What Effects Did The 2011 Japanese Tsunami Have On The Stock Prices Of Japanese Firms? How Long Were These Effects Present?

Natasha Thomas
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Registration Number:0936809

BSC Economics Undergraduate
University of Essex

Abstract

While it is obvious natural disasters affect the value of a firm, I ask the question; how long do these effects on firms stock returns remain in the market? The literature suggests that the impact will be different depending on the market and how capable the economy is in absorbing shocks. I pose two major questions regarding the 2011 Tsunami on Japanese firms. How were stock returns and volatility affected? How long were these effects present for? Additionally I extend my model to consider corporate donation announcements effects on stock prices and their volatility. Using the difference in differences, quasi-experimental technique, I asses distortions in stock returns across ten Japanese firms as a result of the Tsunami. I find evidence of an initial negative effect on Japanese firms' stock returns, however these effects from the impact rapidly diminish. Volatility was also revealed to be affected; however, in contrast these effects were slower to diminish with significant effects remaining evident within the stock market for a longer period of time. As for results on firms who made corporate donation announcements, I found no evidence that donations decreased the effects of the impact of the Tsunami on returns, *however it would appear that making a corporate donation does have a stabilising effect on stock returns.*

Keywords: *Event Study, Difference in Differences, Japanese Tsunami, Stock Returns, Volatility, Corporate Donation Announcements.*

I Introduction

Over the last decade, reports on the number of large natural disasters have increased. This has triggered a course of literature on such topics as global warming and other world issues. Papers such as Oreggia, Fuente and Torre (2008) have assessed how these can cause increases in uncertainty in investment across sectors. Due to there being an absence of studies in what I believe to be such an important strand of economics, I have decided to take a novel approach to analyze the effects of a recent disaster to strike the world economy, the Japanese Tsunami. The Tsunami hit on the 11th of March 2011 and resulted in 15,073 fatalities and 8,657 missing people in the Tohoku and Kanto regions[1]. Through disrupted supply chains and uncertainty the economic effects could be felt throughout Japan and the global economy; these effects will be discussed in greater depth later in the paper. I will be proposing three main questions throughout; does a natural disaster have a significant impact upon stock returns of local firms? How would the impact of disaster effect volatility of investors stock returns, and for how long? Are corporate donation announcements a sufficient strategy, capable of reducing the outcome of a natural disaster on the value of a firm?

To analyse these issues, this paper examines stock returns of ten local Japanese firms; I aim to contribute to the literature assessing the economic impact of natural disasters, focusing particularly on the impact on local firms returns. Stock prices are commonly used throughout previous literature[2] as an indicator of current economic conditions as it is believed that "Prices of individual stocks reflect investors hopes and fears about the future" Chen and Siembs (2004). This means the Tsunami would potentially result in serious implications for the stocks and bonds within Japanese markets. Investment decisions of the buying and selling of these stocks can quickly and inexpensively, be reversed whenever investors expectations for the future dampen. These expectation alterations resulting from the Tsunami would therefore be present through share prices, as risk averse investors of Japanese firms would have an incentive to leave the market in search of safer, more stable financial instruments. This potentially leaves the market open to a period of panic selling. Although it is obvious that a catastrophic disaster of this magnitude will effect stock prices of Japanese firms immediately, in reality every investor will have different expectations on what current stock prices are, more importantly what they will be in the future. I expect the market to eventually reach a new equilibrium; which leads me to pose the question, did the Japanese Tsunami affect the returns for investors into Japanese firms and for how long?

I will conduct an event study using the methodology known as difference in differences (DID); adopted from the studies CARD (1990) and Angrist and Krueger (1999), to isolate the impact of the Tsunami. "Event-studies are used in the field of law and economics to measure the impact on the value of a firm of a change in the regulatory environment" Schwert (1981). This comparative study approach is more sophisticated than the majority of panel data models commonly applied throughout empirical literature. The base of this methodology, is to create an appropriate

[1] Statistics taken from Nanto, Cooper and Donnelly (2011) "Catastrophic Natural Disasters and Economic Growth"
[2] Eldor and Melnick (2004), Arin, Ciferri and Spagnolo (2008) and Chen and Siembs (2004)

prediction through the use of a control group. In this particular case, I will estimate the path of the stock returns of Japanese firms had the Tsunami not hit. I will then examine the Impact of the Tsunami, by comparing the counterfactual estimated using the control group to the actual path observed. "Importantly, the counterfactuals are not estimated by extrapolating pre-event trends from the treated countries but rather, by building a synthetic control group", Cavallo, Galiani, Noy and Pantano (2009). The control group used to estimate the trend will be constructed using firms not 'affected' by the Tsunami and containing similar characteristics to the treatment group. A synthetic control approach is used, due to the belief[3] that, a combination of firms would support a more accurate counterfactual than a single firm alone.

This paper is structured as follows. **Section II** begins by discussing relevant literature on past events studies, focusing on the different types of events and empirical methods applied. **Section III** will then explore the economic impact of the Japanese Tsunami. **Section IV** discusses the data sample and sources used. **Section V** proposes my hypothesis and estimation windows. **Section VI** explains the difference in differences method employed. **Section VII** presents the empirical estimation approach to DID. **Section VIII** presents the empirical results. **Section IX** extends my model to look at effects on returns considering corporate donation announcements. **Section X** Finally will discuss where my methodology and data could be subject to scrutiny and imperfections, going on to conclude on my results.

II Literature review

Event studies date back to the early twentieth century[4], the vast amount of literature typically assess the effects of events upon a firms market value. Typically these papers have covered events which are in a firms control; such as mergers, acquisitions and stock splits.[5] Aduda and Chemarum (2010) investigates the effect of stock splits at the Nairobi Stock Exchange. The returns of nine firms were observed across stock splits between 2002 to 2008. Aduda and Chemarum (2010) employed daily adjusted prices for sample stock across an event window of 101 days, including 50 days before and 50 days after the stock split. Results suggested the Kenyan market reacts positively to stock splits, shown by a general increase in volumes of shares traded around the stock split.

[3]Based on Beliefs from, Abadie.A and Gardeazabal.J (2003). 'The Economic Costs of Conflict: A Case Study of the Basque Country.' *American Economic Review.*

[4] Early twentieth century study Dolley.J (1933). 'Characteristics and Procedure of Common Stock Split-Ups', Who basically analysed the purpose of stock splits.

[5] Such as, Ball and Brown (1968), Fama, Fisher, Jensen and Roll (1969), Bar-Yosef & Brown (1977) and Dacy and Kunreuther (1969), who look at these specific event types, along with a large sum of literature.

In contrast "Studies on Catastrophic disasters relative to other events is reasonably small, although have received some media attention over the last couple of decades" Muller and Kräussl (2007)[6]. There is a resulting gap in the literature of exogenous shocks assessed using the difference in differences model. Therefore in order to determine how I will conduct my analysis, I will focus on past literature of the two strands separately.

The New York terrorist attack in 2001, along with more recent attacks such as the Madrid bombing attack (2004) and the London tube bombings (2005) have shown that the shock of terrorist attacks is a form of risk which investors and financial institutions may be challenged with. Eldor and Melnick (2004) observed how the stock and foreign exchange markets deviated across periods of terrorist attacks. Time series data was collected of 3515 daily observations through the period 1990-2003, from the Tel Aviv Stock Exchange (TASE). Using the market model, Eldor and Melnick (2004) claimed terrorist attacks have an irreversible negative effect on the stock market; however the foreign currency markets remained unaffected. Carter and Simkins (2002) analysed the impact of the 9/11 attack specifically on airline stock returns, it was suggested that market reactions to the attacks on the following day were identical across airlines. "The increased probability of bankruptcy in the wake of the attacks distinguished between airlines based on their ability to cover short-term obligations" Carter and Simkins (2002). More liquid airlines felt the immediate effects the least as cash flows were readily available. The results of Carter and Simkins (2002) suggest that highly capital intensive industries such as heavy duty manufacturing firms are most exposed to these exogenous risks and therefore should present the market conditions most predominantly.

