DID variable is significant, however, unlike the previous panel regression under asset pricing model, it is highly above zero.

This shows an alternative way to explain what happened after the breach. Customers may have chosen to avoid purchasing at Target, however, with rigid

demands of most retailing companies, the goods are highly fungible and individuals may choose other retailors to complete the purchase instead of cutting budgets on all retailing companies.

5 Summary and Interpretations

I generally conducted three series of analysis in the event study. A three factor Fama-French model was used to analyze the significance and impact of the security breach. The first model involves only daily stock price data of Target Corporation under the asset pricing model. The regression shows a negative impact of the security breach, yet the significant level is not as high as expected. The second data set contains twenty comparable companies in the retailing industry based on their scale and past performance in the past ten years. The model regression then considers the company fixed effects of the breach and I obtained a significant negative coefficient on the event dummy which means the security breach had a negative impact on Target considering company factors. Moreover, I incorporated another industry to understand the potential spillover effect of the breach. The chosen eight companies of energy and environmental industry are used as control group, while the twenty companies in retailing are all considered as a treatment group in a five factor Fama-French model. The DID study is based on the interaction variable, which is shown to be negative, but the statistical evidence is weak. This means the credit card security breach could have potentially caused a spillover impact to the retailing industry as a whole.

To further understand the results of the asset-pricing model, in the third part, a PS ratio analysis is conducted to study the firm level performance of the companies after the event. By using PS ratio analysis, it is possible to uncover the breach impact separately from the price factor.

Although price is considered to contain all information of the market theoretically, it is inevitably affected by other non-event factors and has a time lag issue. The PS ratio analysis shows the same result as in previous parts, but it contains more information concerning the inner growth of the company and the competitive problem among retailing companies after the breach.

Table 15 Comparison of regression results

		Asset pricing model						PS Ratio Model	
		CAPM			Fama French				
		Daily	panel	DID	Daily	panel	DID	panel	DID
Market beta	Value	0.95900	0.91080	0.90770	0.97000	0.87367	0.86804		
	significance	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		
Breach dummy	Value	(0.00490)	(0.02870)	0.00896	(0.00490)	(0.01290)	0.02079	0.57430	
	significance	0.02700	0.00000	0.66700	0.02800	0.23200	0.35500	0.00700	
Target dummy	Value		(0.00874)					(0.58546)	(0.65900)
	significance		0.00000					0.02900	0.02100
Industry dummy	Value			0.02125			0.02126		(0.23164)
	significance			0.04900			0.00490		0.52200
DID dummy	Value			(0.03763)			(0.03764)		0.53150
	significance			0.09400			0.09500		0.00800

Table 15 shows a summary of all the regressions. The daily times series CAPM model and Fama-French model both show a negative impact of the breach and the effect is statistically significant. When it comes to quarterly panel data, the classic CAPM model shows a negative and significant event impact while the Fama-French model shows a negative but insignificant effect of the breach. The DID model confirmed a spillover effect from Target to all retailing companies but not a

significant t value. Then, in the third part, PS analysis shows a negative sign for Target dummy but a significant positive effect on breach dummy. The DID study shows a spillover effect on retailing group's PS ratio.

The PS ratio indicates how much investor paid for a share compared to the sales a company generated per share. Higher ratio means the market is willing to pay for each dollar of annual sales. PSR varies across industries. As mentioned in the fourth part, the increasing significant level and switching sign of the DID dummy could indicate a competitive factor after the breach.

