Williams College Libraries
Thesis Release Form

All theses are available online to Williams users with a Williams log-in and password. Select one response for each question. Form to be completed jointly by student and faculty member.

ACCESS TO YOUR THESIS

Faculty claims co-authorship?
_X_ No
___ Yes

When do you want your thesis made available to any user beyond Williams?
_X_ Now
___ 5 years
___ 10 years
___ After lifetime of author(s)

OWNERSHIP/COPYRIGHT

Theses that contain copyrighted material cannot be made available beyond Williams users. Does your thesis contain copyrighted materials without copyright clearance?
_X_ No
___ Yes (Copyrighted sections of the thesis will not be made available online. You have the option to submit a second version of the thesis omitting copyrighted material. Contact College Archives for details, archives@williams.edu)

You own copyright to your thesis. If you choose to transfer copyright to Williams, the College will make your thesis freely available online. When do you want to transfer copyright?
___ Now
___ In 5 years
_X_ In 10 years
___ After lifetime of author(s)

Please provide a brief (1-5 sentences) description of your thesis.

This paper examines the impact of North Korean provocations on South Korean and Japanese financial asset prices. Using event study methodology based on South Korean front-page newspaper articles between 1980 and 2016, I find that South Korean stock market index, Korean Won, and Japanese bond prices exhibit negative cumulative abnormal returns (CARs) following the provocations. Consistent with the expectations, different types of events are shown to have different impacts, with nuclear weapons tests causing the largest shocks. Firm-level analysis shows that South Korean defense industry stocks exhibit positive abnormal returns following the provocations, while economic cooperation stocks show negative abnormal returns even when the overall market is not meaningfully affected. Finally, mean comparison test across sub-period mean CARs provides some evidence that overall the impact of the provocations has become less negative over the study period.

Williams College Libraries
Thesis Release Form

Changes to the thesis release form require a new form to be completed, signed and returned to Special Collections in Sawyer Library.

Theses can be viewed in Special Collections; print copies of Division III and Psychology theses are available at Schow Science Library.

Direct questions about this form to the College Archivist (archives@williams.edu).

Title of thesis: The Impact of North Korean Provocations on Asian Financial Markets: An Event Study Analysis

Author(s): Yoonsang Bae

Signatures:

Student (Print): ___

Signatures Redacted

Student (Signature)

Faculty (Print):

Faculty (Signature):

Faculty (Print): _____ Date: _____

Faculty (Signature): _____ Date: _____

Faculty (Print): _____ Date: _____

Faculty (Signature): _____ Date: _____

Faculty (Print): _____ Date: _____

Faculty (Signature): _____ Date: _____

The Impact of North Korean Provocations on Asian Financial Markets: An Event Study Analysis

by

Yoonsang Bae

Professor Kenneth N. Kuttner, Advisor

A thesis submitted in partial fulfillment
of the requirements for the
Degree of Bachelor of Arts with Honors
in Economics

WILLIAMS COLLEGE

Williamstown, Massachusetts

May 22, 2017

Abstract

This paper examines the impact of North Korean provocations on South Korean and Japanese financial asset prices. Using event study methodology based on South Korean front-page newspaper articles between 1980 and 2016, I find that South Korean stock market index, Korean Won, and Japanese bond prices exhibit negative cumulative abnormal returns (CARs) following the provocations. Consistent with the expectations, different types of events are shown to have different impacts, with nuclear weapons tests causing the largest shocks. Firm-level analysis shows that South Korean defense industry stocks exhibit positive abnormal returns following the provocations, while economic cooperation stocks show negative abnormal returns even when the overall market is not meaningfully affected. Finally, mean comparison test across sub-period mean CARs provides some evidence that overall the impact of the provocations has become less negative over the study period.

Acknowledgement

I would like to thank my advisor, Professor Kuttner, for his patience and guidance throughout the thesis project. I am also grateful to Professor Gentry and Professor Nafziger for helpful comments. All remaining mistakes are entirely my own. Finally, I am deeply indebted to my family and friends, without whom I would not have come this far.

1 Introduction

On September 9th, 2016, North Korea conducted its fifth nuclear weapons test, following the fourth test earlier in January of the same year. It was the most powerful nuclear test so far, and according to Arms Control Association (2017), the seismic activity due to the testing registered a magnitude of 5.0. Ever since, North Korea has continued to experiment with their weapons of mass destruction, further raising the tension around the Korean Peninsula. Since the Korean War and the Cold War period that followed, the North Korean government has consistently engaged in provocative activities against South Korea in various forms—invasion of armed agents, shelling on sea vessels and islands, cyber attacks on governmental agencies—and used these actions as bargaining chips in diplomacy. Following the inter-Korean summit in 2000, there have been some improvements in the relationship between the two Koreas, but the tension escalated to a new level when the North Korean regime resumed experimentations with nuclear weapons in 2009. While the North Korean government insists that these experiments are scientific experiments with nuclear energy and satellite technology, the neighboring countries and the U.S. view these experimentations as something far from being purely scientific and, instead, as provocations with political, diplomatic, and military intentions. Whatever the underlying goals of the experimentation with nuclear weapons and other aggressions may be, these events are seen as a security threat and a reminder that the two Koreas are currently at a temporary armistice without a permanent peace agreement.

These provocations, however, provide an interesting opportunity to study how geopolitical events affect financial markets in neighboring countries. Following the above mentioned event on September 9th, 2016, for instance, the Korea Composite Stock Price Index (KOSPI) dropped from the previous closing price of KRW 2,063.73 to KRW 2,037.87. KOSPI further decreased in the next trading day following the

weekend to close at 1,991.48 on the 12th—a 3.5% decrease in the entire stock market value over just two trading days. The Index started to slowly rebound from this local minimum on the next day, but it took until the 27th of the same month—almost three weeks after the event—to reach the previous closing price when it hit the daily high of 2,064.89. During the same period, the Nikkei 225 (or the Nikkei Index), the stock market index for the Japanese Tokyo Stock Exchange, increased from the previous close of JPY 16,958.77 to JPY 16,965.76 on the 9th, but decreased 1.73% to 16,672.92 on the next trading day. Based on this observation, it would be natural to ask whether the stock market fluctuations in the Korea Exchange and Tokyo Exchange can be attributed to North Korea's nuclear testing. Moreover, although the geographical proximity and close economic ties between South Korea and Japan might make their stock market performances correlated to each other, there is no a priori reason to believe that the two markets would react—if they do react at all—to the threats posed by North Korea in the same way as one another.

While provocative actions taken by a belligerent and unpredictable neighbor could not be a good news for nearby financial markets, it is difficult to predict how those events would affect the prices of particular assets. While some people even consider the South Korean market to be *chronically* depressed due specifically to the presence of a neighboring enemy—a phenomenon called "Korean Discount" as described in Pak et al. (2015)—others also point out that the South Korean citizens are growing accustomed to the repeated provocation by North Korea and that their psychological reaction to the threats has dulled over time. The expected impact of the provocations on the Japanese market is even more ambiguous. Compared to South Korea, with whom North Korea is in temporary armistice, Japan is not a direct military opponent for North Korea. However, as a geographically neighboring country, Japan has not been entirely isolated from the dangers of nuclear weapons and the consequences of North Korean provocations, which have included missiles

launches that landed in the Japanese EEZ. On the other hand, while the Japanese government is condemning North Korea for its provocations at least on surface, it is also using the threat as a rationale for reassessing the restriction on their rules of military engagement that have been in place since the World War II, as Council on Foreign Relations Japanese Studies senior fellow Smith pointed out (2013). This could mean higher expected government spending and growth of military-related industries in Japan, and such an expectation might even benefit the market as well.

Theoretically, it is not surprising to expect that material information about a country's geopolitical risk can and should affect various asset prices within the country. While government-issued bonds are regarded as virtually riskless due to the government's ability to collect tax and print money, the government bonds are also subject to sovereign risk—that is, they are only as safe as the government that issued them. Since a bond is a promise to pay a fixed amount, a rational bond buyer would prefer a bond issued by a "safer" government to an otherwise equivalent bond issued by a "risky" government. Therefore, governments exposed with higher risk—both financial and non-financial—need to offer a higher yield to compensate the investors for accepting the higher level of country-specific risk. The difference between government bond yield in a country and the counterpart in a safe benchmark country is called "country risk premium," and if the investors perceive the North Korean provocations as signals of greater risk, they will demand a higher country risk premium from countries that are exposed to the risk, resulting in a higher bond yield and lower bond prices. Similarly, a higher risk premium pushes up the required return of an equity security and therefore its price must decrease to offer a higher return. One can see this relation through the dividend discount model in which the

country premium is explicitly expressed as in the following formula:

$$P_t = \sum_{j=1}^{\infty} \frac{\mathbb{E}_t(D_{t+j})}{(1 + i_t + \text{country premium})^j}, \tag{1}$$

where the price of a equity security at time t is equal to the sum of all expected future dividents discounted at (1 + interest rate + country premium) annually. In this formula, it is easy to see that a higher country premium corresponds to a lower equity price, all else being equal. Consistent with this feature of the asset pricing models, Bilson et al. (2002) found that political risk plays an important role in explaining variation of returns in financial markets of emerging countries. Similarly, one can also believe that the value of a country's currency is related to the country premium of the country in which the currency is issued and circulated. Willard et al. (1996) relied on this relationship between the war-related risks and the value of a currency (the Greenbacks) in order to identify the events that were perceived as important by the financial market during the American Civil War. If, however, the provocative events do not meaningfully affect the market participants' perceived country risk premium and expectation for future ability to generate income or make promised payments, those events might not affect the asset prices in statistically significant ways.

Finally, it is also possible that the return on a particular company stock or an industry portfolio might systematically deviate from the movement of the overall market index following the events. Companies that produce defense products for the Korean military, for example, might benefit from higher expected revenue due to heightened military tension within a country, which would adversely affect the overall stock market. Conversely, since the inter-Korea summit in 2000, there have also been companies that engage in various economic cooperation projects with North Korea, such as building infrastructure or operating production facilities in the form of direct investment in North Korea (among the widely-known *chaebols*, Hyundai Corp. has

been the most notable player in these activities). These companies that "cooperate" with the enemy can expect to be more severely affected by the deterioration of the inter-Korea relationship than the rest of the market. If we use the above dividend discount formula to value these companies following events that negatively affect the inter-Korea relationship, not only the denominator increases due higher country risk premium, but the expected dividends in the numerator would also be lowered due to decrease in expected earnings.

The unique geopolitical risk posed by North Korea has attracted earlier works including Ahn et al. (2010) and Kim and Jung (2014), which also investigated the effect of the North Korean provocations on the South Korean stock market. As I will discuss further in the Literature Review section, however, these previous studies only cover relatively short time horizons and focus only on the response of the stock markets. My main contribution to the existing body of literature comes from the following three improvements from the previous studies. First, I used a longer historical dataset that covers 37 years from 1980 to 2016. This dataset compares to the datasets from 1998 to 2009 and another from 1999 to 2012 that the two above mentioned studies used, respectively. The longer time-series of my data enables me not only to draw samples from a larger universe of events, but also to investigate whether the nature of the market response has changed over the time horizon. Second, this study makes appropriate adjustments to the data in order to avoid issues related to the overlapping of estimation and event windows when there are multiple events in close succession. These two improvements allow me to define the sample events in a more objective way, without potential biases from "cherry picking" of events by the researchers or through the overlapping of estimation and event windows. Finally, this study extends the analysis to include the Japanese markets and tests the impact on currency and bond markets instead of studying the stock market in isolation. These extensions allow for an understanding of the impact of North Korean provocations in

a fuller perspective.

Instead of approaching the issue anecdotally as briefly done in the opening paragraph with the nuclear testing in September 2016, this study aimed to measure the impact of North Korean provocations on various financial assets in a more scientific fashion using an event study framework as described by Brown and Warner (1980) and MacKinlay (1997). Using data from 1980 to 2016, I estimated the abnormal returns of different financial assets in Korean and Japanese markets following the provocations. The result reveals negative abnormal returns for most financial assets following the events, with the negative responses especially pronounced after experiments with nuclear weapons or long-range missiles (LRMs). In contrast, assets such as Korean government bonds and Japanese Yen are shown to be resilient to the information about North Korean provocations. Consistent with expectations, minor provocations such as maritime border crossings or releases of rumors about nuke or LRMs exhibited relatively little impact in terms of both the magnitude and the statistical significance. The firm-level analysis suggests that on average the South Korean companies that engage in economic cooperation projects with North Korea show greater fall in price than the general market, while the defense industry stocks initially tend to drop with the market but eventually benefit from the threats following nuke-related events over longer event windows. In addition, comparison of mean cumulative abnormal returns across different sub-periods show that, on average, the abnormal return has become less negative over the study period, suggesting that people mighte be getting accustomed to the repeated provocative events. However, due to small sizes of sub-period samples, the evidence to the claim is not highly statistically significant.