One particularly interesting past study was the pioneering literature by Arin, Ciferri and Spagnolo (2008). Arin, Ciferri and Spagnolo (2008) studied the effect of terrorist activity on the markets actions; specifically looking at the effect of terrorism on the stock market and the resulting volatility of returns. Arin, Ciferri and Spagnolo (2008) extracted daily data from 'DataStream' for six countries; Indonesia, Israel, Spain, Thailand, Turkey and UK over the period 2002–2006. Arin, Ciferri and Spagnolo (2008) searched for abnormal returns across daily closing values; returns were calculated using logarithmic differences of stock indices. Stock market volatility resulting from terrorism appeared greater upon developing markets. The largest volatility was measured in "*Indonesia, Israel and Turkey with values equal to – 0.0037, – 0.0027 and – 0.0018, respectively*", Arin et al (2008). Chen and Siembs (2004) examined the response of

[6] This is due to a number of high profile incidents including, terrorist attacks (New York 2001 and London attacks 2005) and natural disasters, (Hurricane Katrina, Kashmiri earthquake in 2005, and Japan tsunami 2011)

the U.S. capital markets to 14 terrorist and military attacks dating back to 1915; additionally assessing global capital market responses to Iraq's invasion of Kuwait in 1990 and the 9/11 attacks. Negative abnormal returns were observed, however the US capital market returned to a steady state faster than other markets. An indication "that financial markets are capable of absorbing the unpredictable shocks, and persist to perform in an efficient way" Chen and Siembs (2004).

Natural disasters unfortunately increase risk posed to investors across some parts of the world. "According to the WHO-sponsored CRED International Disaster Database (EM-DAT, 2007), 3,472 natural disasters have occurred worldwide since 2000, including droughts, famines, earthquakes, flooding, windstorms and extreme temperatures" (Muller and Kräussl 2007), consequently the importance of event study literature on natural disasters has begun to rise. Dacy and Kunreuther (1969) analysed how GDP was affected due exogenous natural disaster shocks; GDP was found to increase after the impact. Since Dacy and Kunreuther (1969), a generalized framework for the economic analysis of natural disasters was proposed. Albala-Bertrand (1993) followed a similar set up and found even after significantly large natural disasters; the effort needed to reconstruct the economy to prevent an excessive plummet in growth was surprisingly low. This displays the markets ability to absorb large exogenous shocks. Okuyama (2003) aimed to measure the total impact of the Kobe Earthquake (1995), where expected negative initial effects in the year of the earthquake were observed. However Okuyama (2003) witnessed following positive economic gains due to sharp boosts in demand for recovery and reconstruction activities. Additionally Okuyama (2003) concluded that if older capital is damaged and destroyed, then the long run productivity of the firm may in fact rise as the replacement of capital technology is modern and therefore benefit from capital efficiency gains.

Another interesting branch of event study literature asses markets reactions to corporate donation announcements. Evidence suggests that corporate donation announcements may potentially generates benefits to a firm such as; through accelerated recovery of the Japanese economic infrastructure and "positive reputation effects among consumers and shareholders" Muller and Kräussl (2007). However there is disagreement of whether in reality investors do interpret donation announcements positively. Muller and Whiteman (2008) revealed that Fortune Global 500 firms donated 1.2 billion dollars of resources and cash in response to Hurricane Katrina and Kashmiri earthquake. Similarly Muller and Kräussl (2007) investigated stock market reactions to corporate donation announcements by 108 US firms, in response to Hurricane Katrina. Results revealed that overall, corporate donations were not linked to neither positive nor negative abnormal returns, although they did observe that a number of factors moderate the relationship between donation announcements and abnormal stock returns; for example firm size and levels of donations themselves. Although Godfrey (2005) had assessed corporate donation announcements on shareholder wealth and concluded that in most cases, "this type of social behaviour should be considered a strategic investment that would benefit both a firm and society which can generate shareholder wealth" Godfrey (2005).

As mentioned earlier, the methodology I shall be employing will be the Difference in Differences method (DID). DID enables effects of an event to be distinguished from the effects of other exogenous factors. One major advantage of DID is it enables me to successfully target the effects of such a recent event, even considering the limited data available. One of the most well known employers of this methodology was Card (1990). Using the DID method Card (1990) examined the impact of the Mariel boatlift (1981-1985) and its resulting effect on the Miami labour force. Card (1990) compared unemployment rates for "whites, Blacks and Hispanics" in Miami (the treatment group), with unemployment rates of these "groups" in four comparison cities (control groups). Card (1990) employed data from the "Current Population Survey". Applying the DD method Card (1990); concluding that the Mariel Boatlift increased the Miami labour force by 7%. However the influx of immigration did not have a significant effect on unemployment nor wages to the unskilled workforce; suggested to be competed out of work by the Cubans immigrating into Miami. Angrist and Krueger (1999) replicated Card (1990), for a Cuban boatlift that was anticipated. Angrist and Krueger (1999) found speculation of the second Mariel boatlift had a large adverse effect on unemployment in Miami; sparking debates on the results of Card (1990) and indicating how speculation can result in changes in market conditions.

Thereafter Card (1990) and Angrist and Kruger (1999), Gruber and Poterba (1994) analysed how changes in tax laws which are anticipated, would increase purchases of health insurance by self-employed individuals but not by other employed individuals. Comparison of the period before the tax change with the period after, predicted purchase of health insurance grew more rapidly among the self-employed relative to regular employed workers. The DID estimator therefore indicated that the tax law increased the purchase of health insurance among the self-employed. (Table 7) below is a summary of the literature reviewed, firstly focusing on studies which have used the difference in differences methodology and secondly studies analyzing catastrophic events. This will help me to incorporate important factors into my study.