Figure 9 Comparable company sales from Q4 2013 to Q3 2014

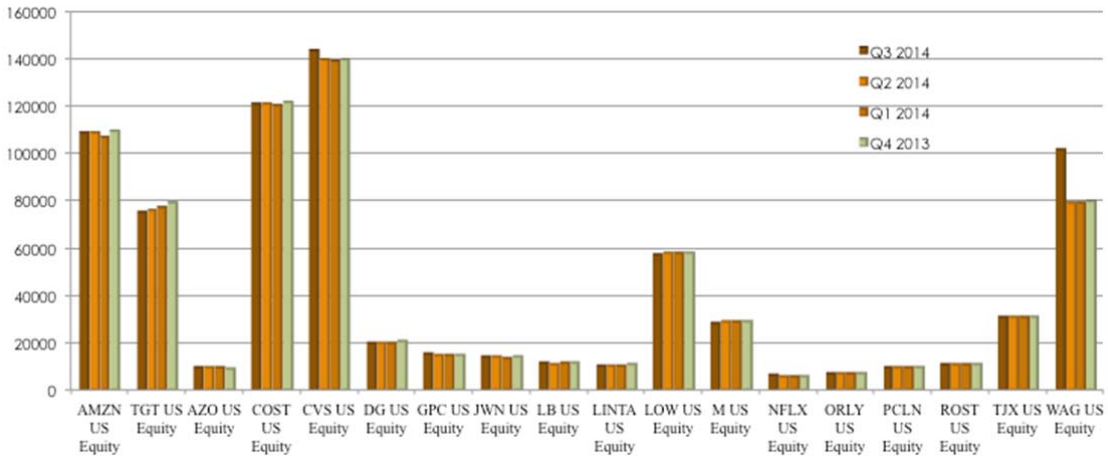
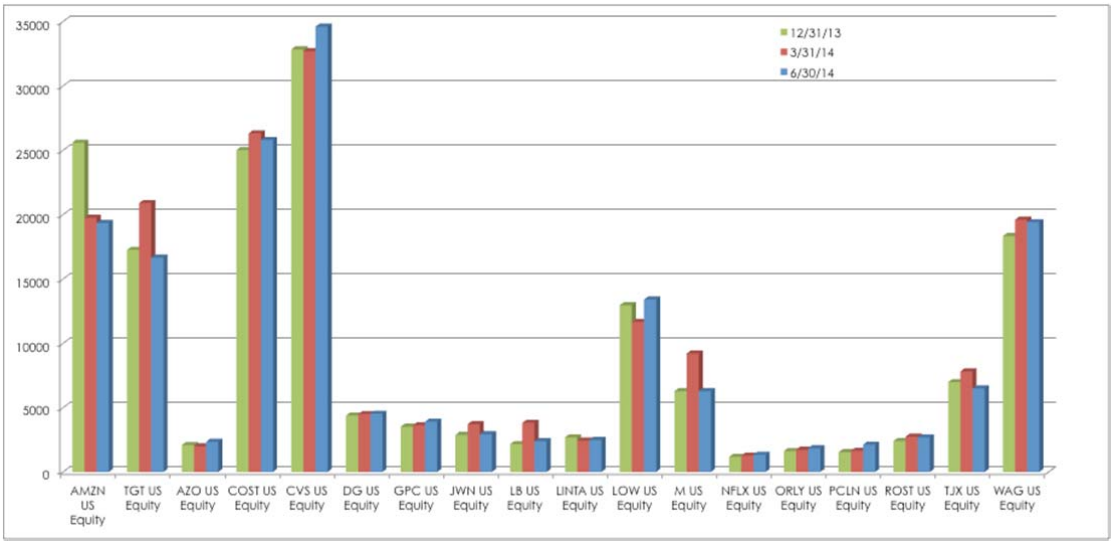


Figure 9 shows that, unlike other companies which have increasing trend in sales in 2014, Target suffered a continuous loss in sales after the breach.

Figure 10 shows an increase in revenue for Target in Q4 2013. However, it is mainly because the security breach is announced to the public at the end of 2013 thus does not affect much of the sales and revenue. It also shows a dramatic drop in revenue on the first quarter of 2014, when other companies have a rising revenue of the same quarter. It indicates the large costs of the security breach start to reflect on

the statements.