The rest of the paper is organized as follows. Section 2 presents some event studies that examined the relationship between terrorism and financial markets both globally and in Korean market setting. Section 3 elaborates on the research ques-

tions and describes the methodology. Section 4 shows how the data are obtained and treated for analyses. Sections 5 to 8 presents the main statistical results of the event study. Finally, Section 9 concludes the paper.

2 Literature Review

2.1 Event Studies Using Global Macro-Events and Terrorism

While the most well-known event studies such as MacKinlay (1997) studied the effect of corporate events such as dividend announcements and board decisions, there exist event studies including Niederhoffer (1971), McDonald and Kendall (1994), and Chen and Siems (2004) that examined the effect of macro- or market-wide events on broad financial markets. Niederhoffer (1971) studied daily returns of the S&P Index surrounding 432 world events that appeared in New York Times' headlines including the Korean War, the Suez crisis, and deaths of important figures including U.S. presidents. This study found greater price fluctuations after releases of major news than in other trading days and a tendency of market to correct for initial over-reactions over the next 2 to 5 days. In a study that looked into the stocks within a specific industry, McDonald and Kendall (1994) examined the reaction of U.S. defense industry stocks to unanticipated political events involving the military. Using 17 such events and 16 defense industry stocks, the authors showed that the stock prices of those firms tended to rise as a result of the military actions, especially following the events involving the former Soviet Union. Based on this result, the study recommended including the defense stocks in an investment portfolio as a way to diversify away the risks involving military-related shocks. Based on an analysis of 14 larger

scale global events that go back to 1915 including the Iraqi invasion of Kuwait and the September 11 attack, Chen and Siems (2004) found not only that U.S. stock and bond markets reacted negatively following the events but also that the development of a stable and liquidity-providing financial sector lead to smaller panic and greater resilience of the capital markets following exogenous shocks.

There also exist event studies that looked specifically at the link between terrorism and stock markets. Karolyi and Martell (2006) conducted an event study on the effect of terrorism on the stock market, using 75 terrorist attacks between 1995 and 2002 that are officially recognized by the Counterterrorist Office of the U.S. Department of State, and found statistically significant negative impact on the stock prices of publicly traded firms. When the events were broken down into multiple categories, the impact on stock prices was more evident in cases in which target countries were wealthier and more democratic and when there were human capital losses such as kidnapping of company executives as opposed to when the losses were physical (e.g. destruction of facilities). Chesney et al. (2011) used terrorist events from 25 countries over 11-year period and price data in the European, American, and Swiss financial markets and found that the different markets, asset classes, and industry indices respond differently following the terrorist events. The authors concluded by proposing to use their result as a strategy to diversify and hedge the terrorism risk in an investment portfolio.

The event study framework has also been used to study the effect of "repeated" terrorist attacks (as is the case with North Korean provocations) within the context of Middle East. Zach (2003) studied returns of two stock market indices that are related to Israel, Tel Aviv Stock Exchange Daily 100 (TAD 100) and a self-constructed equally-weighted index of Israeli stocks traded in the United States, around major political events related to the peace process in the Middle East. The

result based on the sample period of 1993 to 1997 indicates that the volatility of returns tend to increase following major political events for the firms listed in Tel Aviv Exchange and the firms that are listed both in Israel and in the U.S., but not for the Israeli firms listed only in the U.S. market. More recently, Eldor et al. (2012) studied the effect of the conflicts on the Israeli and Palestinian stock markets and found that the acts of terrorism have "bi-directional causality effects of return" felt by both the attacking and victim countries, due to uncertainties regarding retaliation. Compared to other studies that use worldwide terrorist events that are truly surprises, these two studies are similar to the studies concerning North Korean threats in that the attacks could have been anticipated to happen at some point in the future and therefore are as much about the timing of the events as the likelihood of the occurence.

2.2 Event Studies on Korean Financial Markets

In one of the previous works discussing the effects of political events on Korean financial markets, Song (2002) examined the effect of major news on Korean markets in the period following the South Korean foreign currency crises from 1999 to 2002. The empirical results from the study indicates that an arrival of news affects both the stock market and foreign exchange market, with different types of news having a statistically significant effect on different markets. The paper, however, did not find the different sources of the news releases—that is, whether they were domestic or foreign—to have a meaningful impact on the asset prices. There also exist studies that used monthly, as opposed to daily, return data including Kim (2011) and Dibooglu and Cevik (2016). However, since the goal of an event study is to measure the response of markets following specified events, using monthly return data may not properly capture the responses if the responses are susceptible to time and other factors that could occur over the month. For example, when mar-

ket prices have a tendency to bounce back to the pre-event level after a short-term over-reation following the events, monthly return data cannot properly account for short term fluctuations which might be statistically significant and bear important policy implications. In addition, there is simply too much "background noise"—the effect attributable to other important factors that affect asset prices, such as a central bank's rate increases or unexpected financial crises—over a month's time, so even if the effect of the provocation persists, it would be swamped by these background noises that are generated throughout the month. As suggested by both Niederhoffer (1971) and Kim and Jung (2014), asset prices following exogeneous shocks exhibit a tendency to return to previous levels, and therefore use of monthly data will not be able to capture this effect. This is consistent with the conclusion by Morse (1984) that the use of daily return data is superior to the use of monthly data in estimating the effect of information on asset returns.

Two studies conducted by Ahn et al. (2010) and Kim and Jung (2014) served as a benchmart starting point for my own research. Ahn et al. (2010) conducted an event study by dividing the 37 military-related events by North Korea covered in South Korean news medai between 1998 and 2009 into "good news" and "bad news" and found that each correspond to rises and falls in stock market indices, respecively. In addition, with a similar hypothesis to that of McDonald and Kendall (1994) which looked at the U.S. defense industry following large military events, the authors classified some of the securities as "defense stocks" and "economic cooperation stocks" to find that while the cooperation stocks behave similarly to the market indices, the defense stocks reacted positively to only bad news but were dominated by the market's movement in times of good news. I borrowed the list of "economic cooperation" companies from this paper to see if I could replicate the result based on my longer dataset and methodology that is robust to "estimation window contamination," a potential bias that I describe below.

Kim and Jung (2014) used daily microstructure data for the South Korean stock market that includes daily information about stock prices, bid-ask spreads, and short selling activities between 1999 to 2012. The study concluded that there exist statistically significant and negative abnormal return of -1.6% over [-1, 1] event window in the South Korean stock market for nuclear weapons testing and of -1.79% over [-1, 1] window for military threats. The effects, however, were not statistically significant in the cases of military aggressions and warnings. They also found some evidence of information asymmetry among investors, as indicated by larger bid-ask spread and a significant spike in abnormal short selling volume before the events. It is questionable, however, whether we have credible evidence to believe in the existence of "insider trading" by North Korean officials or investors based on planned provocations, especially given the potential biases discussed in the following paragraph. This paper also briefly touches on the impact on Japan and Hong Kong's stock market indices anecdotally, and also on performances of defense stocks and economic cooperation stocks, but does not find any statistically significant results.

Both of the benchmark papers, however, are subject to potential biases in two ways. First, Kim and Jung (2014) lacks a systematic and objective methodology to define the events that were included in their analysis, in which the events are hand-picked according to their subjective ex post historical importance. To measure the immediate response of the market following the events, it is more appropriate to use the events that gained the spotlight at the time of their occurance, as the aforementioned event studies using newspaper coverage did, instead of using the events that later turn out to have historical significance to the diplomatic relationship. While the study by Ahn et al. (2010) starts by gathering newspaper headlines to be used as events, the authors also narrowed down the list of events according to perceived importance and the existence of other "important" events near the event dates, exposing the result to potential bias due to subjectivity. Second and perhaps more importantly,

both papers do not properly account for data contamination issues caused by events that occurred in close succession. This failure to treat data contamination properly could bias the calculation of estimated normal return parameters, which would result in type II error (i.e. failure to reject the null hypothesis when the effect is present). I further describe the mechanism of the bias in estimating the normal returns and propose an alternate way to avoid it in the following Methodology section.

3 Research Questions and Methodology

3.1 Research Questions

The event study framework provides a way to quantitatively measure the immediate impact of an event on asset prices, by identifying abnormal returns on the asset in a period following the event. If the event carries favorable information to the investors, one could expect positive abnormal return after the event, and vice versa. If the information is not meaningful enough, the abnormal return would not be significantly different from zero. Using this framework, I address the question of whether the provocative actions by the North Korean government have a statistically significant effect on the stock, bond, and foreign exchange markets of Korea and Japan. It is not difficult to imagine that such actions could project negative signals about the geopolitical risk to neighboring countries. In addition, I further classify the events into four categories depending on the form of the provocation in order to see how each type of event affects each of the different assets. As Chesney et al. (2010) found, the same information about the market-wide risk could impact different financial assets in different ways, and one could also imagine that different

types of news (e.g. nuclear or non-nuclear) could carry different signals to the prices of different asset classes.

Additionally, we might ask whether a certain company or a certain industry can benefit from the heightened level of war-related risk. Similar to how McDonald and Kendall (1994) did in investigating the reaction of U.S. defense industry following military events, I chose to investigate the defense industry companies that manufacture military-related products in South Korea. I therefore look at the behavior of the return on the defense industry stocks following North Korean provocations to see whether how stock prices of those companies behave relative to the overall market following these events. Since the Japanese government is using the threats from North Korea as an argument for strengthening their defense force, as Smith (2013) pointed out, one might hypothesize that producers of defense products in Japan might be benefitting from the North Korean threats. But the country is still constitutionally constrained from developing its own military (other than its Self-Defense Force) after World War II, and the production of defense products are dominated by large conglomerates like Hitachi, Mitsubishi, and Toyota. Both factors make it difficult to study the true impact on the Japanese defense companies without further processing the data to isolate the impact on the subsectors related to defense products, so addressing this question would be beyond the scope of this study.

On the other hand, there is also a set of South Korean companies that generate revenues from reconciliatory economic policies between South and North Korea, such as the companies that export utilities to North Korea or operate factories within North Korea's territory. Since the operation of these "economic cooperation" companies is often used as a bargaining chip in the negotiations following provocative events, we would expect their stock prices to react more sensitively than the overall market to the changing relationship between the two countries. I analyze these companies

along with the analysis of Korean defense industry. If a portfolio consisted of such companies' stocks that exhibit a pattern of divergence from the broader market index at times of provocative events, one could take appropriate long or short positions in these portfolios to hedge against or make profit from the geopolitical risk.

Finally, I raise the question of whether the magnitude of the shocks on the financial markets changed over time. As mentioned earlier in the Introduction section, contrasting views exist within the general public regarding the North Korean provocation; some people view the threats as negatively affecting the South Korean economy and others have learned over time to regard them as "business as usual." To answer this question, I test whether the nature and degree of the reaction have changed over time after decades of repeated provocations by comparing the mean abnormal returns of different periods using the mean-comparison t-test.

3.2 Estimating Abnormal Returns

In order to conduct the event study, I used the procedure outlined in Brown and Warner (1980) and MacKinlay (1997)—two canonical works on event study methodology. The event study methodology includes the following steps: setting the estimation and event windows, estimating normal returns over the estimation windows, calculating the abnormal returns as the actual return over the estimated normal return, and finally testing for their statistical significance.

Different studies use various sizes of estimation and event windows. The size of the estimation windows generally range from 20 to 200 days ending 10 to 20 days before the event when calculating the expected return. There is no "standard" length for the estimation window with different authors using different windows ranging from 30 to 300 days. I used a 90-day estimation window of [-100, -11] for the analysis. The

event window could be either the day of the event itself, [0], or more traditionally include some days before and after the events to account for the small noise in the timing of the information release. Kim and Jung (2014) used a [-1, 1] trading day window to measure the short-term response and a [-1, 7] trading day window to measure the response over a slightly longer period. Generally, the event windows will include some days preceding the event to address the possibility of "insider trading" in which some parties could have gained the information in advance and acted on that information or some other random noises in determining the event date. While the problem of potential insider trading could be an issue for event studies that look at corporate events where corporate insiders have early access to information, accounting for such a behavior is not a major source of concern in my study of North Korean provocations. Since I am using the newspaper release dates as the event dates, day [0] would correspond to the first full day of trading, instead of the actual day the event occurred (if the two dates are different). To account for the event-day reaction, I also include the day before the event date (or, day [-1]) in my event windows to capture the effect of many news reports that become available on the day before they get published in a newspaper. Throughout the paper, I mainly present and base my interpretation of the parameters from event windows of different lengths from [-1, 0] to [-1, 5].