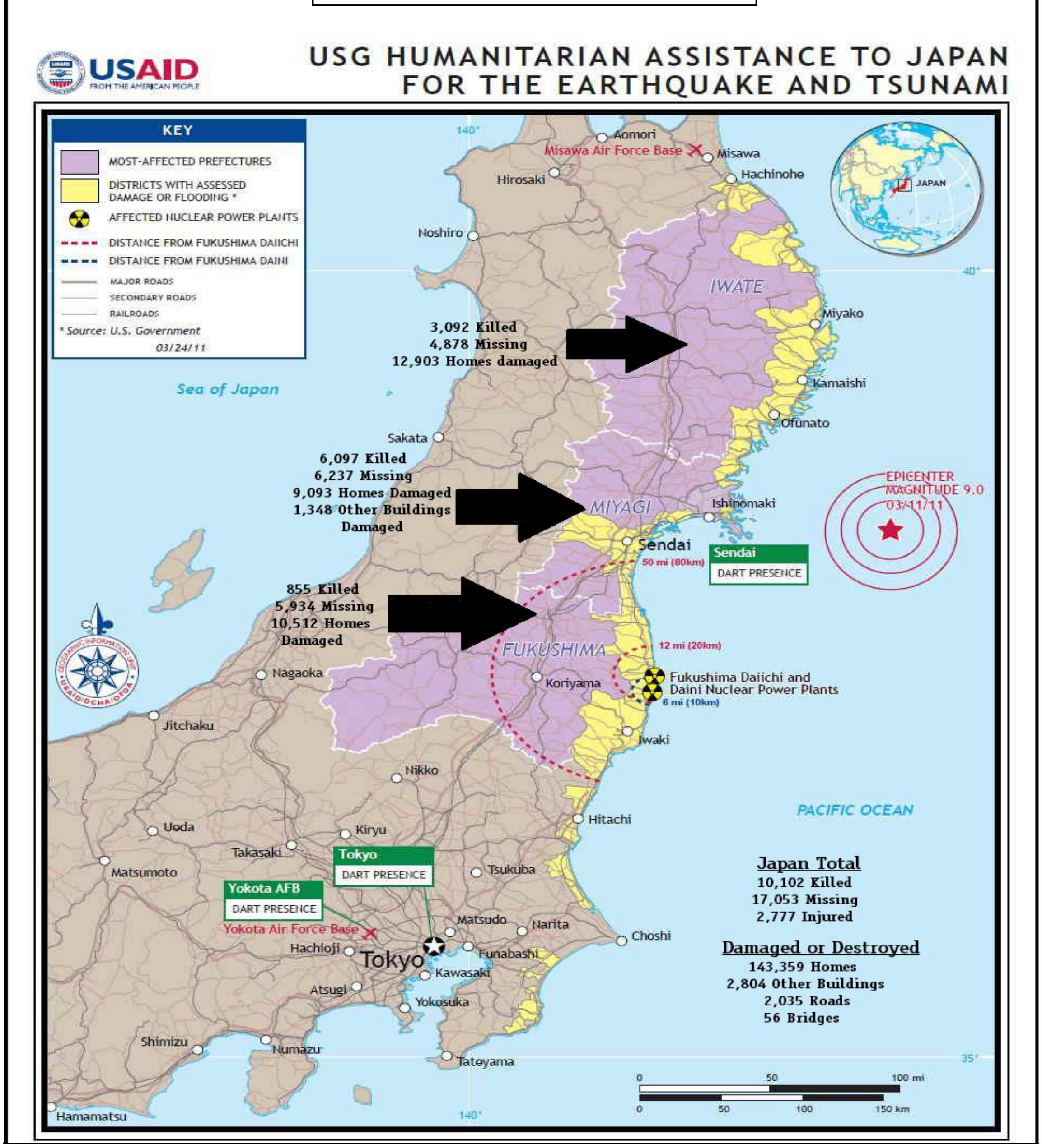
(Table 7)Literature Review Summary

Study	Purpose of study	Methodology	Data	Variables	Observations
Card (1990)	Mariel boatlift (1981-1985) and its effect on the Miami labour force.	Difference in Differences	Data taken from the Current Population Survey	"whites, Blacks and Hispanics" (compared across cities)	Years (1979-1985)
Gruber and Poterba (1994)	Analyzes the changing patterns of health insurance demand before and after tax subsidy	Difference in Differences	Current Population Survey	Self-employed workers and other workers.	Years(1985-1989)
Angrist and Kruger (1999)	Replicated the Card (1990) study for a Cuban boatlift that was anticipated but did not occur.	Difference in Differences	Current Population Survey	*****	*****
Carter and Simkins (2001)	Analysed the impact of 9/11 on airline stock returns.	Abnormal Returns	Dow Jones stock exchange	18 airlines and four airfreight carriers	Varies across Market
Chen and Siembs (2004)	examined the U.S. capital market's response to 14 terrorist/military attacks	Abnormal Returns	Capital Market	Us over different markets	Varies across market
Eldor and Melnick (2004)	stock market and also the foreign exchange market deviated due to terrorism	Abnormal returns	Tel Aviv Stock Exchange (TASE).	Country over time. Israel during (1990-2003)	3515 daily observations
Arin, Ciferri and Spagnolo 2008.	Studied the effect of terrorist events on the markets actions	Abnormal returns	Daily data from 'DataStream' for six countries. And Global stock market index	Countries. (Indonesia, Israel, Spain, Thailand, Turkey and UK)	1368 observations
Muller and Kräussl (2007)	investigated stock market reactions to corporate donation announcements	Abnormal Returns	Daily Data from (S&P 500 Composite) Centre for Research in Security Prices.	108 US firms	229 observations
Aduda and Chemarum (2010)	Investigates the effect of stock splits at the Nairobi Stock Exchange	Abnormal Returns	Nairobi Stock Exchange	9 firms	101 Observations

III Japanese Tsunami Economic Impact

On the 11th of March 2011, at precisely 14:46 local time (05:46 GMT) a giant earthquake ruptured off the pacific cost of Japan, which led to the huge Tsunami. "Physical Damage was estimated at around $250 billion to as much as $309billion dollars, which is roughly four times the damage of US hurricane in 2005, Hurricane Katrina ($81 billion)" Nanto, Cooper and Donnelly (2011).

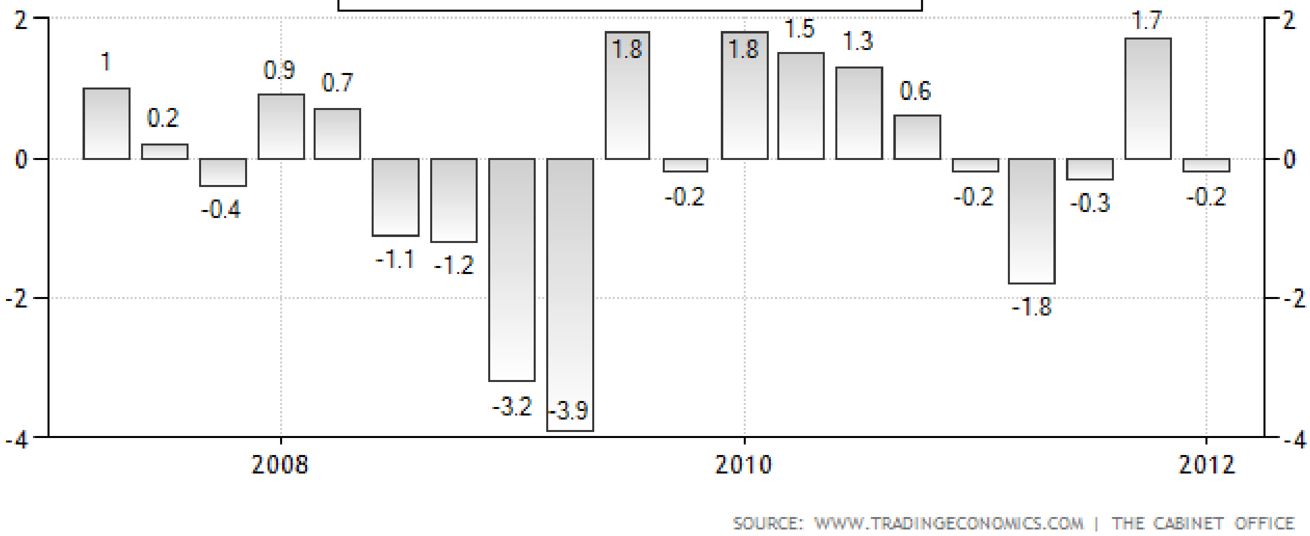
(Figure1): Physical Damage



The damage was exacerbated by a severe fault which occurred at the Fukushima Daiichi Nuclear Power Plant, leading to nuclear contamination resulting in over 200,000 people being evacuated from these areas. The combination of the direct impact and the resulting power plant faults, lead to a shortage of gasoline and of electricity which caused rolling blackouts across Japan's industrial centres; bringing much of the Japanese economy to a standstill. The direct damage of the Japanese earthquake and tsunami impacted mainly the northern region of Japan, however the financial and economic damage rippled throughout Japans economy, the East Asian region and other areas such as Europe. Physical damage statistics dated 23rd of March are presented in (figure 1) above.[7]

Typically we would expect the effects of a natural disaster to be "large immediately after the event and are mostly concentrated in the region directly impacted by the disaster", Nanto, Cooper and Donnelly (2011). Analysts predicted that Japan would recover reasonably quickly from the tragedy; due to their great infrastructure with good wealth conditions. However the combined effects of the earthquake, tsunami and nuclear contamination hampered rescue and recovery efforts. We would expect this to result in a longer lasting and heightened effect on local firms stock prices. Areas in eastern Tohoku that took the full force of the natural disaster, account for about 6% to 7%[8] of Japan's GDP which consequently predicted that real GDP growth of Japan could decline by 0.2 to 0.5 percentage points. (Figure 2)[9] below displays Japanese GDP growth across 2007 to 2012. Here you can see Japan suffering negative GDP growth across three of the four quarters in 2011, as a result of the Tsunami. Overall Japanese GDP shrunk by 0.9% in 2011 relative to 2010.

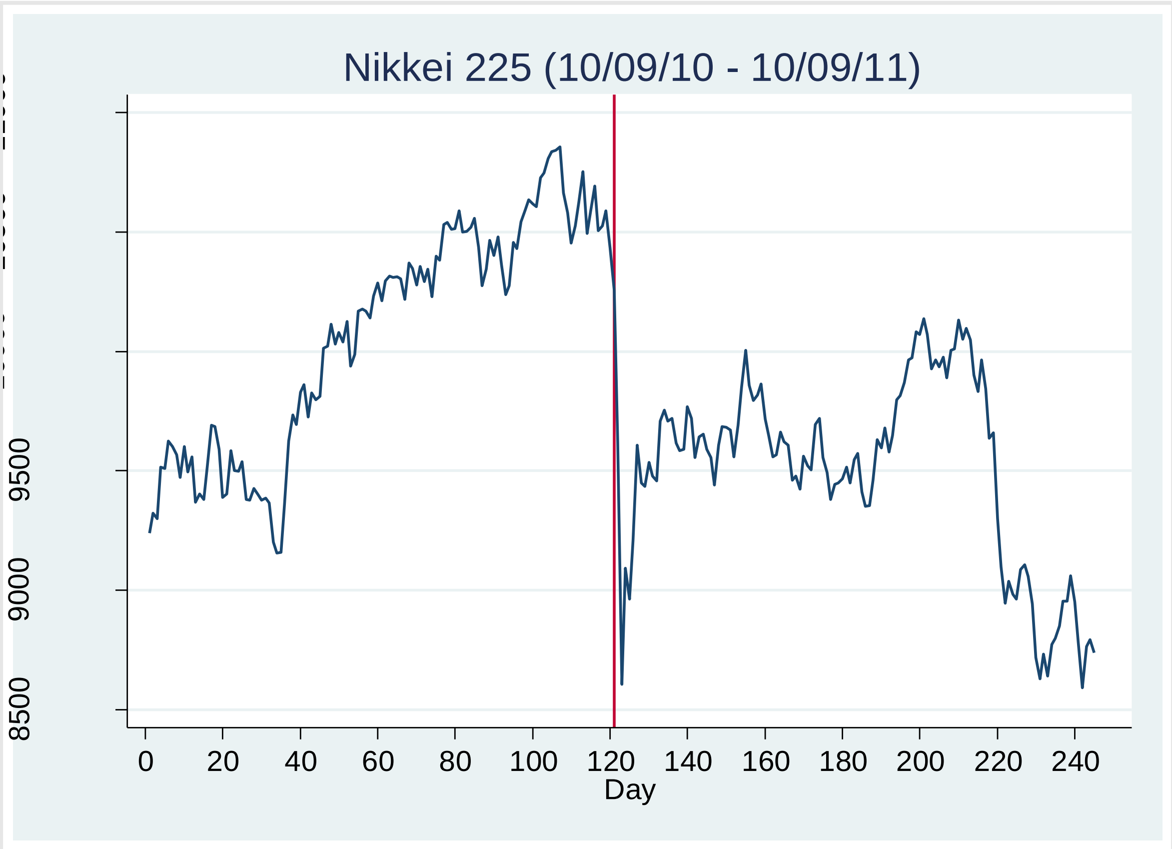
Figure 2 Japan GDP Growth Rate
Percent Change in Gross Domestic Product



[7] **Source** Underlying map from U.S. AID. Casualty and damage data from Japan, National Police Agency, Replicated and edited from the Nanto.D Cooper.W, Donnelly.J and Johnson.R (2011) paper.
[8] Nanto.D Cooper.W, Donnelly.J and Johnson.R (2011). 'Japan's 2011 Earthquake and Tsunami: Economic Effects and Implications for the United States'.