Figure 10 Comparable companies revenue from Q4 2013 to Q2 2014



6 Conclusion

This thesis engaged in an event study of the impact of a security breach to Target, a large retailing company headquartered in the U.S with service in both Canada and the U.S. The daily time series model verified negative impact of the breach. The panel Fama-French asset pricing model shows a negative impact of the breach not statistically strong. Thus, to verify the spillover impact on the retailing sector, the DID is used to eliminate the trend factor during the event window. It removes bias in second period comparisons between the treatment group and control group that could be the result of a permanent difference between those groups, as well as biases from comparisons over time in the treatment group that could be the result of trends. The treatment group in this model is retailing industry and the control group is environmental-energy industry. The DID estimator, although presented to be negative, is not highly statistically significant, only at the 10% level. It may indicate a spillover impact to other companies; however, it may also suggest that, due to the competitive market factor, the competitors would perform better after the breach thus making the overall impact undetermined.

The PS analysis is introduced to further uncover how firms actually acted because of the breach. The difference between the asset price model and PS ratio model is that the latter gives more firm level information and the determinants are company growth variables. The PS ratio analysis finally shows a significant result, but, interestingly, the coefficient of DID dummy is positive. This result indicates that the substitution effect dominates as customers were trying to seek Target's competitors based on rigid

demands. This results in the overall better performance of retailing industry as a whole.

In the business case study, I show some evidence of an unsuccessful crisis management of the breach, after the CEO resignation. Based on the hypotheses tested, the results obtained and taking real world business issues into consideration, Target has suffered from the security breach but spillover effects and inner firm growth cannot be interpreted as the consequence from one single security breach.

7 References

[1]. Armitage, Seth. "Event study methods and evidence on their performance."Journal of economic surveys 9.1 (1995): 25-52.

[2]. Barbee Jr, William C., Sandip Mukherji, and Gary A. Raines. "Do sales-price and debt-equity explain stock returns better than book-market and firm size?."Financial Analysts Journal 52.2 (1996): 56-60.

[3]. Barber, Brad M., and John D. Lyon. "Detecting long-run abnormal stock returns: The empirical power and specification of test statistics." Journal of financial economics 43.3 (1997): 341-372.

[4]. Bellman, Richard Ernest, and Kenneth L. Cooke. "Differential-difference equations." (1963).

[5]. Binder, John J. "Measuring the effects of regulation with stock price data." The RAND Journal of Economics (1985): 167-183.

[6]. Boehmer, Ekkehart, Jim Masumeci, and Annette B. Poulsen. "Event-study methodology under conditions of event-induced variance." Journal of Financial Economics 30.2 (1991): 253-272.

[7]. Bomfim Antulo, N. "Pre-Announcement Effects, News, and Volatility: monetary policy and the stock market"." Paper provided at the Federal Reserve in the series Finance and Economics Discussion Papers (October, 2000) (2000).

[8]. Brown, Stephen J., and Jerold B. Warner. "Using daily stock returns: The case of event studies." Journal of financial economics 14.1 (1985): 3-31.

[9]. Brown, Stephen J., and Jerold B. Warner. "Measuring security price performance." Journal of financial economics 8.3 (1980): 205-258.

[10]. Cowan, Arnold Richard. "Nonparametric event study tests." Review of Quantitative Finance and Accounting 2.4 (1992): 343-358.

[11]. Corrado, Charles J., and Terry L. Zivney. "The specification and power of the sign test in event study hypothesis tests using daily stock returns." Journal of Financial and Quantitative analysis 27.03 (1992): 465-478.

[12]. De Jong, Frank, Angelien Kemna, and Teun Kloek. "A contribution to event study methodology with an application to the Dutch stock market." Journal of Banking & Finance 16.1 (1992): 11-36.

[13]. Duso, Tomaso, Klaus Gugler, and Burcin Yurtoglu. "Is the event study methodology useful for merger analysis? A comparison of stock market and accounting data." International Review of Law and Economics 30.2 (2010): 186-192.