In the final step of constructing estimation windows, I "cleansed" the event data for contamination. Event data contamination occurs when more than one event happens in close succession so that an estimation window overlaps with an event window of another event. If an existence of an event affects asset prices in a systematic way, then having an event occur during an estimation window could bias the estimation of normal return. For instance, if an event has a negative impact on the price of a given asset, having such an overlap between an estimation windows and one or more event windows would bias the normal return downward. The abnormal

return variable calculated as the difference between the return over the event window and the calculated normal return would therefore be closer to zero than it should be without the contamination, and therefore significance tests based on abnormal return parameters could suffer the type II error ("false negative") of failing to appropriately reject the null hypotheses. If the impact of the event on the asset price is positive, the calculated normal return would be higher and we would still get abnormal return parameters that are biased downward. Neither Ahn et al. (2010) nor Kim and Jung (2014) correctly account for the issue of data contamination. The standard procedure of accounting for data contamination is to drop the events whose estimation windows overlap with any other event windows. Following this procedure with the North Korean provocation data with estimation windows of longer than 70 days, however, results in dropping more than half of the events, leading to reduced power of statistical testing to correctly reject the null hypotheses. So instead of dropping all of the "contaminated" events following the standard procedure, I made "holes" in the estimation window by dropping the price data that are less than a week apart from other events that happened during the estimation window. If an event was preceded by another event by less than a week of time, that event was dropped. As long as the effect of the events does not last for longer than a week, the estimation of normal return based on daily data that are cleansed for confounding events this way will not be biased, and the larger number of events included in the analysis can increase the power of statistical tests. A sample timeline with a 90-day estimation window of [-100, -11], 3-day event windows of [-1, 1], and a cleansing for an overlapping event window is illustrated in Figure 1.

Once the estimation and event windows are specified, the normal return for a given index or an asset is calculated over the chosen estimation window. I used the Constant Mean Return Model for market-wide data including the stock indices, exchange rate, and government bond price data, and the Market Model (or

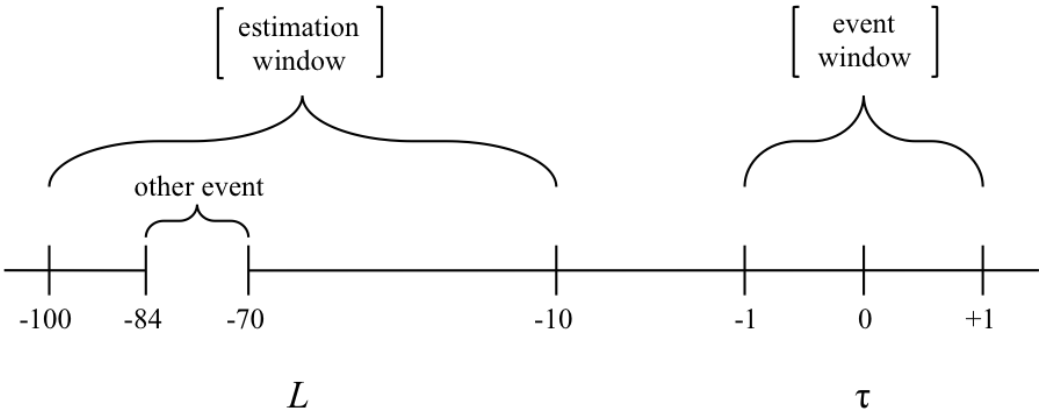


Figure 1: Sample event study timeline, using the notations from MacKinlay (1997).

OLS Model) for the firm-level stock price data. The Constant Mean Return Model assumes that the daily price return follows a constant mean for a given asset or index and uses the arithmetic average of daily returns over the estimation window as the normal return of the asset or the index. In other words, the estimated normal return under the Constant Mean Return Model has a form of

$$E_{constant}(R_i) = \frac{1}{L}\sum_{L} R_{it} \tag{2}$$

where R_i is the daily return of the index or asset i, $E(R_i)$ is the estimated mean return, and L is the set of days in the estimation window.

Firm-level stock price data are used to test the response of South Korean defense industry and economic cooperation companies to the provocation events. As a first step, I construct two equally weighted portfolios: one consisted of defense companies and the other consisted of economic cooperation companies. Then I estimate the portfolio-level normal return using the Market Model based on Ordinary Least Square estimator. The estimated normal return of the portfolio i on a given day t

within the event window in this model is calculated as

$$E_{OLS}(R_{it}) = \alpha_i + \beta_i R_{mt} \tag{3}$$

where i is the identifier for a given portfolio, R_{mt} is the daily return of the broader market index m on day t (in my case, the daily return of KOSPI Index on day t), and α_i and β_i are estimated by the standard OLS regression based on the historical data over the estimation window. This procedure is based on the guideline for industry-level analysis provided by MacKinlay (1997). There exist other complicated models such as the Multi-Factor Model that requires additional input variables like firm size and book value. However, the simpler Constant Mean Return Model and the Market Model are both unbiased, and both MacKinlay (1997) and Brown and Warner (1980) concur that the simpler models have similar powers as the more complex models. The gains from using the complex models therefore are small, especially when the data for the additional variables are not easily obtainable and therefore might lead to fewer observations.

Once the normal return is estimated using the above models, the abnormal return is calculated simply as the average excess return of the actual over the normal return. Often, the abnormal return (or average abnormal return) is cumulated over the event window as the cumulative abnormal return (or cumulative average abnormal return) to measure the aggregate effect of the shock. In other words,

$$AR_{it} = R_{it} - E(R_{it}) \tag{4}$$

$$CAR_i = \sum_{\tau} AR_{it} \tag{5}$$

where AR_{it} and CAR_i are abnormal return and cumulative abnormal return for the asset or portfolio i on the trading day t, respectively. The abnormal return can be

interpreted as the excess return relative to the calculated constant mean when the Constant Mean Return Model is used, and as the excess return relative to what is expected by the movement of the overall market when the Market Model is used.

The final step of the analysis is to test for the significance of the calculated parameters. Rejecting the null hypothesis would mean that the Cumulative Abnormal Return is statistically different from zero and that the events have a statistically significant impact on the asset returns, and failure to reject the null would mean that the size of the impact is not statistically different from zero. In generally, the traditional t-test based on standard deviation of returns measured over estimation windows is used most frequently in event studies. However, Boehmer et al. (1991) found that the standard deviation of returns during event windows tends to be larger than the estimation window standard deviation. In such a case where there exists event-induced variance increase, the authors argue that using the traditional t-test based on estimation window standard deviation could result in too frequent rejections of null hypotheses of zero abnormal returns. The authors therefore suggest an alternative 'standardized cross-sectional test' (or 'BMP-test', after the initials of the authors) which standardizes the parameters by both the estimation window variance and the event window variance, and "yields appropriate rejection rates when the null is true and yet is equally powerful when the null is false" (Boehmer et al., 1991). I use the BMP-test in conjunction with the traditional t-test. Additionally, I also provide the results of the non-parametric generalized sign test as an additional robustness check. Appendix A provides the formulae and detailed explanations of these test statistics.

4 Data

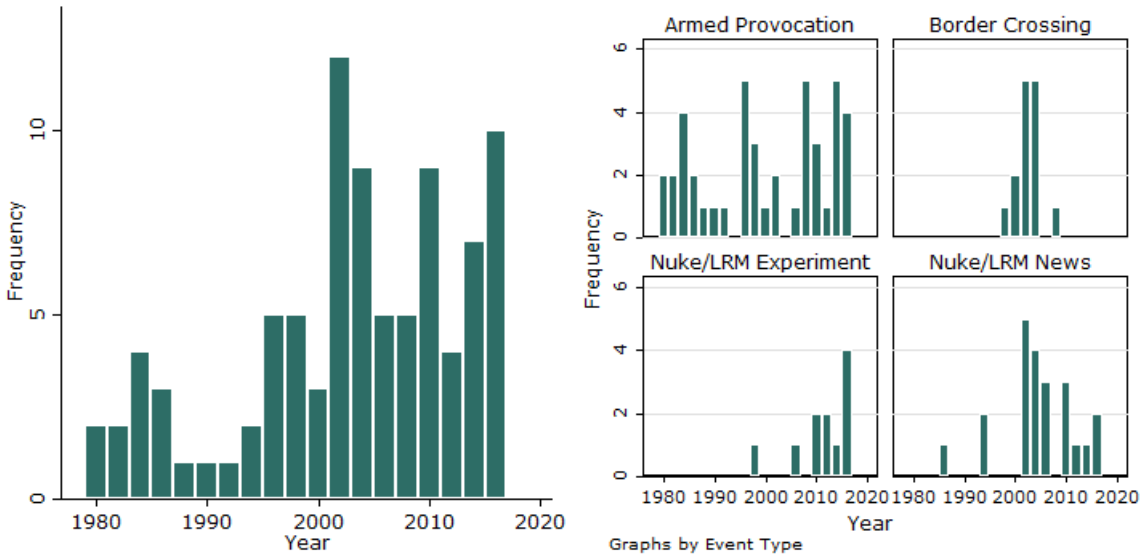
An event study requires two sets of data: events data and daily asset price data. In my study, the asset price data include the data for Korean and Japanese market-wide stock indices, firm level stock prices for industry-level analysis, exchange rates of Korean Won and Japanese Yen (relative to US Dollar), and government bond prices.

4.1 Events Data

The list of events is constructed using the three major Korean newspapers (Chosun, Joongang, and Donga) that have enjoyed an oligopoly of newspaper subscription in South Korea since the 1960s. According to the Korea Audit Bureau of Certification reports that track the publication data of Korean newspapers (2010, 2016), the three papers combined commanded about 68% of the market share by the number of printed copies in 2010 when the report began to be released, and they still command 47% of the market of the 25 largest publishers in the most recent 2016 report. All three companies offer simple ways to search headline articles dating as far back as 1980, the earliest year included in my analysis, based on the titles and the words within the bodies of the articles. I began by gathering front page newspaper articles containing keywords such as "North Korea," "North Puppet" (as both South Korean government and the public used to call the North Koreans in a disparaging way prior to 2000s), "Provocation," and "Nuke". I gathered the total of 371 provocative actions taken by North Korea that appeared on the front pages of the papers from 1980 to 2016, and further narrowed the list down to 97 that commonly appeared in all three papers. Events that appeared only in one or two of the newspapers are considered to have been of less importance or overshadowed by other events that were

deemed more newsworthy at the time. For example, on April 30, 2014, the news about the North Korean military's shooting exercises that did not cross the Northern Limit Line (NLL, the maritime demarcation line) appeared only on Chosun and Donga's front pages, and the news about testing with ballistic missiles on July 3, 2014 featured only on Chosun's front page, as other news media were focusing on the coverage of the Korea-China summit at the time. The former news is an example of an event with less intrinsic significance compared to other provocations, and the latter has a significant confounding factor (the Korea-China summit) whose effect on financial market returns might swamp the effect of the provocation. Finally, 7 out of the 97 events had to be dropped during the "cleansing" procedure described in an earlier section because they were preceded by other events by less than 7 days. In the end, there were a total of 90 events left for the final analysis. For an analysis by the types of the events, the list is classified into 43 armed threats and provocations ("armed provocations"), 14 border crossings without militant action ("border crossings"), 11 experiments with nuclear weapons or Long Range Missiles ("Nuke/LRM experiments"), and 22 rumors about nuclear weapons and LRMs ("Nuke/LRM rumors") that did not directly involve experiments or missile launches. These are natural categories to classify the events into based on whether there were nukes or LRMs involved and whether the event involved physical engagement or actual experimentation. This classification can be done relatively objectively and we can assume that the four categories convey information of different natures and degrees. The distribution of the events is shown in Figure 2, and the full list of the 90 events and their classifications is included in Appendix B below.

Compared to the approaches used in both of my benchmark papers by Kim and Jung (2014) and Ahn et al. (2010), in which the authors handpicked the events from a chronology of the provocations, my approach of defining the events based on newspaper headlines accomplishes three things. First, it provides an objective



(a) Final events data after cleansing (b) Event distribution by event type

Figure 2: Distribution of the events over the study period.

way to construct a dataset that's free from any potential human errors including deliberate cherry picking and unintentional selection bias due to subjectivity. Second, the approach lets us focus on the events that gained the broadest spotlight at the time of the occurrences as opposed to the ones that were discovered or determined to be important ex post based on its long-term consequences. As Willard et al. (1996) put it, "an event may be important to us as later observers, or the event might have been important to people who lived at the time." Using the events that appeared on major news headlines helps me focus on those events were broadly regarded as newsworthy by the contemporaries. Finally, the fact that all three major newspapers covered the same event on their front pages also suggests that there were less likely other major news events that were significant enough to entirely overshadow the news about the provocation on the same day (like the Korea-China summit that happened on the same day with a missile test, as mentioned above). Therefore, this method of sampling the events based on news headlines lets us objectively choose the events that were widely regarded as newsworthy than the ones that reflect business decisions

by one or two news publishers.