[9] Source Taken from www.TradingEconomics.com

<u>**(Figure 3): Tokyo Stock Exchange Index[10]**</u>



(Tsunami impact date represented by reference line)

An enormous plummet in the index of the Tokyo Stock Exchange is visible immediately after the impact of the Tsunami. As firms suspended production and uncertainty began to spread through the Japanese stock market, risk adverse investors began to flee the market. This lead to a sharp drop in demand for Japanese stocks and an excess of supply into the stock market. Immediate government responses were employed in an attempt to minimise any long-run effects in the economy. The Japanese central bank, the Bank of Japan reacted to the nosedive of the Nikkei 225 through large levels of quantative easing. The Bank of Japan eased its monetary policy by injecting a record 15 trillion Yen into the Japanese economy and an extra 5 trillion Yen through additional acquisitions of government and corporate bonds; this lowered Japanese interest rates to virtually 0%. Additionally the Japanese Government announced that 1.3 trillion from the initial announced Fiscal budget of 2011 would be reallocated from areas of the announced budget, instead towards the recovery of the economy.[11]

[10] Nikkei 225^, Daily stock prices, Adjusted for dividends taken from yahoo finance from the 11 of September 2010 until 11th September 2011 (Trading Days).

[11] Information from this section was based from the review by Nanto, Cooper and Donnelly (2011).

The question posed is whether the combination of these policies, along with the economies ability to absorb shocks were sufficient in order to recover the Japanese stock markets nosedive. I will be aiming to test whether Japans efforts were successful in turning around these consequences of the Tsunami in recovering stock values of affected firms and also the risk associated with these stocks.

IV Data Sample

I have extracted my sample of daily closing stock prices (adjusted for dividends) in US Dollars($), for 10 Japanese firms from the New York Stock Exchange[12]. The data set covers the period from the 10th September 2010, trading day 1, until the 10th of September 2011, trading day 253; where trading day 127 is the day that the Tsunami hit; 11th of March 2011.

The ten Japanese firms, (See Table 2) will be used as my "treatment group" as they were exposed to the direct domestic economic effects of the Tsunami. Although none of these firms were situated within a close enough radius to be directly physically damaged, I will be analysing whether the resulting shockwaves through the economy had an affect on stock prices of these 10 Japanese firms.

(Table 2): 10 Japanese Firms (Treatment Group)

"Treatment Group"	Industry	Corporate Donation Announcements
Canon	Manufacturing (Electric Machinery)	14th of March 2011
Sony	Manufacturing (Electrical Machinery)	12th of March 2011
Hitachi	Manufacturing (Electrical Machinery)	14th of March 2011
Konami	Services	13th of March 2011
Honda	Manufacturing (Automotive)	12th of March 2011
Mitsubishi UFJ Financial Group	Finance	12th of March 2011
Toyota	Manufacturing (Automotive)	23rd of March 2011
Panasonic	Manufacturing (Electric Machinery)	14th of March 2011
Mizuho Financial Group	Finance	18th of March 2011
Kyocera	Manufacturing (Electrical Machinery)	12th of March 2011
Returns for each firms can be viewed in the Data Appendix in (figure 6), Graphs(1 – 10)		

[12] I have taken my data set from Yahoo Finance . Daily Stock prices are in terms trading days and therefore are not consecutive days.

(Table 3): 10 US Firms (Control Group)	
"Control Group"	**Industry**
Plum creek Timber Company	Manufacturing
Boston Beer	Manufacturing
Kapstone paper and packaging	Manufacturing
Team Health Holdings	Services
Medifast	Manufacturing
Wright Express	Finance Services
Deere & Co	Manufacturing
Lindsay inc	Manufacturing
American Financial Group	Finance
AGCO	Manufacturing
Returns for each firms can be viewed in the Data Appendix in (figure 6), Graphs(11 – 20)	

In order for me to be able to successfully identify the isolated effects of the Tsunami on the Japanese economy; the selection of the control group used is vital. The DID method relies on the control group to provide an unbiased prediction of how the treated group would have behaved, in the absence of the treatment. I decided to use firms from the United States (US) as my control group (see Table 3), due to similarities between the two economies. Both economies have been recently on the road to recovery from the recent global financial crisis (see figure 2 and figure 9), encouraging investment decisions with both central banks setting interest rates at around 0%. I have selected large Japanese firms in order to observe whether these firms market values were able to recover quickly due to large reserves of financial capital settling investors expectations, or whether even the larger firms were significantly hit by the Tsunami.

When selecting my control group, it was also important to avoid industries which would have been sufficiently integrated with large sectors from the Japanese economy. As these US firms would have experienced 'shockwaves' through "specific sectors and firms for which trade and investment with Japan is particularly important" (Nanto et al, 2011). With the Japanese economy holding a significant amount of market power in the global market for automobiles, it was important to avoid US firms from the automotive industry; as they would be likely to be strongly affected through the change in market conditions. US automotive stock returns could have been positively influenced through a temporary fall in global competition from Japan. Additionally a possible negative effect through disruptions of supply chains of intermediaries. Therefore when selecting my control group, I have selected low-tech manufacturing industries (beer, timber, paper, etc…) and financial firms in order to prevent competition and supply chain effects from generating bias' in the slope of my control group. I will discuss this potential bias later in **Section X**.

V Hypothesis and Estimation Windows

Hypothesis

Claim 1: The Tsunami had a negative effect on Japanese firms' stock returns in the short run as firms suspended production. We would expect to see these effects diluted gradually throughout time. It will be interesting to see whether Japan experienced a rapid recovery, similar to Chen and Siembs (2004).

Claim 2: Similar to Arin, Ciferri and Spagnolo (2008), I believe the Japanese stock markets would experience an increase in the risk on firms assets in the short run, due to the period of panic selling of risk adverse investors. However as the stock market begins to incline; as mentioned above in "claim 1", we would expect to see the stock market return to a new equilibrium and volatility to settle along with the recovery of stock values.

Claim 3: As mentioned by previous literature Muller and Whiteman (2008) and Muller and Kräussl (2007), similarly I would expect to see Japanese firms announcing corporate donations to help recover faster from the Japanese tsunami, relative to firms who did not make announcements. As discussed in **Section II**, donation announcements have been linked with indirect benefits.

Estimation Windows

I will analyse effects of the Tsunami on the stock returns of the 20 firm sample across five estimation windows of different lengths in order to capture the effect of the Tsunami and how its effects were absorbed by the Japanese economy. Unlike *Campbell, Lo and MacKinlay (1997)* who suggest that "It is important that the estimation period and the event window do not overlap". I have decided to keep the date of the Tsunami in my analysis, trading day 127. As my sample of stock returns were extracted from the New York stock exchange, therefore stock returns in this equity market will not have been directly affected when the Tsunami hit Japan; therefore trading day 127 will be in included in the 'post' period.

The first estimation window will include 12 trading days, beginning on the 1st March 2011, trading day 117 and ending on the 12th March 2011, trading day 128. That is ten days before, the day of and the day after the tsunami. This estimation window is adopted from the estimation window used in the study Carter and Simkins (2001) to analyse immediate effects of the Tsunami impact. I assume that markets process perfect information immediately. I will then extend my estimation window to 20 trading days; beginning on the 25th February 2011, trading day 117, through to the 25th of March 2011, trading day 137. As I have taken my stock prices from the New York Stock Exchange, effects will be lagged relative the Tokyo Stock Exchange and therefore this period will display the more stable effects of the Tsunami. Additionally I will begin assessing the volatility of stock returns within this period.