[14]. Domowitz, Ian, R. Glenn Hubbard, and Bruce C. Petersen. "Business cycles and the relationship between concentration and price-cost margins." The RAND Journal of Economics (1986): 1-17.

[15]. Dyckman, Thomas, Donna Philbrick, and Jens Stephan. "A comparison of event study methodologies using daily stock returns: A simulation approach." Journal of Accounting Research (1984): 1-30.

[16]. Dimson, Elroy, and Paul Marsh. "Event study methodologies and the size effect:

The case of UK press recommendations." Journal of financial Economics 17.1 (1986): 113-142.
[17]. Fama, Eugene F., and Kenneth R. French. "Industry costs of equity." Journal of financial economics 43.2 (1997): 153-193.
[18]. Fama, Eugene F., and G. William Schwert. "Asset returns and inflation." Journal of financial economics 5.2 (1977): 115-146.
[19]. Fama, Eugene F., and Kenneth R. French. "Common risk factors in the returns on stocks and bonds." Journal of financial economics 33.1 (1993): 3-56.
[20]. Fisher, Franklin M. "On the misuse of the profits-sales ratio to infer monopoly power." The Rand Journal of Economics (1987): 384-396.
[21]. Hou, Kewei. "Industry information diffusion and the lead-lag effect in stock returns." Review of Financial Studies 20.4 (2007): 1113-1138.
[22]. Hand, John RM, Robert W. Holthausen, and Richard W. Leftwich. "The effect of bond rating agency announcements on bond and stock prices." The journal of finance 47.2 (1992): 733-752.
[23]. Hand, John RM, Robert W. Holthausen, and Richard W. Leftwich. "The effect of bond rating agency announcements on bond and stock prices." The journal of finance 47.2 (1992): 733-752.
[24]. Hautsch, Nikolaus, and Dieter Hess. "Bayesian learning in financial markets: Testing for the relevance of information precision in price discovery." Journal of Financial and Quantitative Analysis 42.01 (2007): 189-208.
[25]. Im, Kun Shin, Kevin E. Dow, and Varun Grover. "Research report: A reexamination of IT investment and the market value of the firm—An event study methodology." Information systems research 12.1 (2001): 103-117.
[26]. Kale, Prashant, Jeffrey H. Dyer, and Harbir Singh. "Alliance capability, stock market response, and long-term alliance success: The role of the alliance function." (2002).
[27]. Kross, William, and Douglas A. Schroeder. "An empirical investigation of the effect of quarterly earnings announcement timing on stock returns." Journal of Accounting Research (1984): 153-176.
[28]. McWilliams, Abagail, and Donald Siegel. "Event studies in management research: Theoretical and empirical issues." Academy of management journal40.3 (1997): 626-657.
[29]. MacKinlay, A. Craig. "Event studies in economics and finance." Journal of economic literature (1997): 13-39.
[30]. Pastor, Lubos, and Pietro Veronesi. Learning in financial markets. No. w14646. National Bureau of Economic Research, 2009.
[31]. Pastor, Lubos, and Pietro Veronesi. Learning in financial markets. No. w14646. National Bureau of Economic Research, 2009.
[32]. Rodriguez, J. "Hedging demand under incomplete information." Unpublished manuscript, Massachusetts Institute of Technology (2002).
[33]. Report from the Consumer Bankers Association and Credit Union National. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[34]. Scholes, Myron, and Joseph Williams. "Estimating betas from nonsynchronous

data." Journal of financial economics 5.3 (1977): 309-327.
[35]. Timmermann, Allan G. "How learning in financial markets generates excess volatility and predictability in stock prices." The Quarterly Journal of Economics(1993): 1135-1145.
[36]. Veronesi, Pietro. "How does information quality affect stock returns?." The Journal of Finance 55.2 (2000): 807-837.
[37]. Vachadze, George. "Recovery of hidden information from stock price data: A semiparametric approach." Journal of Economics and Finance 25.3 (2001): 243-258.