4.2 Daily Price Data

I used Bloomberg Terminal to obtain daily data for KOSPI index, Nikkei index (Nikkei 225), firm-level stock prices of all 777 firms listed on the Korean Stock Exchange[1], and 3-year and 10-year maturity government bond yields of Korea and Japan. Daily exchange rate data on the Korean Won (KRW) and Japanese Yen (JPY) relative to the US Dollar are obtained from Federal Reserve Bank of St. Louis' FRED (https://fred.stlouisfed.org) and converted to prices in US Dollar per unit currency (i.e. USD per KRW and USD per JPY, respectively). Finally, I calculated the bond prices (1,000 unit currency face value zero-coupon bond) based on the bond yields data to be used for daily return calculation to make the interpretation of the "abnormal return" consistent across different asset classes.[2] For the analysis of defense and economic cooperation stocks listed on the Korea Stock Exchange[3], I used the defense companies whose Bloomberg Industry Classification Systems (BICS) classification is "Aerospace & Defense" and the economic cooperation companies from the list Ahn et al. (2010) compiled based on the classifications by Samsung Securities, Korea Investment & Securities, and Paxnet. The list of these companies includes 4 defense industry companies and 14 economic cooperations companies. The names and the descriptions of the companies can be found in Appendix C.

The earliest data are from the beginning of 1980, and while some time-series datasets were available only from later times, all datasets share the same last event

[1]Number of firms as of November 6, 2016.

[2]A common practice when working with bond yield data is look at the *change* in bond yield as opposed to the *rate of change* in bond price, as done in here. The yield and price of a bond are inversely related, so an increase in bond yield would correspond to negative return in the bond price and vice versa, but this change does not materially affect the outcome of the analyses.

[3]KOSPI is the market-capitalization weighted index for Korea Stock Exchange.

Variables	Obs	Mean	Mean return(%)	Start date	End date
KOSPI Index	9,977	894.30	0.0410	1/4/80	11/4/16
Nikkei Index	9,069	15531	0.0201	1/4/80	11/4/16
Korean Won (in USD)	8,931	0.0011	0.0039	4/13/81	12/30/16
Japanese Yen (in USD)	9,297	0.0082	0.0100	1/2/80	12/30/16
T-Bond Yield (Korea, 3 yrs)	4,065	4.0300	-0.0285	8/7/00	12/30/16
T-Bond Yield (Korea, 10 yrs)	3,972	4.5296	-0.0218	12/19/00	12/30/16
T-Bond Yield (Japan, 3 yrs)	6,791	1.2807	-0.2563	10/2/89	12/30/16
T-Bond Yield (Japan, 10 yrs)	7,433	2.3669	0.1405	10/22/87	12/30/16

Table 1: Summary statistics of the daily data

that falls on September 10th, 2016.[4] Summary statistics of the datasets including the start date of each time-series are shown in Table 1.

5 Baseline Results

The baseline results using all events are presented in Table 2. First, the cumulative abnormal return (CAR) parameters of the KOSPI index are negative throughout most event window periods. While the parametric t-test and BMP test results are not robust to changes in event windows, the results of non-parametric sign test suggest that the sign of the abnormal return is negative and statistically significant at high confidence levels (5% to 10%, depending on the event window lengths). The magnitude of CARs is between -0.3% and -0.4% depending on the choice of the event window, which is about 10 times larger compared to the magnitude

[4]KOSPI index is set to the base value 100 as of January 4th, 1980, which also corresponds to the earliest year of the study period.

of 0.041% mean index return. On the other hand, the CARs of Nikkei index over the time windows turn out to be positive and even significant in some intervals. The sign test results of the same index data, however, turn out to be uniformly negative and statistically significant, suggesting that the test results are not robust to assumptions regarding parametric and non-parametric analyses. Such a divergence of test results warrants a further analysis about the nature of the events. The results of the analyses by the type of the events in the following section might provide an insight into this.

The parameters for Korean Won (KRW) and Japanese Yen (JPY) indicate abnormal returns of each currency value measured in US Dollars. From the result based on all 90 events, we can see that the Korean Won behaves similarly to the KOSPI index. While the parameters are statistically significant at the 10% significance level, the direction of the excess return is in most cases negative and the statistically significant sign test results support the negative abnormal return. The mean return of KRW/USD rate is 0.0039%, suggesting that the exchange rate approximately follows a random walk, and a change of about -.0.1% to -0.2% is again quite large compared to the mean return. Japanese Yen, on the other hand, is shown not to be affected meaningfully by the provocative events in the baseline analysis. The magnitude of the CARs turn out to be relatively small at less than 0.07% in every choice of event window, compared to 0.001% mean return (which, again, is approximately a random walk), and both the parametric and non-parametric test results fail to reject the null hypothesis at the 10% significance level. Therefore, the value of the Japanese Yen can be considered relatviely insusceptible to the North Korea risk, indicating high investor confidence in the global key currency at times of heightened geopolitical risk.

Similar to the case for Nikkei index, the abnormal return on holding Korean treasury bonds exhibit divergence of different test results. In both cases, the CAR

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
KOSPI (N=90)	[-1, 0]	0.043	0.187	-0.234	-1.746*
	[-1, 1]	-0.384	-1.353	-1.282	-1.961**
	[-1, 3]	-0.447	-1.219	-1.309	-1.746*
	[-1, 5]	-0.115	-0.266	-1.062	-2.392**
Nikkei (N=90)	[-1, 0]	0.503	2.450**	1.832*	-0.898
	[-1, 1]	0.359	1.429	1.125	-1.339
	[-1, 3]	0.306	0.942	0.768	-2.220**
	[-1, 5]	0.443	1.155	0.728	-2.661**
KRW (N=90)	[-1, 0]	-0.140	-1.228	-0.883	-1.984**
	[-1, 1]	-0.159	-1.133	-1.337	-1.553
	[-1, 3]	0.007	0.039	-0.145	-1.553
	[-1, 5]	-0.217	-1.016	-0.882	-1.338
JPY (N=90)	[-1, 0]	-0.039	-0.379	-0.175	-0.851
	[-1, 1]	0.018	0.145	0.299	-1.063
	[-1, 3]	0.061	0.374	0.647	-0.427
	[-1, 5]	0.035	0.184	0.512	-0.427
Bond(KR, 3yr) (N=61)	[-1, 0]	-0.009	-0.269	-0.945	-1.272
	[-1, 1]	0.045	1.054	0.650	-1.272
	[-1, 3]	0.046	0.826	0.136	-0.745
	[-1, 5]	0.030	0.456	-0.534	-2.327**
Bond(KR, 10yr) (N=61)	[-1, 0]	0.063	0.595	-0.153	-1.181
	[-1, 1]	0.209	1.617	0.759	-1.181
	[-1, 3]	0.200	1.203	0.167	-0.659
	[-1, 5]	0.127	0.642	-0.505	-1.181
Bond(JP, 3yr) (N=78)	[-1, 0]	-0.012	-1.017	-0.811	-3.006**
	[-1, 1]	-0.022	-1.560	-0.952	-2.549**
	[-1, 3]	-0.040	-2.189**	-0.995	-2.549**
	[-1, 5]	-0.051	-2.390**	-0.759	-3.462**
Bond(JP, 10yr) (N=78)	[-1, 0]	-0.010	-0.180	0.364	-1.188
	[-1, 1]	-0.067	-0.975	-0.574	-1.646*
	[-1, 3]	-0.090	-1.009	-0.735	-0.729
	[-1, 5]	-0.060	-0.569	-0.390	-1.417

Table 2: Baseline CARs (All Events by Asset Class)

Notes: CARs are in percentage points. Numbers inside the parentheses show the number of observations. * and ** next to the test-statistics indicate statistical significance at the 10 and 5 percent levels, respectively.

parameters exhibit positive signs in most event windows, while the sign test provides the opposite results with negative signs. However, both results do not consistently exhibit statistical significance, again suggesting that an in-depth analysis by event types might help us better understand the nature of bond price returns. Compared to the stock market reaction, investor confidence in the bond market can be understood to be less susceptible to the exogenous shocks, consistent with general expectation. On the other hand, the 3-year Japanese treasury bond price showed negative CARs as one could normally expect following an event signalling heightened risk. Both the t-test and the sign test suggest that the 3-year-maturity government-issued bonds generate negative and significant abnormal return following the events. This is in contrast to the result we saw with Korean financial markets where the bond market seemed relatively stable at times of provocative events. In the later section for analysis by event type, I investigate what types of events are driving this overall result. The abnormal returns on longer term 10-year Japanese treasury bonds also exhibit negative signs, but the parametric test results fail to reject the null hypotheses. While the sign test results are significant at the 10% level in some choices of event windows, the return on the 10-year bonds does show a smaller response than that on the shorter term bonds.

In summary, we see that the KOSPI index, Korean Won, and Japanese government bond prices all exhibit a robust pattern of negative abnormal returns following North Korean provocations. However, other assets provide inconclusive (e.g. Korean bond or Japanese Nikkei index) statistical test results. One could also point out that, when broken down into different event type categories, about half (43 out of 90) of the events are classified as "Armed Threats and Provocations", suggesting that the baseline result might be significantly driven by the effect of those events. In addition, most of the events concerning nuke- or LRM-related experiments are concentrated in the recent past due to the nature of technology development com-

pared to the armed provocations which are distributed throughout the study period, suggesting that the timing of the events might also be another confounding factor.

6 Result by Types of Events

One could easily hypothesize that not all provocative events would affect the asset returns in the same way. In order to test this hypothesis, I classified the events into the following categories as defined earlier: armed provocations, border crossings, nuke/LRM experiments, and nuke/LRM rumors. As shown in Figure 2(b), the timing of each type of events is distributed differently, warranting further analysis based on the types of events.

6.1 Armed Provocations

The results based on armed provocation events are summarized in Table 3. Similar to what we saw in the baseline analysis, the KOSPI Index exhibited some evidence of negative abnormal returns in the baseline analysis, while the statistical test results are not statistically significant, with an exception of non-parametric sign test in the [-1, 5] window. The similarity between the baseline result and the result from "armed provocation" events is not surprising, given that the baseline analysis was heavily driven by nearly half (43 out of 90) of the sample events that fall into this cateogory. For the Japanese Nikkei index, while the CAR parameter is shown to be positive at 0.69% and statistically significant on the [0, 1] event window following armed provocations, the results again show inconsistent signs between parametric and non-parametric test statistics, barring any conclusive comments about the response

of the Japanese stock market index.

The Korean currency, on the other hand, exhibits a negative and highly significant (at 5% level) abnormal returns of -0.38% immediately following the armed provocations on [0, 1] event window. However, one can see a reversal of the sign after the initial two-day response period, and the CAR parameters quickly become insignificant after inclusion of day ($t = 1$) and even slightly positive in [-1, 3] and [-1, 4] event windows. As was in the case in the baseline analysis, the value of Japanese Yen relative to USD following armed provocations does not show any significant sign of non-zero abnormal return, with calculated parameters being very small between 0.1% and 0.2% in most cases and statistically not significant. This again reflects the resilience of the country's strong currency.