My third estimation window will consist of 30 trading days; beginning on the 17th of February 2011, Trading day 112, until the 1st of April 2011, Trading day 142; again including the event date. This window will include all announcements made by the 10 Japanese firms (12th-23rd of March). Godfrey (2005) found that donation announcements made by firms can have a significant impact on stock value of the firm; this window will aim to see whether these announcements eradicated the effects of the Tsunami upon both stock returns and their volatility.

My penultimate estimation window will consist of 40 working days; beginning on 10th of February, trading day 107, up until the 8th of April 2011, trading day 147. Increasing the duration of observations should display the Japanese markets recovery from the damage as Government spending, corporate donations and stimulated investments through monetary policy are pumped into the Japanese economy. My final estimation window will be including 80 trading days beginning 12th of January 2011, trading day 87, until the 9th of May 2011, trading day 167. I have decided to stop at this point as too broad estimation windows will begin including changing of causal factors in the Japanese economy which are not linked to the Tsunami. Raising the probability of an omitted variable bias. "To minimize the chance that other important factors influence the outcome of this study; the period has to be kept short" McWilliams and Siegel (1997).

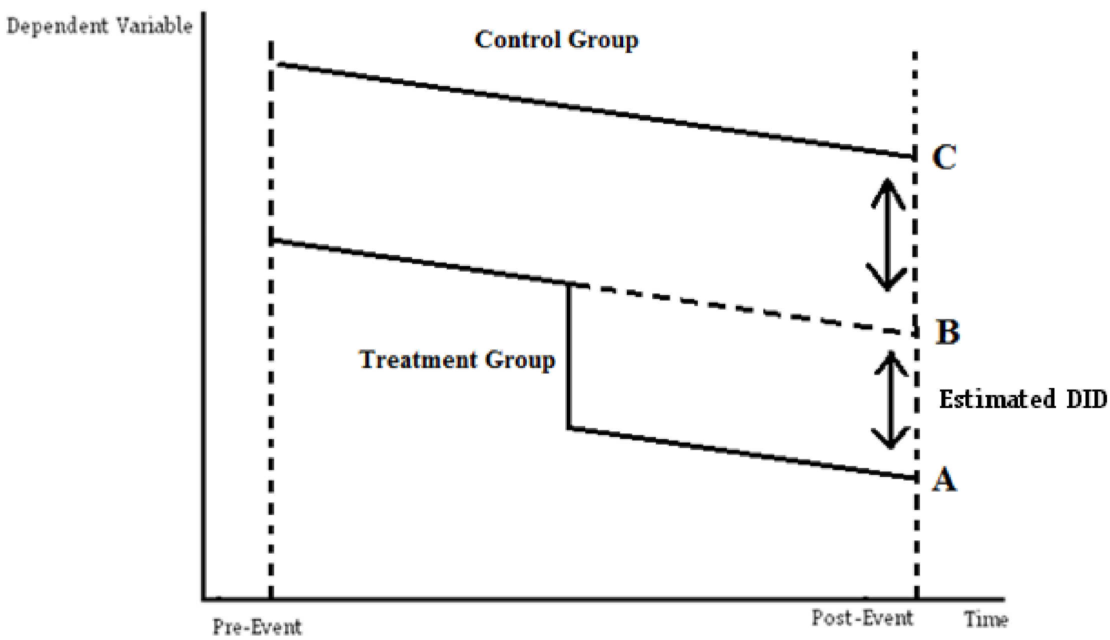
VI Methodology

1 Difference in Difference

There has been small amounts of research dedicated to increasing the ability of firms to predict the effects of disasters; "economic research on natural disasters and their aftermath is fairly limited" Cavallo, Galiani, Noy and Pantano (2009). I aim therefore to contribute to the literature covering the effects of natural disasters, analysing the effects of the Japanese Tsunami on the returns of 10 local, relatively large Japanese firms.

The methodology adopted is the Difference in Differences (DID) method as mentioned earlier. Event studies which have employed this method are scarce but some previous literature which has employed the method are; *Card (1990), Athey and Imbens (2006)* and *Hansen (2007)* and several other studies, including Meyer (1995), Angrist and Krueger (2000), Blundell and MaCurdy (2000). Unlike many other methods of empirical testing DID allows, and accounts for the presence of unobserved factors and trends throughout time. This method requires two periods of data (before and after "treatment") and two groups (the treatment and control group). Both groups are observed before the treatment in order to observe the difference between the control and treatment group. The treatment group is then exposed to the treatment of interest in the second period and the control group remains unaffected throughout the sample from the treatment.

Figure 4 : Illustration of Difference in Differences



The control group enables me to account for possible trending unobserved factors across time, which is unrelated to the "treatment"; such as advancing technology, changes in market demand and other market factors which could cause a potential trend, we have to assume that illustrated by dotted line "B" in (figure 4).[13]

Including a control group isolates the effects on stock returns from global trends, allowing the difference in differences to be estimated distance A-B (see figure 4 above). In order for the control Group to be effective in doing so we have to assume that all factors, barring exposure to the event, are similar between the two groups and that they both have the same trends across time. Cavallo, et al (2009) suggests that this assumption may be difficult to be satisfied, as it is uncommon that the conditions for firms across two countries would be identical. However the assumption trends can be identical are genuinely accepted, allowing the difference between groups in the absence of any treatment to be estimated (distance B-C).

VII Empirical Estimation

Using daily closing stock prices, I have calculated daily returns on stocks using the typical logarithmic formulae[14]. The DID setup is as follows; $Firm_i$ belongs to a group, $Japan_i \in \{0, 1\}$; where if $Japan_i$ equals 1 is the treatment group and if $Japan_i$ equals 0 is the control group. $Firm_i$ is observed in time period $Post_t \in \{0, 1\}$; where if $Post_t$ equals 1 it is the period after the Tsunami). For $i = 1, . . . ,N$, a sample from the population, firm $_i$s group identity and time period can be treated as random variables.[15]

$$Returns_{it} = \beta_0 + \beta_1 \, Japan_i + \beta_2 \, Post_t + \beta_3 \, Japan_i{*}Post_t + \varepsilon_{it} \qquad [1]$$

Letting the outcome be $Returns_{it}$, the data are the triple ($Returns_{it}$, $Japan_i$, $Post_t$). The second coefficient β_1 represents group-specific, time-invariant component. The coefficient β_2 represents the time component (Pre-Tsunami, Post-Tsunami). The coefficient β_3 is the difference in differences estimator (interaction term between the two dummy variables $Japan_i$ and $Post_t$) calculated as follows; (See equation 2).

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[13] Figure 4 is adapted from London School of Economics. "Difference in differences and a brief introduction to panel data".

[14] Where Logarithmic returns is given by $R=Pe^{rt}$, where R = Return , P = Principal amount, r = rate, t = time period .

[15] Based on the methodology of Athey.S and Imbens.G (2006). 'Identification and Inference in Nonlinear Difference-in-Differences Models'. *Econometrica.*

$$^{Returns}DID = E[Yi|Japan_i = 1, Post_t = 1] - E[Yi|Japan_i = 1, Post_t = 0] - [E[Yi|Japan_i = 0, Post_t = 1] - E[Yi|Japan_i = 0, Post_t = 0]] \quad \textbf{[2]}$$

In more detail, the population average difference over time in the control group ($Japan_i = 0$) is subtracted from the population average difference over time in the treatment group ($Japan_i = 1$), to remove biases associated with a common time trend unrelated to the intervention. The final coefficient ε_{it} represents unobservable characteristics of the individual. This term is assumed to be independent of the group indicator and have the same distribution over time. One past criticism of the DD estimations is that "most papers rely on many years of data and focus on serially correlated outcomes. Yet almost all these papers ignore the bias in the estimated standard errors that serial correlation introduces", (Bertrand, Duflo, and Mullainathan 2004). In order to account for possible serial correlation and heteroskedasticity within firms returns, I will use clustered standard errors, which are a robust covariance estimator according to a formula developed by Liang and Zeger (1986), this means that standard errors presented will be adjusted for 20 'clusters' of firms. I will also be estimating using the fixed effects model, where fixed effects account for characteristics that each individual firm posses, which are fixed over time.

Similar to the study by Arin, Ciferri and Spagnolo (2008) I calculate the squares of the logarithms returns, in order to estimate the effects of the Japanese Tsunami on volatility of stock returns. Using the previous regression model, but now volatility of returns denotes the dependent variable of volatility of returns at time t. I will again take into consideration the possibilities of heteroscedasticity and serial correlation and will be using a robust covariance estimator.

$$\text{Volatility of Returns}_{it} = \beta_0 + \beta_1 \text{Japan}_i + \beta_2 \text{Post}_t + \beta_3 \text{Japan}_i{*}\text{Post}_t + \varepsilon_{it} \quad \textbf{[3]}$$

$$^{\text{Volatility of Returns}}DID = E[Yi|Japan_i = 1, Post_t = 1] - E[Yi|Japan_i = 1, Post_t = 0] - [E[Yi|Japan_i = 0, Post_t = 1] - E[Yi|Japan_i = 0, Post_t = 0]] \quad \textbf{[4]}$$

The results for equation [1] are presented below in (Table 4) and results of equation [3] are presented in (Table 5).