The response of the Korean bond market shows positive and statistically significant excess returns of both 3-year and 10-year maturity government bond prices. Not only their signs are positive, the magnitude of the CAR parameters is significantly greater than the baseline figures. This suggests that the armed threats and provocations do not necessarily lead to loss of investor confidence in the Korean government's ability to honor the bond repayments, and that the market participants in fact bid the price up following those events. The increase in bond prices in conjunction with the decrease in stock returns might suggest that there exists a pattern of "flight to safety" where the Korean investors demand relatively safer assets (government-issued bonds) than riskier assets (stocks). In the Japanese bond market, on the other hand, the 3-year Treasury bond price shows significant and negative returns following the events in all three statistical tests. Like the 3-year maturity Japanese bonds, the 10-year Japanse bond data show negative CARs in varying event windows choices, but the result is not statistically significant in both parametric and non-parametric tests, showing less event-driven volatility in a longer-maturity bond than one would

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
KOSPI (N=43)	[-1, 0]	0.189	0.645	-0.092	-1.040
	[-1, 1]	-0.167	-0.466	-0.882	-0.732
	[-1, 3]	-0.369	-0.797	-1.141	-1.040
	[-1, 5]	-0.131	-0.239	-0.958	-1.655*
Nikkei (N=43)	[-1, 0]	0.692	2.560**	2.171**	0.046
	[-1, 1]	0.517	1.562	1.246	-0.912
	[-1, 3]	0.589	1.377	1.098	-1.231
	[-1, 5]	0.416	0.823	0.387	-2.189**
KRW (N=43)	[-1, 0]	-0.379	-2.839**	-1.390	-2.292**
	[-1, 1]	-0.230	-1.405	-1.002	-1.040
	[-1, 3]	0.225	1.065	0.212	-0.414
	[-1, 5]	-0.150	-0.598	-0.401	0.525
JPY (N=43)	[-1, 0]	0.104	0.707	1.062	0.723
	[-1, 1]	0.187	1.039	1.034	0.417
	[-1, 3]	0.140	0.603	0.698	0.112
	[-1, 5]	0.162	0.588	0.651	0.112
Bond(KR, 3yr) (N=21)	[-1, 0]	-0.017	-0.378	-0.714	-1.577
	[-1, 1]	0.116	2.125**	1.187	0.648
	[-1, 3]	0.138	1.963**	0.896	0.648
	[-1, 5]	0.107	1.286	0.016	-0.687
Bond(KR, 10yr) (N=21)	[-1, 0]	0.146	1.053	0.473	-0.943
	[-1, 1]	0.574	3.387**	1.461	1.708*
	[-1, 3]	0.641	2.930**	1.258	0.383
	[-1, 5]	0.486	1.879*	0.445	-0.059
Bond(JP, 3yr) (N=32)	[-1, 0]	-0.013	-0.591	-1.343	-1.449
	[-1, 1]	-0.039	-1.486	-2.491**	-1.095
	[-1, 3]	-0.055	-1.638	-2.201**	-1.095
	[-1, 5]	-0.076	-1.904*	-2.081**	-2.158**
Bond(JP, 10yr) (N=32)	[-1, 0]	0.053	0.609	0.605	-0.336
	[-1, 1]	-0.031	-0.293	-0.288	0.020
	[-1, 3]	-0.086	-0.625	-0.541	0.020
	[-1, 5]	-0.041	-0.249	-0.072	-0.336

Table 3: CARs (Armed Provocations by Asset Class)

Notes: See the notes from Table 2.

expect. In theory, it is hard to come up with a reason why the Japanese bond prices drop following the events while the equivalent maturity bond issued by the Korean government goes up in value. Perhaps this might be due to increased pressure for government spending given the high level of the current Japanese government debt, but it is difficult to see whether the Japanese government indeed reacts quickly to the armed provocation events by increasing spending.

Overall, the armed provocation events are shown not to result in significant abnormal returns on stock indices in both countries. It is possible that the high frequency of provocations of this type has led to the perpective of viewing such events as "business as usual." While the Japanese Yen seems immune to those events, Korean Won exhibited negative short-term response which also become insignificant in longer event windows. The government bond prices produced the most surprising result: the Korean bond prices went up following the provocations while the Japanese bond prices dropped during the same time frames. But due to the lack of convincing theoretical explanation, I do not make further inferences from this result.

6.2 Border Crossing

Border crossings refer to illegal crossings of North Korean naval or civilian vessels into the South Korean or Japanese territorial waters without direct military engagement (the ones involving fire exchanges were classified as armed provocations). Such non-militant events have historically been followed by more severe forms of provocations in the following weeks or months, but one would expect that the effect of such events on financial market would be small relative to other more direct aggressions or nuclear-related threats. It is for the same reason that while incidents of sea border crossing are much more commonplace than shown in the event distribution,

a majority of those events are not included in my event dataset as they were less likely to appear on major newspaper headlines. Given only 14 such events included in the final dataset, one would expect that the power of the statistical tests would be relatively low.

Consistent with the prior expectation that border crossings are considered minor events compared to other types of more direct provocations, both the KOSPI and Nikkei indices produce insignificant test statistics. While the small size of the sample (14 such events) might be at least in some part responsible for the failure to reject the null hypothesis, the CAR parameters are positive in most cases, suggesting that the border crossing incidents do not, if at all, negatively affect the stock market performances. This result is also plausible, given the relative insignificance of the events themselves. Both the Korean Won and Japanese Yen datasets produce negative CARs in terms of US Dollars, but, again, the parameters are not statistically significant here as well.

The bond market data behave largely in a similar way to other markets, with insignificant parameter estimates. The only exception is the Japanese 3-year maturity bond, which shows negative and significant sign-test results in two intervals, but the CAR parameters are still very low—between 0% and 0.08%—in all event windows. Overall, both the Korean and Japanese financial markets are not significantly affected by the effect of border crossing events by North Korean vessels, as was expected. Table 4 summarizes the CAR parameters and test-statistics.

6.3 Nuke/LRM Experiment

It is natural to expect that experimentation with weapons of mass destruction such as nuclear weapons would convey much stronger signals about risk than

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
KOSPI (N=14)	[-1, 0]	0.128	0.150	0.106	-0.891
	[-1, 1]	-0.198	-0.189	-0.381	-1.441
	[-1, 3]	1.229	0.910	0.331	0.208
	[-1, 5]	2.159	1.350	0.277	0.208
Nikkei (N=14)	[-1, 0]	1.037	1.791∗	1.269	0.080
	[-1, 1]	1.175	1.657∗	1.552	0.634
	[-1, 3]	0.939	1.027	0.864	-1.029
	[-1, 5]	1.623	1.499	1.310	-0.474
KRW (N=14)	[-1, 0]	-0.037	-0.126	-0.083	-0.633
	[-1, 1]	-0.016	-0.043	-0.289	0.452
	[-1, 3]	-0.235	-0.509	-0.562	-1.175
	[-1, 5]	-0.104	-0.191	-0.055	-1.175
JPY (N=14)	[-1, 0]	-0.309	-1.144	-1.204	-1.588
	[-1, 1]	-0.373	-1.126	-1.062	-1.049
	[-1, 3]	-0.389	-0.909	-0.744	-0.510
	[-1, 5]	-0.287	-0.567	-1.067	-0.510
Bond(KR, 3yr) (N=11)	[-1, 0]	0.044	0.364	0.097	-0.021
	[-1, 1]	0.056	0.380	-0.037	-0.649
	[-1, 3]	0.124	0.650	0.235	-0.021
	[-1, 5]	0.071	0.315	-0.078	-0.649
Bond(KR, 10yr) (N=11)	[-1, 0]	0.284	0.801	1.366	0.679
	[-1, 1]	0.208	0.479	0.341	-0.568
	[-1, 3]	0.375	0.670	0.300	0.679
	[-1, 5]	0.385	0.580	0.123	0.679
Bond(JP, 3yr) (N=14)	[-1, 0]	-0.006	-0.222	0.295	-1.156
	[-1, 1]	0.003	0.102	0.801	-0.614
	[-1, 3]	-0.048	-1.163	-0.063	-2.239∗∗
	[-1, 5]	-0.071	-1.472	-0.597	-2.239∗∗
Bond(JP, 10yr) (N=14)	[-1, 0]	0.021	0.127	0.906	-0.103
	[-1, 1]	0.059	0.296	1.218	-0.645
	[-1, 3]	0.182	0.709	1.484	0.982
	[-1, 5]	0.114	0.375	0.869	-0.103

Table 4: CARs (Border Crossings by Asset Class)

Notes: See the notes from Table 2.

other types of events such as minor border crossings. Such weapons not only increase the expected damage from a potential attack, but also raise questions whether the facilities in North Korea can properly control the nuclear power, a failure of which will result in indirect damages to geographically neighboring regions. While there have been many rumors about North Korea's plans to develop such weaponry since late 1980s, actual experimentations are distributed mostly in post-2000 period and exhibit an increasing trend, as shown in Figure 2(b).

While there are only 11 events classified as Nuke/LRM experiments, one can see from Table 5 that the absolute values of the test statistics are in many cases large enough to reject the null hypotheses. This might be due to the relatively clear message that nuke- or LRM-related experiments add to the risk profile of the neighboring markets. First, the KOSPI index shows negative and statistically significant t-test and sign-test results for most time windows. The negative CAR persists throughout the different event window lengths considered, and the magnitude of the negative returns are also large relative to other types of events, with -2% to -3% cumulative abnormal returns compared to 0.3% to 0.4% CARs from the baseline analysis and the simple mean (not abnormal) return of 0.04%. The Nikkei index, however, does not seem to be meaningfully affected by North Korean experiments with nuclear weapon and LRMs. The test statistics do not exhibit statistical significance at the 10% level, and the t-test and sign test produce different signs for test-statistics as well. One possible explanation would be that the investors do not perceive Japan as a potential target of North Korean aggressions or that the negative information is offset by the optimism for producers of defense products.

In the currency market, Korean Won exhibited negative CARs whose sign test statistics were significant in [-1, 3] and [-1, 5] event windows. While the magnitude of the calculated CARs are large compared to the baseline result or other events and

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
KOSPI (N=11)	[-1, 0]	-1.789	-3.167**	-1.287	-2.533**
	[-1, 1]	-2.258	-3.264**	-1.230	-1.905*
	[-1, 3]	-3.265	-3.656**	-1.604	-1.905*
	[-1, 5]	-2.137	-2.023**	-1.242	-1.905*
Nikkei (N=11)	[-1, 0]	-0.007	-0.011	-0.285	-0.776
	[-1, 1]	0.150	0.207	-0.102	-0.776
	[-1, 3]	0.656	0.701	0.326	-0.141
	[-1, 5]	1.143	1.033	0.633	-0.776
KRW (N=11)	[-1, 0]	-0.066	-0.170	0.358	-0.891
	[-1, 1]	-0.443	-0.936	-0.697	-1.504
	[-1, 3]	-0.318	-0.520	-0.192	-2.116**
	[-1, 5]	-0.470	-0.650	-1.677*	-2.116**
JPY (N=11)	[-1, 0]	0.123	0.380	0.275	-0.383
	[-1, 1]	0.309	0.782	0.709	-0.999
	[-1, 3]	0.246	0.482	0.369	-0.999
	[-1, 5]	0.042	0.069	0.159	-0.999
Bond(KR, 3yr) (N=10)	[-1, 0]	-0.047	-0.682	-0.653	-0.883
	[-1, 1]	-0.024	-0.278	-0.165	-1.540
	[-1, 3]	-0.091	-0.831	-0.967	-2.196**
	[-1, 5]	-0.094	-0.725	-1.015	-2.196**
Bond(KR, 10yr) (N=10)	[-1, 0]	-0.157	-0.680	-1.083	-1.229
	[-1, 1]	-0.110	-0.391	-0.402	-1.873*
	[-1, 3]	-0.271	-0.744	-0.867	-1.229
	[-1, 5]	-0.231	-0.535	-0.705	-1.229
Bond(JP, 3yr) (N=11)	[-1, 0]	-0.032	-1.654*	-0.775	-2.169**
	[-1, 1]	-0.033	-1.393	-1.248	-2.783**
	[-1, 3]	-0.028	-0.918	-0.518	-1.555
	[-1, 5]	-0.012	-0.326	-0.345	-0.941
Bond(JP, 10yr) (N=11)	[-1, 0]	-0.117	-1.247	-0.909	-1.474
	[-1, 1]	-0.123	-1.071	-1.177	-2.086**
	[-1, 3]	-0.169	-1.144	-1.037	-0.863
	[-1, 5]	-0.128	-0.731	-0.898	-0.863

Table 5: CARs (Nuke/LRM Experiments by Asset Class)

Notes: See the notes from Table 2.

are consistently negative, the parametric results do not show statistical significance. Here the statistical power might have been limited due to the small sample size of only 11 events. The data on Japanese Yen, as is the case else where within this study, could not reject the null hypothesis of zero cumulative abnormal return. The calculated CAR parameters were very small and were positive while the sign-test statistics were negative.

Both the 3-year and the 10-year maturity Korean government bonds exhibited negative CARs and significant sign-test results. This is in contrast to the case of armed provocations where the abnormal returns on Korean government bonds turned out to be positive. These results suggest that investors regard the nuclear experiments as a genuine threat to the government's ability to repay the bond promises, while other types of provocations are not perceived to be as big of a risk factor to the government. The CAR on Japanese government bonds of both maturities also turned out to be negative, but their magnitudes (0.01% to 0.04% for 3-year bonds and 0.1% to 0.17% for 10-year bonds) are smaller than the CARs for the Korean equivalents and naturally less statistically significant. Again, this statistical insignificant might be due to the lack of power of statistical tests with small sample sizes. However, overall the results show consistently negative CAR parameters across most assets in different event windows, with two exceptions of the Nikkei Index and the Japanese Yen.

6.4 Nuke/LRM Rumors

Compared to other types of events such as direct experiments with nuclear weapons, rumors about the development nuke or LRM do not pose a direct or imminent threat, but do still have potential to affect investor confidence in financial

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
KOSPI (N=22)	[-1, 0]	0.555	1.257	0.875	0.410
	[-1, 1]	-0.042	-0.077	0.003	-0.479
	[-1, 3]	-0.276	-0.395	-0.212	-0.923
	[-1, 5]	-0.722	-0.874	-0.382	-1.367
Nikkei (N=22)	[-1, 0]	0.159	0.353	0.412	-1.399
	[-1, 1]	-0.240	-0.435	-0.242	-1.399
	[-1, 3]	-0.604	-0.849	-0.629	-1.844∗
	[-1, 5]	-0.282	-0.336	-0.541	-1.399
KRW (N=22)	[-1, 0]	0.200	0.713	0.571	0.320
	[-1, 1]	0.024	0.069	-0.567	-0.988
	[-1, 3]	-0.084	-0.189	-0.105	-0.116
	[-1, 5]	-0.227	-0.433	-0.749	-0.988
JPY (N=22)	[-1, 0]	-0.226	-1.151	-0.938	-1.215
	[-1, 1]	-0.207	-0.861	-0.742	-1.215
	[-1, 3]	0.100	0.320	0.609	0.082
	[-1, 5]	0.035	0.096	0.471	0.082
Bond(KR, 3yr) (N=19)	[-1, 0]	-0.017	-0.265	-0.331	0.047
	[-1, 1]	-0.011	-0.137	-0.109	-1.375
	[-1, 3]	-0.036	-0.355	-0.074	-0.427
	[-1, 5]	-0.022	-0.183	-0.133	-1.375
Bond(KR, 10yr) (N=19)	[-1, 0]	-0.037	-0.199	-0.524	-0.737
	[-1, 1]	-0.030	-0.131	-0.561	-2.147∗∗
	[-1, 3]	-0.127	-0.434	-0.702	-1.207
	[-1, 5]	-0.226	-0.651	-1.110	-1.677∗
Bond(JP, 3yr) (N=21)	[-1, 0]	-0.003	-0.181	-0.040	-1.509
	[-1, 1]	-0.007	-0.298	0.062	-1.065
	[-1, 3]	-0.016	-0.557	0.266	-0.621
	[-1, 5]	-0.022	-0.625	0.545	-1.509
Bond(JP, 10yr) (N=21)	[-1, 0]	-0.071	-0.648	-0.001	-0.728
	[-1, 1]	-0.178	-1.319	-0.650	-1.174
	[-1, 3]	-0.234	-1.348	-0.846	-1.620
	[-1, 5]	-0.176	-0.857	-0.578	-1.620

Table 6: CARs (Nuke/LRM Rumors by Asset Class)

Notes: See the notes from Table 2.

markets, perhaps to a lesser degree than the effect of experimentations. The result of the event study analysis is presented in Table 6. Not surprisingly, KOSPI index data indicate negative CARs following the release of rumors about nuke or LRMs, but both the magnitude and statistical significance of the parameters are much smaller than in the case of actual experiments. While Nikkei index shows positive (but not significant) CAR in the shortest event window of [-1, 0], the CARs actually turn negative in the following days in the window. The sign-test results show statistical significance at the 10% level in some event window choices, but other test statistics are not significant at that level.

The Korean Won also does not seem to display CARs that are significantly different from zero. While the sign-test result is significant on event window of [-1, 5] at 5% level, non-significant test statistics from shorter event windows suggest that this might simply be due to random chance. The Japanese Yen data exhibit no discernable pattern of CARs with no statistically significant test-statistics, again confirming the resilience of the currency to the North Korea risk.

For both the Korean and Japanese government bonds with differing maturities, the CAR parameters were small compared to those following nuclear experiments, and were not statistically significant. Only the non-parametric sign-test rejected the null hypothesis on some event windows, but this was not consistent either. The rumors about North Korea's nuclear facilities and long range missiles therefore can be understood to be somewhat adverse to the bond market investors, but we cannot make a conclusive statement that the magnitude of the shock is statistically different from zero.

7 Defense Industry and Economic Cooperation Stocks

In order to measure the response of the 4 defense stocks and the 14 economic cooperation stocks listed in Korea Exchange, I first created an equal-weighted portfolio for each of the two groups of stocks and calculated the abnormal return parameters of these portfolios, following the procedure suggested by MacKinlay (1997). I used the firm-level daily stock price data from May 15, 1989 for defense companies, which is when the price data of the first two company stocks became available, and from July 2000 for economic cooperation stocks. The daily return values on these portfolios are used to calculate CARs using the OLS Market Model. As described earlier under the Methodology section, the Market Model uses OLS regression to find the beta for the stock/portfolio concerned, and the beta is then used to calculate the normal return based on the CAPM. The resulting parameters therefore need to be interpreted as the abnormal return in excess of what can be predicted by the past sensitivity to the market and the actual market return (KOSPI index, in this case). A CAR parameter would be zero if the portfolio performed the same way as in the past relative to the market index, and would be different from zero if it over- or under-reacted to specific events relative to its past performance relative to the market. This isolates the effect of the provocations from the abnormal return attributable to movement of the overall market. The reason for using the shorter time-series for the economic cooperation portfolio is that the history of economic cooperation is not long, and most of the conciliatory or cooperative programs have started as result of the North-South Korea summit in June 2000. It is unclear whether Ahn et al. (2010) made such adjustments not to include the pre-summit data for the analysis of economic cooperation stocks. The arithmetic means of each portfolio's return over the time series are 0.075% for the defense stocks and 0.023% for the economic cooperation stocks.

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
All Events (N=78)	[-1, 0]	0.137	0.337	-0.040	-0.235
	[-1, 1]	-0.686	-1.378	-1.300	-1.825∗
	[-1, 3]	0.011	0.016	0.131	-0.689
	[-1, 5]	1.260	1.657∗	1.656∗	1.128
Provocations (N=32)	[-1, 0]	1.301	2.120∗∗	1.370	0.605
	[-1, 1]	0.384	0.510	-0.157	-1.163
	[-1, 3]	0.917	0.945	0.122	-1.163
	[-1, 5]	1.143	0.995	0.261	-0.102
Border Crossing (N=14)	[-1, 0]	-1.325	-1.077	-0.809	0.227
	[-1, 1]	-3.257	-2.161∗∗	-1.765∗	-0.310
	[-1, 3]	-4.052	-2.082∗∗	-1.475	-0.846
	[-1, 5]	-1.927	-0.837	-0.614	-0.310
Nuke/LRM Experiment (N=11)	[-1, 0]	-1.122	-1.130	-2.052∗∗	-1.917∗
	[-1, 1]	-1.157	-0.951	-1.550	-1.917∗
	[-1, 3]	-0.546	-0.348	-0.510	-0.095
	[-1, 5]	1.905	1.025	1.204	1.120
Nuke/LRM Rumors (N=21)	[-1, 0]	-0.002	-0.003	-0.039	-0.005
	[-1, 1]	-0.355	-0.428	-0.105	-0.446
	[-1, 3]	1.654	1.545	1.962∗∗	0.877
	[-1, 5]	3.509	2.769∗∗	3.156∗∗	1.759∗

Table 7: CARs (Defense Industry Stocks by Event Type)

Notes: See the notes from Table 2.

As McDonald and Kendall (1994) found with US defense stocks, one could imagine that defense portfolios would react positively to signs of external threats. As shown in Table 7, the baseline analysis of the Korean defense portfolio using all events, however, provides statistical test results with inconsistent signs, again requiring further analyses by event types. Armed provocations are found to produce positive CARs of between 0.384% and 1.301% depending on the event window for the defense portfolio. These parameters are large compared to the average return of 0.075% and statistically significant in the [-1, 0] event window case at the 5% significance level. Surprisingly, following the border crossings, the defense portfolio exhibited negative

CARs of as large as -4.052% and the t-statistics rejected the null hypotheses in most windows as well. While this is consistent with the previous findings that incidents of border crossings do not produce a strong signal about the geopolitical risk to the investors, it is difficult to understand why the parameters would in fact be negative.

Following the releases of rumors about nuclear weapons or LRMs, the defense portfolio is found to decline with the market (over short-term event windows [-1, 0] and [-1, 1]), but the abnormal return parameter turns positive on the third day, leading to positive and significant CARs over longer event windows ([-1, 4], [-1, 5], and [-1, 6]). In fact, we can see a similar reversal of the initial trend following nuclear experiments as well, but the positive CARs are not statistically significant in the latter case. This might be due to two facts. First, the sample size for nuclear experiments is again very small with only 11 events, so the power of the tests many not be strong enough to appropriately reject the null hypotheses. Second, defense industry companies are not isolated from the negative consequences of war. In fact, defense product manufacturers might be the first targets of the enemies and therefore could potentially be more susceptible to certain types of threats than other companies. This might be especially true if there is a threat of aerial attack through missiles and nuclear weapons. The second theory helps explain the reversal in signs of CARs over longer event windows, as investors are assured against the initial threats and start to view the heightened threat as good news for the producers of defense products.

The results of the analysis on the economic cooperation portfolios are summarized in Table 8. Consistent with prior expectation, the baseline analysis of the economic cooperation stocks based on all of the events provides negative and statistically significant CARs. The test-statistics for the sign-test are even more significant, rejecting the null hypotheses in all event windows at the 5% level. This makes sense as the economic cooperation firms would exhibit greater sensitivity to news that are

Asset	Window	CAR(%)	Test statistics		
			t-test	BMP-test	Sign Test
All Events (N=61)	[-1, 0]	-0.412	-1.592	-1.553	-3.786**
	[-1, 1]	-0.311	-0.981	-0.974	-3.007**
	[-1, 3]	-0.610	-1.489	-1.407	-2.487**
	[-1, 5]	-0.949	-1.958*	-1.853*	-3.266**
Provocation (N=21)	[-1, 0]	-0.542	-1.357	-1.066	-2.473**
	[-1, 1]	-0.181	-0.371	-0.360	-2.034**
	[-1, 3]	-0.089	-0.141	-0.211	-2.034**
	[-1, 5]	-0.394	-0.527	-0.626	-2.034**
Border Crossing (N=11)	[-1, 0]	-0.031	-0.049	-0.154	-0.934
	[-1, 1]	0.688	0.869	0.788	-0.321
	[-1, 3]	-0.290	-0.284	-0.550	-0.321
	[-1, 5]	-0.923	-0.763	-0.757	-0.321
Nuke/LRM Experiment (N=10)	[-1, 0]	0.597	1.007	1.439	0.036
	[-1, 1]	0.584	0.804	0.891	0.036
	[-1, 3]	0.238	0.254	0.246	0.036
	[-1, 5]	0.471	0.425	0.371	-0.608
Nuke/LRM Rumors (N=19)	[-1, 0]	-1.020	-2.005**	-2.185**	-3.508**
	[-1, 1]	-1.504	-2.413**	-2.150**	-3.039**
	[-1, 3]	-1.820	-2.262**	-2.393**	-2.101**
	[-1, 5]	-2.368	-2.488**	-2.597**	-3.039**

Table 8: CARs (Economic Cooperation Stocks by Event Type)

Notes: See the notes from Table 2.

not conducive to a healthy inter-Korea relationship. While the CAR parameters are not significant following armed provocations, their signs are all negative and are supported by statistically significant sign-test results, again at the 5% level in most windows. The test statistics for both parametric and non-parametric tests in the case of border crossing event type are not significant anywhere, again supporting the earlier findings that border crossings do not provide significant information about the North Korea risk.

As was the case for the defense portfolio, the economic cooperation port-

folio also does not deviate from the overall market movement following the nuclear experiments. Again, this could be partly due to the small sample size and partly to the fact that the market reaction is significant enough that it does not leave much room for a particular portfolio to lose even more value relative to the market. What is most interesting is that the cooperation portfolio exhibits negative and significant CARs following rumors about nuke or LRMs, while the overall market do not respond significantly to the same events. The magnitude of the abnormal returns ranges from 1.020% to 2.368%, compared to the average return of 0.023%. A possible explanation might be that, since rumors about nuclear weapons are often used as bargaining chips in inter-Korea diplomacy, the news that does not affect the overall market index could still negatively affect the companies that generate revenue from reconciliatory policies.

One final note is that, while I was able to focus on the companies whose core functions are manufacturing of military products, the same was not possible for economic cooperation stocks. No single company included in the economic cooperation portfolio solely "specializes" in the North Korea-related revenue streams, and therefore each company's degree of exposure to North Korea risk would be different. Due to the difficulty in accounting for this subtlety, it may be advisable to give more weight to the signs rather than the magnitude of the estimated parameters when interpreting the result, as I have done here.

8 Time Variation

In order to see whether the market response to the provocation has changed over the course of the time period examined, I broke the study period into three

sub-periods: period (A) from 1980 to 2000, (B) from 2001 to 2011, and (C) from 2011 to 2017. Such a breakdown is based on two major political events that changed the dynamic within the Korean Peninsula. First, the Inter-Korean Summit held in June 2000[5] between the leadership of the two Koreas marked a step away from military competition towards economic cooperation and communication. South Korean President Kim Dae-jung was also awarded the Nobel Peace Prize in that year, for his contribution to the improved inter-Korean relationship in the same year. The second breakpoint is the death of North Korea's General Secretary Kim Jong-il and the subsequent succession by Kim Jong-un at the turn of the year from 2011 to 2012. The unexpected change of regime following the death of the former leader led to a juncture in previous diplomatic policies and heightened the uncertainty about the risk posed by North Korea. No events fell ambiguously near those breakpoints.