VIII Empirical Results

(Table 4) Effects of Tsunami on Stock Returns

Dependant Variable Returns	Initial Impact Window 12 Trading Day	20 Trading Day Window	30 Trading Day Window	40 Trading Day Window	80 Trading Day Window
_Cons	-.0046788 (.0037337)	-.0046788 (.0037235)	-.005657** (.0024394)	-.0030027** (.0017527)	-.0006783 (.0011559)
Japan	.0019777 (.0039588)	.0019777 (.0039481)	*.0021443* *(.0026353)*	.0010007 (.0018743)	-.0000903 (.00124)
Post	.0153513 (.0126122)	.010078* (.0049406)	.0101661*** (.0027789)	.0054688*** (.0018612)	.0022167 (.0015783)
Japan_Post	-.0822075*** (.0183019)	-.0141501** (.0055827)	-.0116368*** (.0033637)	-.0089129*** (.002414)	-.0025971 (.0017996)
R^2	0.1944	0.0250	0.0227	0.0129	0.0024
Observations	240	420	620	820	1620

Robust standard errors are presented in parenthesis (adjusted for 20 "clusters")
[*=Denotes: **p< 0.1**, ** Denotes: **p<0.05*** Denotes: **p<0.01**[16]

(Table 5) Effects of Tsunami on stock returns volatility

Dependant Variable Returns Volatility	20 Trading Day Window	30 Trading Day Window	40 Trading Day Window	80 Trading Day Window
_Cons	.0012186 (.0007915)	.0011464* (.0005828)	.0009816** (.0004463)	.000638** (.0002378)
Japan	-.0009316 (.0007936)	-*.0008638* *(.0005845)*	-.0007289 (.0004475)	-.0003745 (.0002403)
Post	-.000909 (.0007015)	-.0008208* (.0004553)	-.000634** (.0002882)	-.0002518 (.000152)
Japan_Post	.0021052** (.0007474)	.0016612*** (.0004965)	.0013027*** (.0003261)	.000557*** (.0001705)
R^2	0.0167	0.0145	0.0118	0.0044
Observations	420	620	820	1620

Robust standard errors are presented in parenthesis (adjusted for 20 "clusters")
[*Denotes: **p< 0.1**, ** Denotes: p<**0.05** and *** Denotes: **p<0.01**]

[16] When using the fixed effects model, to calculate the difference in differences estimator for effects on returns and volatility, my results were unchanged.

Throughout the various time windows observed, all except one of the coefficients for dummy variable 'Japan' were positive yet particularly small; they were also highly insignificant throughout. This reveals that within my sample, the returns on the 10 Japanese firms stocks, excluding the effects of the tsunami, were higher than the returns of the sample of the 10 US firms' stock returns. However the regressions suggest that the returns of Japanese firms were not statistically significantly different to US firm's stock returns. The insignificance of the "Japan" variable suggests that the US firms selected were a successful control group as this small coefficient implies both the Japanese and US returns are relatively similar.

Similarly the coefficient for the dummy variable "post", across the different estimation windows was positive ranging from 0.0153 to 0.0022, in contrast however was significant across the 20, 30 and 40 trading day event window. This reveals that the aggregated returns for the US and Japan witnessed higher returns after the tsunami effects. Although results are significant, the coefficient is still small. These results for the coefficients of Japan and Post where symmetrical in the results when considering stock return volatility.

The immediate impacts of the Japanese tsunami upon Japanese firm's returns can be observed from the difference in differences estimator "Japan_Post" interaction variable in the first estimation window. The model predicts that Japanese firms experienced an immediate plunge in stock returns by approximately 8.2% points due to the impact of the Tsunami, ceteris paribus. The variable was highly significant with a p value of $p<0.01$. This immediate fall in stock returns could be a result of; the precautionary closures of production plants, risk averse investors panic selling in order to escape the now 'riskier' Japanese market and possible direct physical damage to firm labour/capital from the tsunami.[17]

As I start to slightly increase the estimation window observed to the 20 trading days, I witness a large dilution of the impact of the Tsunami. The effects on stock returns was of a much smaller magnitude than the previous window; with stock returns on equity only falling by 1.4% points, just over a sixth of the shock fall in returns immediately after the Tsunami. This is possibly a result of firms outside the radius of physical damage from the Tsunami; (i.e. loss of firm land labour or capital) beginning operations as usual. Japanese firms witnessed a significant ($p<0.01$) rise in volatility of returns of approximately 0.21% points across the 20 trading day window. Higher volatility of stock returns would be a result of heightened levels of uncertainty and risk surrounding the Japanese economy as the market begins to search for a new equilibrium.

[17] Note that for this time estimation window I did not analyse the effects on the volatility of stock returns, as two observations after the tsunami is not enough data in order to generate valid predictions.

The results predicted when using the estimation window of 30 trading days, revealed that effects on stock returns predicted a fall of 1.2% points. This was again of a smaller magnitude than the predeceasing estimations window although within this window, the effects of returns has suggested to have been highly significant (p value $p<0.01$). For this estimation window, results of volatility were also reduced relative to the 20 day window; with now the model predicting volatility 0.17% higher relative to had the tsunami not hit. Once more the DID estimate for the Tsunami was highly significant in explaining the changes in returns volatility across periods. Similarly as I expand again to 40 trading day estimation window, there is another rapid, large dilution of the effects on stock returns; where returns were only 0.89% points below expected. Similarly there was a settlement of volatility, with volatility now approximately 0.13% points above expected. I believe this to be a crucial window to the recovery of firms. As it will be around this period when investors will make judgements on whether the Japanese firms will fully return to previous success.

When I expand the estimation window to 80 trading days, the difference in difference estimator suggests that the Tsunami no longer has a significant influence on stock returns. There was an insignificant difference in differences estimator presented in the 80 day window. This suggests that Japanese firms recovered relatively quickly in regards to firm returns. However from looking at the Nikkei ^225, stock prices of the Tokyo Stock Exchange did not return to pre-Tsunami levels (See figure 3). The coefficient of the DID estimator is still negative, yet we can no longer reject at any level that the Tsunami effected stock returns over this window. Similarly the volatility of returns have again been diluted as the markets begins to settle at their new equilibrium, over the 80 day window the variance is only 0.06% points above what the model would have predicted it to have been without the Tsunami effects. What is interesting, is how the volatility in (table 2) suggests uncertainty and volatility have remained more rooted in the Japanese stock market with the p value still being very small ($p<0.01$). The effects of the Tsunami are still evident therefore through increased risk in Japanese assets, even if the returns observed themselves seem to have fully recovered.

IX Extension of My Model

As suggested by previous literature *Muller and Whiteman (2008*) and Muller and Kräussl (2007)**,** public donation announcements can play a vital role in determining the market value of firms. I will now go on to distinguish whether announcements of corporate donations towards aiding Japans recovery softened the impact of the tsunami upon the firm's returns. I will be employing the same ten Japanese firms as the "treatment group"; defined in **Section IV**, which made donation announcements. I have then used three Japanese firms who did not make donation announcements as the control group.[18] (see in Table 6).

(Table 6) Three US Firms Who did not make Corporate donation Announcements(Control Group)	
Firms	**Industry**
Kubota	Manufacturing
Nidec	Manufacturing
Nomura Holdings	Financial Services

Throughout this extension I shall only consider the 80 trading day window, beginning 12th of January 2011 trading day 87, until the 9th of May 2011 which is trading day 167. This is due to the necessity of elimination of the dates of announcements from the data. That is data between 11th of March 2011 up to and including the 23rd of March 2011[19], will be eliminated. I shall be computing the DID estimate using the same methodology as presented in my main model (equation 1). The DID estimate will be calculated using the regression:

$$Returns_{it} = \beta_0 + \beta_1\, Donation_i + \beta_2\, Post_t + \beta_3\, Donation_i * Post_t + \varepsilon_{it} \qquad [5]$$

The coefficient β_3 is again the difference in differences estimator, where the DID estimate is given by:

$$^{Returns}DID = E[Y_i|Donation_i = 1, Post_t = 1] - E[Y_i|Donation_i = 1, Post_t = 0] \quad [6]$$
$$-[E[Y_i|Donation_i = 0, Post_t = 1] - E[Y_i|Donation_i = 0, Post_t = 0]\ ]$$

As before, I have gone on to asses the effects on the volatility of stock returns. The results are presented in (Table 7) below.