For each asset class and type of event, I then calculated the mean CAR over the representative [-1, 5] event window for each event. The mean of the CARs are then compared across different sub-periods using Welch's mean-comparion t-test, which accounts for unequal variance in the subgroup observations. The results are shown in Table 9. Notice from Figure 2 that, virtually all of border crossing events are concentrated in the middle (or "(B)") sub-period, so the border crossing category is excluded from this analysis. Also, the number of observations within each sub-period (shown in the parentheses in the tables) also tends to be quite small, leading one to expect low power of the statistical analyses.

Consistent with the expectation, the differences in means parameters shown on the right two columns of Table 9 are not statistically significant in most cases. In the case of KOSPI following armed provocations, the mean CAR increases by 2.5907% points (statistically significant at $> 5\%$ level) going from period (A) to period (B),

[5]There is no provocative event in the year 2000 included in the list of events used for this study, which made the breakdown simple.

Asset Type	Event Type	1980-00 (A)	2001-11 (B)	2012-17 (C)	(B)-(A)	(C)-(B)
KOSPI	Provocation	-1.430 (N=22)	1.161 (N=12)	1.292 (N=9)	2.591 (1.038)**	0.131 (1.709)
	Experiment	-5.981 (N=1)	-5.125 (N=3)	-0.067 (N=7)	0.855	5.059 (2.422)*
	Nuke Rumors	6.031 (N=3)	-0.101 (N=15)	-4.669 (N=4)	-6.941 (3.041)*	-3.759 (4.773)
Nikkei	Provocation	0.017 (N=22)	0.849 (N=12)	0.229 (N=9)	0.833 (1.172)	-0.620 (1.557)
	Experiment	1.178 (N=1)	-1.906 (N=3)	2.012 (N=7)	-3.084	3.918 (1.922)*
	Nuke Rumors	2.887 (N=3)	-0.817 (N=15)	-0.975 (N=4)	-3.704 (4.166)	-0.158 (2.899)
KRW	Provocation	-0.027 (N=22)	-0.457 (N=12)	0.073 (N=9)	-0.430 (0.990)	0.530 (1.049)
	Experiment	-1.398 (N=1)	0.032 (N=3)	-0.553 (N=7)	1.430	-0.585 (0.378)
	Nuke Rumors	-0.024 (N=3)	-0.013 (N=15)	-1.028 (N=4)	0.011 (0.387)	-1.015 (0.819)
JPY	Provocation	0.348 (N=22)	0.223 (N=12)	-0.358 (N=9)	-0.125 (0.611)	-0.580 (0.954)
	Experiment	6.241 (N=1)	-1.181 (N=3)	-0.320 (N=7)	-7.423	0.862 (0.696)
	Nuke Rumors	1.050 (N=3)	-0.126 (N=15)	-0.060 (N=4)	-1.176 (0.677)	0.066 (1.339)

Table 9: Time Variation by Asset and Event Types

Notes: Numbers indicate mean CAR over [-1, 5] event windows in percentage terms. Parentheses on the right two columns show standard error of the difference in means. * and ** indicate statistical significance at the 10 and 5 percent levels, respectively.

indicating disappearance of the negative Korean stock market response over that time period. This might support the idea that the market participants are growing accustomed to the provocations, or this might be due to the change in perception about North Korea as an enemy after the Inter-Korean Summit in 2000. The mean CARs following nuke/LRM experiments went up significantly for both KOSPI and Nikkei

Asset Type	Event Type	1980-00 (A)	2001-11 (B)	2012-17 (C)	(B)-(A)	(C)-(B)
KR Bond (3Yr)	Provocation		0.235 (N=12)	-0.082 (N=9)		-0.317 (0.203)
	Experiment		-0.114 (N=3)	-0.070 (N=7)		0.083 (0.061)
	Nuke Rumors		-0.024 (N=15)	0.018 (N=4)		0.041 (0.126)
KR Bond (10Yr)	Provocation		0.905 (N=12)	-0.198 (N=9)		-1.102 (0.530)*
	Experiment		-0.169 (N=3)	-0.242 (N=7)		-0.073 (0.448)
	Nuke Rumors		-0.213 (N=15)	-0.014 (N=4)		0.199 (0.647)
JP Bond (3Yr)	Provocation	-0.092 (N=11)	-0.094 (N=12)	-0.032 (N=9)	-0.001 (0.112)	0.061 (0.061)
	Experiment	-0.101 (N=1)	-0.087 (N=3)	0.033 (N=7)	0.014	0.120 (0.079)
	Nuke Rumors	-0.570 (N=2)	-0.001 (N=15)	0.172 (N=4)	0.568 (0.350)	0.173 (0.151)
JP Bond (10Yr)	Provocation	0.064 (N=11)	-0.160 (N=12)	-0.019 (N=9)	-0.224 (0.378)	0.141 (0.275)
	Experiment	-0.333 (N=1)	-0.280 (N=3)	-0.034 (N=7)	0.053	0.246 (0.460)
	Nuke Rumors	-1.747 (N=2)	-0.181 (N=15)	0.532 (N=4)	1.566 (0.325)**	0.713 (0.538)

Table 9: Time Variation by Asset and Event Types (Continued)

indices from period (B) to period (C). Again, this might be due to the fact that both markets were becoming used to hearing about nuke experiments conducted by North Korea after the initial period of surprises. Lastly, we can also observe that the CARs for Korean government bond prices following armed provocations decreased on average from period (B) to period (C). While it is unclear why such a shift happened, we can perhaps infer from here that the surprising result of positive CARs for Korean bond prices following armed provocations that we found in Section 5 was driven by the

positive CARs during the period of relative peace between 2001 and 2011. Overall, while the t-statistics are generally low due to small sample sizes, the mean CARs in the later period tend to be higher than in earlier periods (the differences in the right two columns tend to be positive) for most Korean and Japanese assets, except for the case of Korean government bonds. This supports the claim that the magnitude of the shock has become smaller over time and that more investors started to view these events as a "buy" opportunity than they did in earlier periods. An additional explanation might be that the more mature and stable financial markets have contributed to higher resilience of the asset prices compared to earlier subperiods, as Chen and Siems (2004) argued. Again, one needs to be careful when drawing conclusions from these results, as the number of observations is very low and, statistically speaking, we might be getting seemingly significant results by pure chance with the probability equal to the level of significance that we observe.

9 Conclusion

The goal of this paper was to understand how Korean and Japanese financial markets respond to the geopolitical risk posed by North Korean provocations. The baseline conclusion of the paper is that both the type of the provocation and the type of the financial asset matter in estimating the impact of the provocations. While KOSPI Index, Korean Won, and Japanese governmnet bonds exhibited negative abnormal returns following the provocations in various choices of event windows and event types, I did not find a consistently significant negative returns on Nikkei Index, Japanese Yen, or Japanese government bonds. Consistent with prior expectations, armed provocations and experiments with nuclear weapons or LRMs had larger

impact on the asset returns in both magnitude and statistical significance than relatively minor news such as maritime border crossings or rumors about the weapons. Interestingly, the values of some assets that are generally regarded as safer, such as Korean government bonds or Japanese Yen, exhibited even positive abnormal returns following the provocations, providing some evidence of "flight to safety" at times of increased uncertainty.

In an analysis of how particular sets of company stocks responded to the shocks, the economic cooperation stocks exhibited significantly negative abnormal returns relative to the market based on the non-parametric sign test. This is consistent with prior expectations as these companies are more susceptible to the fluctuations in the inter-Korean relationship. These firms have more to lose than other companies following even minor events such as border crossings or nuclear rumors that are not significant enough to affect the investor confidence of the overall market but bad enough to affect the paths of the cooperative projects between the two Koreas. I also found that the defense industry companies tend to react negatively along with the overall market over short event windows. But in longer event window choices such as [-1, 3] or [-1, 5], the cumulative abnormal return parameters relative to the market fluctuation actually turned positive for these companies, suggesting that investors see the provocative events as potential growth opportunities for the defense industry firms after they overcome the initial shocks. This result has an implication similar to that of MacDonald and Kendall (1994) paper, in which the authors suggested the use of defense stocks as a way to hedge against the geopolitical risks.

Compared to the benchmark studies by Ahn et al. (2010) and Kim and Jung (2014), the use of more objective event dataset led to lower rejection rate of the null hypotheses. This suggests that the results from the previous studies might be suffering from subjective bias during the selection of the events. In the context of this

study based on daily return data, a failure to reject the null hypothesis could mean any of the following things. First, there in fact may be no meaningful relationship between the news about the provocation and the asset prices. Second, the low power of statistical tests due to having a small sample prevents us from adequately rejecting the null hypothesis. One could interpret this to mean that the newspaper headlines carry a non-trivial information but are often regarded as "business as usual," leading to non-significant market reactions. Third, it is also possible that the abnormal returns of each asset, where they exist, are already well-understood by the arbitrageurs and are quickly made to disappear, making it impossible to be fully captured in a study using daily data. The mean-comparison analysis across different time periods in Section 8 shows that, while statistically not so significant, on average the magnitude of the negative returns have been mitigated over time. This result suggests that the statistically insignificant effect of North Korean provocations might be attributable to maturer and more stable financial markets and growing impassiveness towards the provocative events by the investors.

Reference

Arms Control Association. 2017. "Chronology of U.S.-North Korean Nuclear and Missile Diplomacy." Last modified March 12. https://www.armscontrol.org/factsheets/dprkchron.

Ahn, Hee-Joon, Seung-Pyo Jeon, and Jong-Bum Chay. 2010. The effects of the news related to the North-South Korean relationship on the Korean stock markets. *Journal of Korean Economic Analysis* 16 (August): 199-238.

Bilson, Christopher M., Timothy J. Brailsford, and Vincent C. Hooper. 2002. The explanatory power of political risk in emerging markets. *International Review of Financial Analysis* 11 (1): 1-27.

Boehmer, Ekkehart, Jim Musumeci, and Annette B. Poulsen. 1991. Event-study methodology under conditions of event-induced variance. *Journal of Financial Economics* 30 (December): 253-72.

Brown, Stephen J and Jerold B. Warner. 1980. Measuring security price performance. *Journal of Financial Economics* 8 (February): 205-58.

Chen, Andrew H., and Thomas F. Siems. 2004. The effects of terrorism on global capital markets. *European Journal of Politial Economy* 20 (June): 349-66.

Chesney, Marc, Ganna Reshetar, and Mustafa Karaman. 2010. The impact of terrorism on financial markets: an emperical study. *Journal of Banking & Finance* 35 (February): 253-67.

Cowan, Arnold R. 1992. Non-parametric event study tests. *Review of Quantitative Finance and Accounting* 2 (December): 343-58.

Dibooglu, Sel, and Emrah I. Cevik. 2016. The effect of North Korean threats on financial markets in South Korea and Japan. *Journal of Asian Economics* 43 (April): 18-26.

Eldor, Rafi, Shmuel Hauser, Yoram Kroll, and Sharbel Shoukair. 2012. Financial markets and terrorism: the perspective of the two sides of the conflict. *Journal of Business Administration Research* 1 (July): 18-29.

Karolyi, George Andrew and Rudolfo Martell. 2006. Terrorism and the stock market. *SSRN Electronic Journal* 2 (June).

Kim, Chi Wook. 2011. Inter-Korean relations and "Korea Discount": an analysis of foreign investors' stock trading. *Journal of Peace and Unificiation Studies* 3 (1): 219-52.

Kim, Young Han (Andy), and Hosung Jung. 2014. Investor trading behavior around the time of geopolitical risk events: evidence from South Korea. Bank of Korea Working Paper 2014-10.

Kolari, James W., and Seppo Pynnonen. 2010. Event study testing with cross-sectional correlation of abnormal returns. *Review of Financial Studies* 23 (Novembmer): 3996-4025.

Korea Audit Bureau of Certification. 2010. Regular report on 2010 daily newspaper publication data. Seoul, South Korea: Korea Audit Bureau of Certification.

Korea Audit Bureau of Certification. 2017. Regular report on 2016 daily newspaper publication data. Seoul, South Korea: Korea Audit Bureau of Certification.

MacKinlay, Craig. 1997. Event studies in economics and finance. *Journal of Economic Literature* 35 (March): 13-39.

McDonald, James E and Walter R. Kendall. 1994. An econometric analysis of the choice of daily versus monthly returns in tests of information content. *Journal of Accounting Research* 22 (2): 605-623.

Morse, Dale. 1984. Measuring the economic effects of political events: war and the U.S. defense industry. *Journal of Applied Business Research* 10 (1): 57-61.

Niederhoffer, Victor. 1971. The analysis of world events and stock prices. *The Journal of Business* 44 (April): 193-219.

Pak, Yunjung, Yong-jin Kim, Min Song, Yong-Hak Kim. 2015. Shock waves of political risk on the stock market: the case of Korean companies in the U.S. *Development and Society* 44 (1): 145-65.

Smith, Sheila A. 2013, North Korea in Japan's strategic thinking. *The Asan Forum.* 7 October.

Song, Chi Yong. 2002, News and financial prices. *International Economic Journal* 8 (December): 1-34.

Willard, Kristen L., Timothy W. Guinnane, and Harvey S. Rosen. Turning Points in the Civil War: Views from the Greenback Market. *The American Economic Review* 86 (September): 1001-18.

Zach, Tzachi. 2003. Political events and the stock market: evidence from Israel. *International Journal of Business* 8 (August): 244-66.

A Appendix: Test Statistics

Throughout the Appendix A, I use the following notations:

N = number of events (indexed with j)

τ = days within the event window

s_i = standard deviation of returns over the estimation window for asset i

AR_{it} = abnormal return of asset i on day t

SAR_{it} = standardized abnormal return of asset i on day t

$CSAR_i$ = cumulative standardized abnormal return cumulated over the event window

$\overline{CSAR_i}$ = mean cumulative standardized abnormal return over N

The traditional t-test implicitly assumes that the variances of returns over the estimation windows and over the event windows are the same. The t-statistic therefore uses the standard deviation of abnormal returns from the estimation window to standardize the Cumulative Abnormal Return (CAR) parameters. Therefore, the test statistic under the null hypothesis $H_0 : CAR_i = 0$ for asset i is

$$t_{CAR,i} = \frac{CAR_i}{S_{CAR,i}} \tag{6}$$

where

$$S^2_{CAR,i} = (\text{event window length}) \times s_i^2. \tag{7}$$

Boehmer et al. (1991) found that the standard t-test rejects the null hy-

potheses of zero abnormal returns too frequently when there exists an event-induced volatility increase (i.e. when aforementioned the implicit assumption does not hold). The authors therefore suggest the use of an alternative 'standardized cross-sectional test' that controls for event-induced variance by normalizing each day's ARs into SARs before aggregating over the event window and dividing the CSAR by the cross-sectional standard deviation across the events. Therefore, the standardized cross-sectional test, or simply the BMP-test statistic after the initials of the authors, is

$$t_{BMP} = \frac{\overline{CSAR}}{S(\overline{CSAR})} \tag{8}$$

where

$$\overline{CSAR_i} = \frac{1}{N}\sum_{j=1}^{N} CSAR_i \tag{9}$$

$$CSAR_i = \sum_{\tau} SAR_{it} \tag{10}$$

$$SAR_{it} = \frac{AR_{it}}{s_i} \tag{11}$$

and

$$S(\overline{CSAR}) = \sqrt{\frac{1}{N(N-1)}\sum_{j=1}^{N}[CSAR_j - \overline{CSAR}]^2}. \tag{12}$$

In otherwords, the BMP test statistic incorporates the both the variance from the estimation window and the variance from the event window by first standardizing abnormal returns using estimation window standard deviation and applying the event-window cross-sectional standard deviation. If there is no event-induced variance

increase, the cross-sectional standard deviation for standardized abnormal returns would be equal to 1 and the BMP-test should produce the same result as the traditional t-test.

As an additional robustness-check, a non-parametric generalized sign test from Cowan (1992) is used in conjuction with the t-test and the BMP-test. The test focuses only on the sign (i.e. positive or negative) of the parameters (CARs) and the null hypothesis states that the proportion of positive cumulative abnormal returns during the event window, p_0^+, is equal to the proportion of positive returns during the estimation window, p_{est}^+. The test statistic is calculated as

$$t_{sign} = \frac{p_0^+ - p_{est}^+}{\sqrt{p_{est}^+(1 - p_{est}^+)/N}}. \tag{13}$$

B Appendix: List of Provocative Events

Date	Event Type	Description
9/10/1980	Armed Provocation	NK abducts 19 South Korean fishermen
12/2/1980	Armed Provocation	NK dispatches 3 armed agents to SK
9/11/1981	Armed Provocation	NK fires at SK guard posts in DMZ
7/10/1982	Armed Provocation	NK and SK exchange fires in DMZ
6/20/1983	Armed Provocation	NK dispatches 3 armed agents to SK
8/5/1983	Armed Provocation	NK dispatches an armed spy ship to SK
8/13/1983	Armed Provocation	NK dispatches an armed command ship to SK
10/9/1983	Armed Provocation	Rangoon bombing incident
6/7/1985	Nuke/LRM News	ABC reports on NK nuke facility
10/22/1985	Armed Provocation	NK naval ship engages battle with SK forces
9/15/1986	Armed Provocation	Bombing of SK's Gimpo Airport
12/2/1987	Armed Provocation	KAL 858 bombing by NK agent
3/5/1990	Armed Provocation	An infiltration tunnel gets discovered
5/23/1992	Armed Provocation	NK dispatches 3 armed agents to SK
3/12/1993	Nuke/LRM News	NK threatens to withdraw from nuclear NPT
6/14/1994	Nuke/LRM News	NK withdraws from IAEA
5/31/1995	Armed Provocation	NK shoots at and abducts SK fishing vessel
6/25/1995	Armed Provocation	NK threatens to terminate armistice
10/18/1995	Armed Provocation	NK dispatches armed agents to SK
5/18/1996	Armed Provocation	Armed NK soldiers infiltrates DMZ
9/18/1996	Armed Provocation	Armed NK infiltrators kills SK soldiers
7/17/1997	Armed Provocation	NK and SK exchange heavy fires in DMZ
10/18/1997	Armed Provocation	Armed NK agents abduct 2 SK farmers
6/23/1998	Border Crossing	An NK submaline found in East Sea
7/13/1998	Armed Provocation	Armed NK agents infiltrate into SK
9/1/1998	Nuke/LRM Experiment	NK launches Daepodong 1 missile

Date	Event Type	Description
3/24/1999	Border Crossing	An NK ship crosses into Japanese border
6/9/1999	Border Crossing	6 NK patrol ship cross into the border
6/16/1999	Armed Provocation	First battle of Yeonpyeong
6/7/2001	Border Crossing	NK merchant ship crosses SK border
6/15/2001	Border Crossing	NK merchant ship crosses SK border
6/25/2001	Border Crossing	NK shipping vessel crosses SK border
11/28/2001	Armed Provocation	NK fires at SK guard posts in DMZ
12/24/2001	Border Crossing	NK ship crosses into Japanese border
6/30/2002	Armed Provocation	Second battle of Yeonpyeong
8/9/2002	Nuke/LRM News	NK refuses to comply with IAEA
10/18/2002	Nuke/LRM News	NK admits the development of nuclear weapon
10/26/2002	Nuke/LRM News	NK refuses to abandon its nuclear plans
11/21/2002	Border Crossing	NK patrolship crosses NLL
12/23/2002	Nuke/LRM News	NK cuts seals on its nuclear facilities
12/31/2002	Nuke/LRM News	NK commits to develop nuclear weapons
1/10/2003	Nuke/LRM News	NK withdraws from NPT
2/21/2003	Border Crossing	NK fighter plane crosses NLL
3/4/2003	Border Crossing	NK fighter plane approches US patrol plane
6/2/2003	Border Crossing	8 NK fishing vessel cross NLL
7/2/2003	Nuke/LRM News	NYT reports on NK's nuke warhead
7/19/2003	Nuke/LRM News	NK adds an LRM battalion
10/3/2003	Nuke/LRM News	NK announces beginning of nuke production
7/14/2004	Border Crossing	NK patrolship crosses NLL
11/2/2004	Border Crossing	3 NK patrolship cross NLL
5/2/2005	Armed Provocation	NK launches 3 short-range missiles to East Sea
6/17/2006	Nuke/LRM News	NK prepares Daepodong 2 missile launch
7/5/2006	Nuke/LRM Experiment	NK luanches 7 Daepodong 2 missiles
8/19/2006	Nuke/LRM News	ABC reports on imminent underground nuke test

Date	Event Type	Description
10/4/2006	Nuke/LRM News	NK announces intention to conduct nuke tests
5/26/2007	Armed Provocation	NK launches missiles into sea
3/29/2008	Armed Provocation	NK launches 3 missiles into West Sea
7/12/2008	Armed Provocation	NK soldier shoots a SK civillian tourist
10/8/2008	Armed Provocation	NK launches a missile into West Sea
11/25/2008	Armed Provocation	NK cuts economic ties with SK
2/25/2009	Nuke/LRM News	NK hints about Daepodong 2 test
3/26/2009	Nuke/LRM News	NK prepares Daepodong 2 missile launch
4/6/2009	Nuke/LRM Experiment	NK launches a rocket, fails to reach the orbit
5/25/2009	Nuke/LRM Experiment	NK conducts second nuclear testing
11/11/2009	Border Crossing	Battle of Daecheong
3/27/2010	Armed Provocation	SK corvette Cheonan sinks near the NLL
5/19/2010	Armed Provocation	NK found responsible for corvette sinking
11/22/2010	Nuke/LRM News	NK reveals a 2,000-centrifuge uranium facility
12/18/2010	Armed Provocation	NK threatens to hit back to SK response
8/11/2011	Armed Provocation	NK fires artillery to NLL near Yeonpyeong Island
3/17/2012	Nuke/LRM News	NK announces a plan for LRM launch
4/14/2012	Nuke/LRM Experiment	NK launches an LRM, which explodes in the air
12/13/2012	Nuke/LRM Experiment	NK successfully conducts an ICBM launch
1/25/2013	Nuke/LRM News	NK announces another nuke experiment plan
2/13/2013	Nuke/LRM Experiment	NK conducts third nuclear testing
3/6/2013	Armed Provocation	NK threatens the repeal of armistice agreement
4/4/2013	Armed Provocation	NK closes down Kaesong complex
3/27/2014	Armed Provocation	NK fires 2 missiles into East Sea
5/23/2014	Armed Provocation	NK fires to SK naval ship near NLL
10/8/2014	Armed Provocation	NK and SK exchange fires in DMZ
8/11/2015	Armed Provocation	NK plants mines in DMZ, injuring SK soldiers
8/21/2015	Armed Provocation	NK fires towards SK loudspeakers near DMZ

Date	Event Type	Description
9/15/2015	Nuke/LRM News	NK threatens to launch a rocket
1/7/2016	Nuke/LRM Experiment	NK conducts fourth nuclear testing
1/29/2016	Nuke/LRM News	NK is reported to be preparing a missile launch
6/23/2016	Nuke/LRM Experiment	NK successfully tests LRM Musudan
7/20/2016	Armed Provocation	NK launches 3 ballistic missiles into East Sea
8/3/2016	Armed Provocation	NK launches a missile into Japanese EEZ
8/25/2016	Nuke/LRM Experiment	NK succeeds at a SLBM test
9/10/2016	Nuke/LRM Experiment	NK conducts fifth nuclear testing

C List of Defense and Economic Cooperation Stocks

1. Defense Industry Stocks in Korea Exchange

Ticker	Company Name	Description
010820	Firstec Co Ltd	Manufactures military weapons and maneuverable vehicles
012450	Hanwha Techwin Co Ltd	Manufactures security imaging and semiconductor equipments
047810	Korea Aerospace Industries Ltd	Manufactures military aircraft parts
079550	LIG Nex1 Co Ltd	Manufactures military and defense weapon systems

2. Economic Cooperation Stocks in Korea Exchange

Ticker	Company Name	Description
000720	Hyundai E&C Co Ltd	Contractor for road construction
000990	Dongbu HiTek Co Ltd	Supplies fertilizers to NK
001120	LG International Corp	Owns manufacturing facilities in NK
001520	Tongyang Inc	Owns manufacturing facilities in NK
001550	Chobi Co Ltd	Supplies fertilizers to NK
002100	Kyung Nong Corp	Supplies fertilizers to NK
007610	Seondo Electric Co Ltd	Supplies electricity to NK
009270	Shinwon Corp	Operates within Kaesong complex
011200	Hyundai Merchant Marine Co Ltd	Owns beneficial interest in Hyundai Corp
011760	Hyundai Corp	Runs various cooperation projects
015760	Korea Electric Power Corp	Supplies equipment and electricity to NK
017040	Kwang Myung Electric Co Ltd	Supplies electricity to NK
017800	Hyundai Elevator Co Ltd	Owns beneficial interest in Hyundai Corp
025860	Namhae Chemical Corp	Supplies fertilizers to NK