[18] In this regression I am only using three firms as the control group, the reasoning behind this it that the amount of Japanese firms in the New York Stock Exchange; that did not make donation announcements is very scarce, although I believe this to be an interesting extension and therefore will discuss any issues later.

[19] I will eliminate this estimation window of announcement dates, as it would make the identification of my estimator unclean.

(Table 7) Effects of Tsunami on Stock returns and stock Returns Volatility, When Making a Corporate Donation Annoucnement		
Independent Variables	Dependant Variable: **Returns**	Dependant Variable: **Returns Volatility**
_Cons	.0012701 (.000512)	.000234*** .0000207
Donation	.0004321 (.0010659)	.0002658*** (.0000431)
Post	-.0020285 (.0007414)	.0001428*** (.00003)
Donation*Post	-.0005621 (.0015433)	-.0003171*** (.0000625)
R^2	0.0036	0.0147
Observations	3107	3107
Robust standard errors are presented in parenthesis (adjusted for 20 "clusters") [*Denotes: **p< 0.1**, ** Denotes: **p<0.05** and *** Denotes: **p<0.01**]		

The results (Table 7) provides a disagreement with the findings of *Muller and Whiteman (2008*), my model predicts that announcements actually decreased returns of Japanese firms and exacerbates the effects of the Tsunami. The model suggests that the 10 Japanese firms who made corporate donation announcements experienced on average a fall in returns of 0.05% as a result of making announcements. However this coefficient was highly insignificant and therefore could be put to chance, or other influential factors i.e, small control group.

On the other hand, the model found a strong, highly significant relationship between more stable returns for firms who made corporate donation announcements. Firms who made donations towards Tokyo and Kanto's recovery, witnessed a stabilising of volatility by 0.03% as a result of public corporate announcements. This could be viewed as a result of the announcements offering a signal of reassurance from the firms to its investors. If the firm has enough funds to employ into "unproductive investments" then investors would assume that the firm has enough funds to recover itself. It is important to note the identification of my estimator may be biased, as stock returns in the control group may have been affected to different extents regardless of donation announcements. A larger control group would be beneficial and lower the probability of this being an issue, however my results do provide an insightful result to the social behaviour of firms.

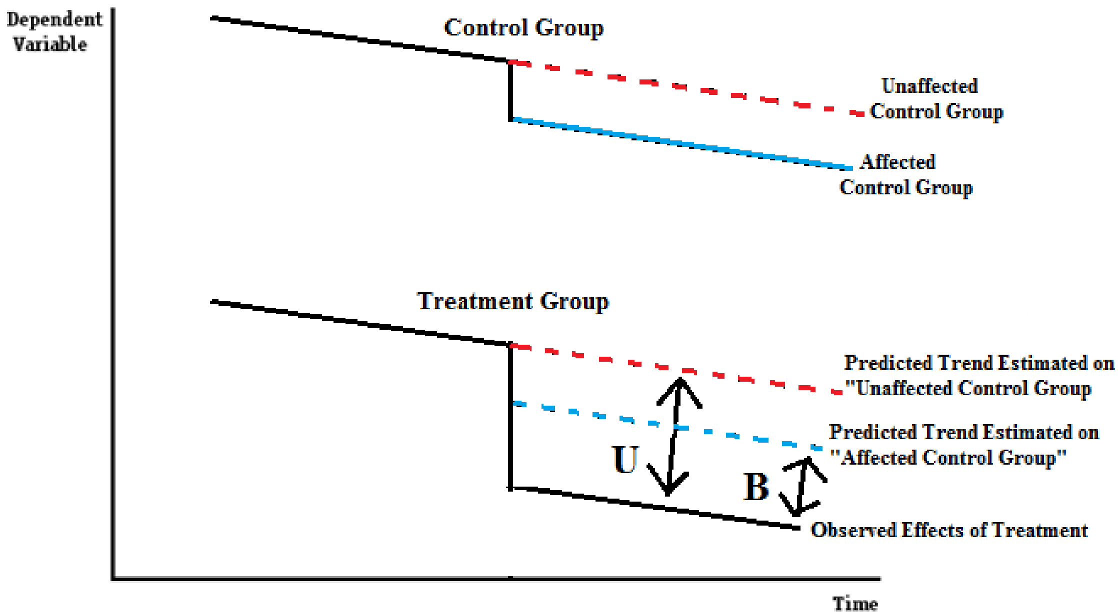
X Critical Discussion and Conclusion

Discussion

I believe that this novel investigation has provided some insightful intuitions and has opened a window for future extensions. However there are some potential issues which have been raised for the DID method which may place my investigation under scrutiny. Firstly, although all precautions were taken it is almost impossible to eliminate the risk of an indirect effect upon a control group when such a large economy such as Japan has been affected. Japanese exports to the US temporarily were suspended due to port damage, domestic US firms could have experienced a short run increase in demand due to reduction in Japanese substitutes for consumers. There is not only a risk of bias through consumers, when the risk associated with Japanese stocks rise (as displayed through volatility DID), it is likely that investors could move to US substitute stocks which would have caused indirect abnormal movements in US stock returns.

Also with the lack of firm level information available, it would be impossible to rule out potential supply chain links from my control group to Japan. (Figure 5) is an adaptation of (figure 4), presenting how an influenced control group can present biased estimations. (Figure 5) shows that if the US firms were indirectly effected through the channels mentioned above, then the identification of my estimator could be open to potential bias. Similar issues arise if there were to be distortion of economic conditions between the two groups at the same time as the treatment is introduced.

Figure 5: Potential Biases In DID Estimations



If US firms were negatively influenced by the Tsunami then this would result in a drop of the measured trend of the control group from the true trend in the absence of any influence, ("unaffected control group"→"Affected control group"). The DID method assumes that the measured values of the control group represents the trend the treatment group would have followed, in the absence of the Tsunami. However (Figure 5) above shows how the estimated DID can be subject to bias when the control group is also influenced by the event, where the true unbiased DID is given by "U". However due to a negatively influenced control group the DID estimation assumes the wrong trend only capturing upwards biased estimator "B" (figure 5). Similarly if the US firms were to be positively influenced, then the DID estimate would be larger than the true DID, presenting a downwards biased estimate.

Additionally when observing the market indexes; NIKKEI 225 (Figure 3), New York Stock Exchange (Appendix Figure 7) and the FTSE (Appendix Figure 8), there appears to be a large plummet in all three indexes around (Trading day 150), which is included in my largest estimation window. This suggests a lagged second order effect of the Tsunami across the global economy, or an entirely different event altogether. Therefore when observing the 80 day window the estimation window potentially incorporates this global nosedive within the observations. Again possibly leading to either biases of my final estimation window, or even indicating that a fraction of the effects of the Tsunami may have been lagged and therefore the full effects may have been missed from my analysis.

When conducting the extension of my model, the lack of control group density generates the possibility that the conclusions drawn are potentially down to chance, and will not represent the true relationship across the whole population. This was an issue due to the limited data available as most Japanese firms did make donations, due to the scale of the disaster caused by the Tsunami.

Conclusion

This paper explored the financial consequences for stock returns as a result of a large exogenous shock. I have provided some empirical evidence on the effect of the natural disaster on stock market returns and volatility. My paper has added to a scarce branch of literature, which benefits investors and firms alike, by enabling for a greater accuracy of predictions during periods of exogenous uncertainty. My study was partly motivated by the study Arin, Ciferri and Spagnolo (2008), who also analyzed the effects of a shock on stock market returns and stock market returns volatility. I discovered how in the wake of a large exogenous shock, investors and firms should expect a sharp decline in returns on equity. However I witnessed that with respect to returns, stocks recover relatively quickly. This was supported in the data with a rapid decline witnessed of the DID effects predicted, as the size of the estimation windows increased. However the stock prices had not necessarily returned to valuation prior to the Tsunami.

Firms should expect that volatility of stock returns will remain significantly higher for an extended period than with stock returns. I witnessed significant coefficients even in the largest 80 day window. Stock markets experience a large increase in the risk on firms assets in the short run, due to the period of panic selling of risk averse investors mentioned earlier; however these results are also diluted through time. I expect to see the stock market return to a new equilibrium firstly and volatility to settle after an extended period.

Overall this paper has shed light on how a large economic shock, can result in even large and successful international firms to suffer significant affects. Empirical analysis provided an indication for the duration which a firm can expect stock returns to be distorted, before the effects from the shock are 'absorbed' by the market. Disasters are not a frequently repeated phenomena and the damages from a disaster vary considerably depending on different factors. However I believe I have contributed to the understanding of large scale exogenous events as a risk factor which firms can faced with. I have shown how it may be in the firms best interest to commit to corporate donations as a stabilising strategy. Corporate donation announcements led to reduced volatility of returns on equity and therefore may potentially attract additional investors.

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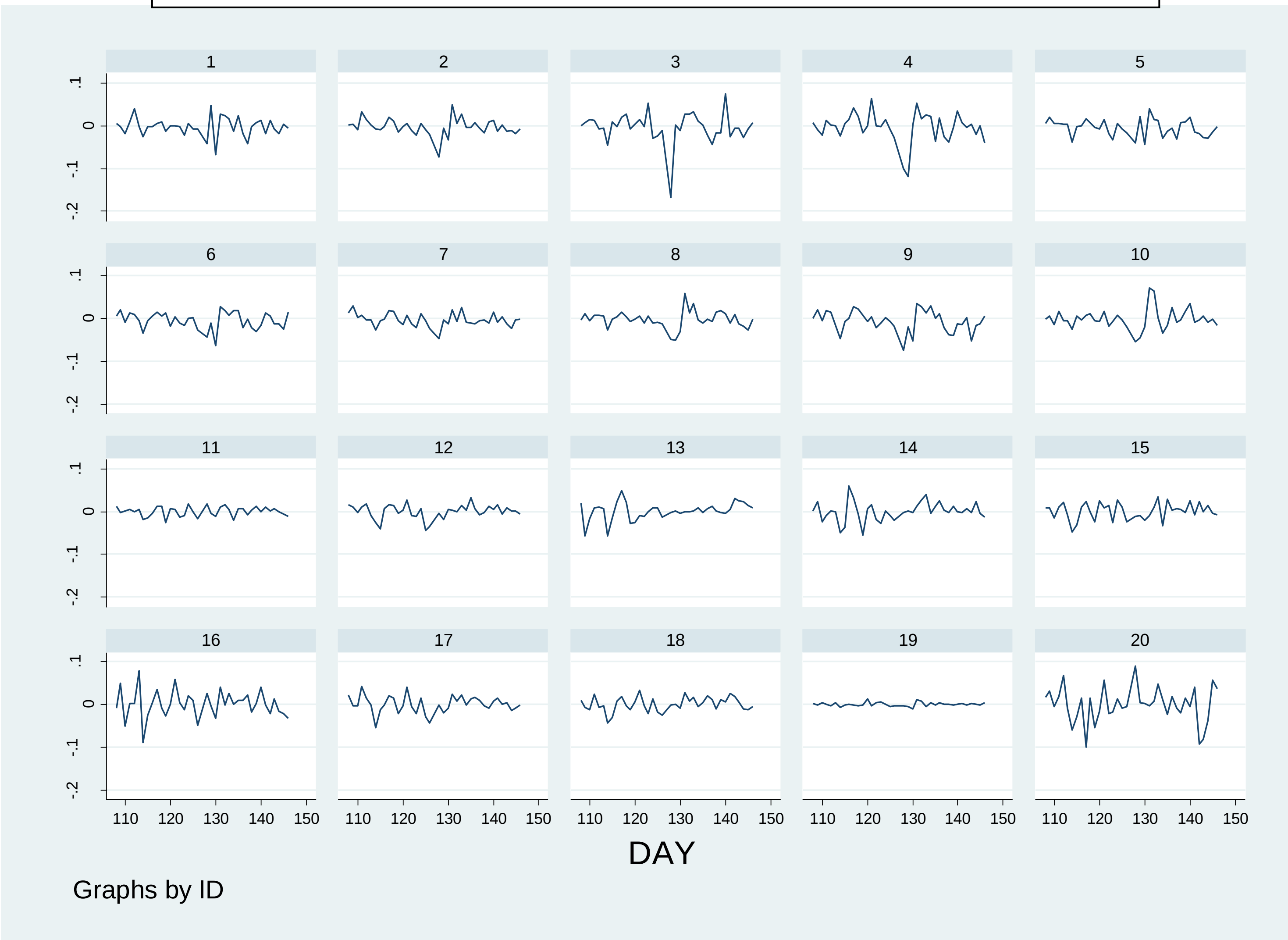
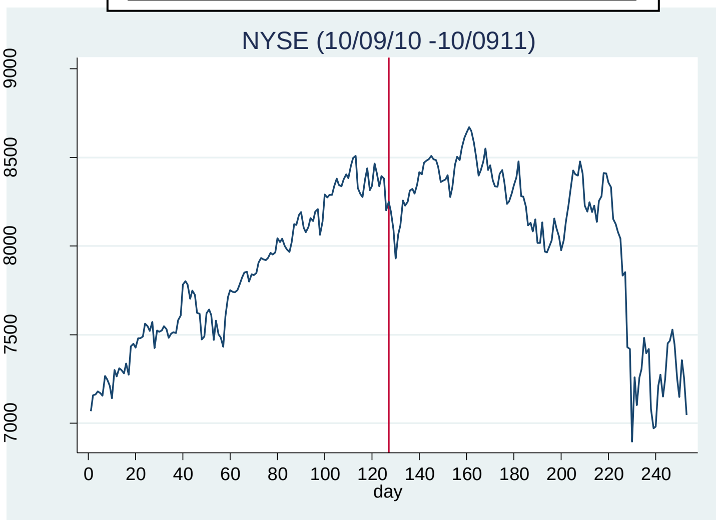
Data Appendix

(Table 8): Descriptive Statistics (Stock Prices)					
Id	Number of observations	Mean	Std. Dev.	Min	Max
Cannon (1)	253	47.05225	2.070824	42.22	52.26
Sony (2)	253	30.43601	4.754139	19.63	36.84
Hitachi (3)	253	52.90921	5.749456	42.51	64.57
Konami (4)	253	21.67198	4.770206	17.17	37.04
Honda (5)	253	37.74617	3.055673	29.67	44.49
Mitsubishi UFJ Financial group (6)	253	4.877628	.3496755	4.15	5.64
Toyota (7)	253	79.15486	5.805826	67.8	93.68
Panasonic (8)	253	12.7936	1.336507	9.83	14.95
Mizuho Financial group (9)	253	3.334941	.4044128	2.71	4.26
Kyocera (10)	253	101.3125	4.616195	85.08	110.05
Plum Creek Timber Company (11)	253	37.39399	2.63536	32.06	42.11
Boston Beer (12)	253	85.11447	8.461301	66.23	99.53
Team Health Holdings (13)	253	17.64047	3.088967	12.73	23.75
Kapstone Paper and Packaging (14)	253	15.26581	1.563705	11.43	17.8
Wright Express (15)	253	46.68466	6.04697	32.82	57.05
Lindsay inc (16)	253	62.62055	8.860317	38.94	78.73
AGCO (17)	253	47.9451	5.473394	35.14	58.13
Deere & co (18)	253	81.65439	7.820914	65.91	97.64
American Financial Group (19)	253	23.38739	.5923161	22.07	24.49
Medifast (20)	253	22.88292	3.981561	14.46	31.29
Kubota (21)	253	46.23099	3.540283	36.96	55.38
Nidec (22)	253	23.07964	1.680764	19	26.55
Nomura Holdings(22)	253	5.315415	.7033629	3.78	6.67

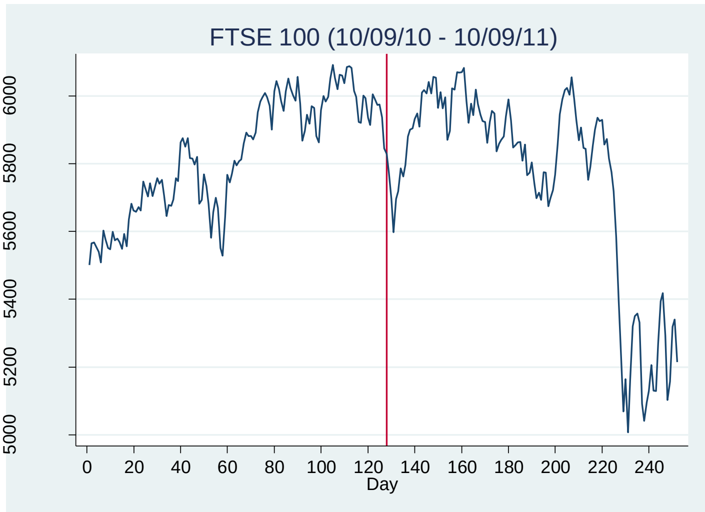
(Figure 6) Effects of the Tsunami on Each Individual Firm
(1- 10 treatment group) and (11-20 control Group)



(Figure7) New York Stock Exchange (NYSE)



(Figure 8) London Stock Exchange (FTSE 100)



(Tsunami impact date represented by reference line)

(Figure 9) United States GDP Growth Rate

Percent Change in Gross Domestic Product